

## University of Southampton Research Repository ePrints Soton

Copyright © and Moral Rights for this thesis are retained by the author and/or other copyright owners. A copy can be downloaded for personal non-commercial research or study, without prior permission or charge. This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the copyright holder/s. The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the copyright holders.

When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given e.g.

AUTHOR (year of submission) "Full thesis title", University of Southampton, name of the University School or Department, PhD Thesis, pagination

# Gear Controller Case-study (Time Added Manually)

---

## Table of Contents

Context c0 .....	2
Context c1 .....	2
Context c2 .....	2
Context c3 .....	2
Context c4 .....	3
Context c5 .....	3
Context c6 .....	3
Context c7 .....	4
Machine m0 .....	5
Machine m1 .....	7
Machine m2 .....	11
Machine m3 .....	15
Machine m4 .....	20
Machine m5 .....	25
Machine m6 .....	32
Machine m7 .....	41
Machine m8 .....	53
Machine m9 .....	68
Machine m10 .....	89
Decomposed Machine Controller .....	116
Decomposed Machine Channel .....	130
Decomposed Machine Engine .....	141
Decomposed Machine Gear .....	143
Decomposed Machine Clutch .....	145
Decomposed Machine Clutch (Second Level of Abstraction) .....	147

# Gear Controller Case-study (Time Added Manually)

## Context c0

```
CONTEXT
c0
CONSTANTS
ChangeDL
AXIOMS
axm1 :ChangeDL > 0
END
```

## Context c1

```
CONTEXT
c1
EXTENDS
c0
CONSTANTS
R_TN //ToNeu Releasing deadline
R_NN //NoNeu Releasing deadline
S_NN //NoNeu Setting deadline after a normal releasing process
S_NN_RC //NoNeu Setting deadline with opened clutch during releasing process
S_FN //FromNeu Setting deadline
R_NN_NC_EX //NoNeu Releasing without clutch expiry (500)
AXIOMS
axm1 :R_TN > 0
axm2 :R_NN > 0
axm3 :S_NN > 0
axm4 :S_NN_RC > 0
axm5 :R_TN > 0
axm6 :R_TN ≤ ChangeDL
axm7 :R_NN + S_NN_RC ≤ ChangeDL
axm8 :R_NN_NC_EX + S_NN ≤ ChangeDL
axm9 :S_FN ≤ ChangeDL
axm10 :S_FN > 0
END
```

## Context c2

```
CONTEXT
c2
EXTENDS
c1
CONSTANTS
SyncOpen_DL // 355
SetGear_DL // 350
CloseClutch_DL // 200
Sync_EX // 150
AXIOMS
axm1 :SyncOpen_DL > 0
axm2 :SetGear_DL > 0
axm3 :CloseClutch_DL > 0
axm4 :SyncOpen_DL + SetGear_DL + CloseClutch_DL ≤ S_FN
axm5 :Sync_EX > 0
axm6 :Sync_EX ≤ SyncOpen_DL
END
```

## Context c3

```
CONTEXT
c3
EXTENDS
c2
CONSTANTS
ZeroOpen_DL // 455
Release_DL // 250
Zero_EX // 250
AXIOMS
axm1 :ZeroOpen_DL > 0
axm2 :Release_DL > 0
axm3 :ZeroOpen_DL + Release_DL + CloseClutch_DL ≤ R_TN
```

## Gear Controller Case-study (Time Added Manually)

```
axm4 :Zero_EX > 0  
axm5 :Zero_EX ≤ ZeroOpen_DL
```

**END**

### Context c4

**CONTEXT**

c4

**EXTENDS**

c3

**AXIOMS**

```
axm2 :Zero_EX + Release_DL ≤ R_NN_NC_EX  
axm3 :ZeroOpen_DL + Release_DL + CloseClutch_DL ≤ R_NN  
axm4 :SyncOpen_DL + SetGear_DL + CloseClutch_DL ≤ S_NN  
axm5 :SetGear_DL + CloseClutch_DL ≤ S_NN_RC
```

**END**

### Context c5

**CONTEXT**

c5

**EXTENDS**

c4

**CONSTANTS**

```
Zero_DL // 155  
OpenClutch_DL // 200  
Sync_DL // 255  
OpenClutch_Zero_DE // 250  
OpenClutch_Sync_DE // 150
```

**AXIOMS**

```
axm1 :Zero_DL > 0  
axm2 :OpenClutch_DL > 0  
axm3 :Zero_DL + OpenClutch_DL ≤ ZeroOpen_DL  
axm4 :Sync_DL > 0  
axm5 :Sync_DL + OpenClutch_DL ≤ SyncOpen_DL  
axm6 :Zero_DL ≥ Zero_EX  
axm7 :Sync_DL ≥ Sync_EX  
axm8 :OpenClutch_Zero_DE > 0  
axm9 :OpenClutch_Sync_DE > 0  
axm10 :OpenClutch_Zero_DE > Zero_EX  
axm11 :OpenClutch_Sync_DE > Sync_EX  
axm12 :OpenClutch_Zero_DE ≤ Zero_DL  
axm13 :OpenClutch_Sync_DE ≤ Sync_DL
```

**END**

### Context c6

**CONTEXT**

c6

**EXTENDS**

c5

**CONSTANTS**

```
Channel_DL // 5  
Engine_Sync_DL // 100  
Engine_Zero_DL // 200  
Clutch_Open_DL // 150  
Clutch_Close_DL // 150  
Gear_Set_DL // 300  
Gear_Release_DL // 200
```

**AXIOMS**

```
axm1 :Channel_DL > 0  
axm2 :Engine_Sync_DL > 0  
axm3 :Engine_Zero_DL > 0  
axm4 :2*Channel_DL + Engine_Sync_DL ≤ Sync_EX  
axm5 :2*Channel_DL + Engine_Zero_DL ≤ Zero_EX  
axm6 :Clutch_Open_DL > 0  
axm7 :Clutch_Close_DL > 0  
axm8 :2*Channel_DL + Clutch_Open_DL < OpenClutch_DL  
axm9 :2*Channel_DL + Clutch_Close_DL < CloseClutch_DL  
axm10 :Gear_Set_DL > 0
```

## Gear Controller Case-study (Time Added Manually)

```
axm11 :Gear_Release_DL >0  
axm12 :2*Channel_DL + Gear_Set_DL < SetGear_DL  
axm13 :2*Channel_DL + Gear_Release_DL < Release_DL
```

**END**

### Context c7

**CONTEXT**

c7

**EXTENDS**

c6

**CONSTANTS**

```
Clutch_Open_DE  
Error_Clutch_Open_DE  
Clutch_Close_DE  
Error_Clutch_Close_DE
```

**AXIOMS**

```
axm1 :Clutch_Open_DE > 0  
axm2 :Error_Clutch_Open_DE > Clutch_Open_DE  
axm3 :Clutch_Close_DE > 0  
axm4 :Error_Clutch_Close_DE > Clutch_Close_DE  
axm5 :Error_Clutch_Open_DE ≤ Clutch_Open_DL  
axm6 :Error_Clutch_Close_DE ≤ Clutch_Close_DL
```

**END**

## Machine m0

### MACHINE

**m0** // *Deadline(Request, Response  $\vee$  Error, ChangingDL)*

### SEES

**c0**

### VARIABLES

Request  
Response  
Error // *Flags*  
time  
RequestT // *Time*

### INVARIANTS

inv1 : RequestT  $\in \mathbb{N}$   
inv2 : time  $\in \mathbb{N}$   
inv3 : Request  $\in \text{BOOL}$   
inv4 : Error  $\in \text{BOOL}$   
inv5 : Response  $\in \text{BOOL}$

### EVENTS

**INITIALISATION  $\triangleq$**   
**STATUS**

**ordinary**

### BEGIN

act1 : Error := FALSE  
act2 : Request := FALSE  
act3 : RequestT := 0  
act4 : time := 0  
act5 : Response := FALSE

### END

**Request  $\triangleq$**   
**STATUS**

**ordinary**

### WHEN

grd1 : Request = FALSE

### THEN

act1 : Request := TRUE  
act2 : RequestT := time

### END

**Response  $\triangleq$**   
**STATUS**

**ordinary**

### WHEN

grd1 : Request = TRUE  
grd2 : Error = FALSE  
grd3 : Response = FALSE

### THEN

act1 : Response := TRUE

### END

**Error  $\triangleq$**   
**STATUS**

**ordinary**

### WHEN

grd1 : Error = FALSE  
grd2 : Request = TRUE  
grd3 : Response = FALSE

### THEN

act1 : Error := TRUE

### END

**FINAL  $\triangleq$**   
**STATUS**

**ordinary**

### WHEN

grd1 : Response = TRUE

### THEN

act1 : Request := FALSE  
act2 : Response := FALSE

### END

**Tick\_Tock  $\triangleq$**   
**STATUS**

**ordinary**

### ANY

## Gear Controller Case-study (Time Added Manually)

```
    tick
WHERE
  grd1 : tick > 0
  grd2 : Request = TRUE  $\wedge$  Response = FALSE  $\wedge$ 
        Error = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL + RequestT
THEN
  act1 : time := time + tick
END

END
```

# Gear Controller Case-study (Time Added Manually)

## Machine m1

### MACHINE

```
m1 // Deadline(RequestFromNeu, FromNeu  $\vee$  Error_FromNeu, ChangingDL)
    // Deadline(RequestNoNeu, NoNeu  $\vee$  Error_NoNeu, ChangingDL)
    // Deadline(RequestToNeu, ToNeu  $\vee$  Error_ToNeu, ChangingDL)
```

### REFINES

```
m0
```

### SEES

```
c0
```

### VARIABLES

```
RequestFromNeu
RequestNoNeu
RequestToNeu
FromNeu // Changing from the neutral gear to a gear
ToNeu // Changing from a gear to another gear
NoNeu // Changing from a gear to the neutral gear
Error_FromNeu // Flags
Error_NoNeu
Error_ToNeu // Flags
time
RequestFromNeuT
RequestNoNeuT
RequestToNeuT // Time
isNeu // Gear Status
```

### INVARIANTS

```
inv1 : {ToNeu, FromNeu, NoNeu, isNeu, RequestFromNeu, RequestNoNeu,
        RequestToNeu, Error_FromNeu, Error_NoNeu, Error_ToNeu}  $\in \mathbb{P}(\text{BOOL})$ 
inv2 : (FromNeu = TRUE  $\vee$  ToNeu = TRUE  $\vee$  NoNeu = TRUE)  $\Rightarrow$  Response = TRUE
inv3 : (FromNeu = FALSE  $\wedge$  ToNeu = FALSE  $\wedge$  NoNeu = FALSE)  $\Rightarrow$  Response = FALSE
inv4 : (RequestFromNeu = TRUE  $\vee$  RequestNoNeu = TRUE  $\vee$  RequestToNeu = TRUE)  $\Rightarrow$  Request = TRUE
inv5 : (RequestFromNeu = FALSE  $\wedge$  RequestNoNeu = FALSE  $\wedge$  RequestToNeu = FALSE)  $\Rightarrow$  Request = FALSE
inv6 : RequestFromNeu = TRUE  $\Rightarrow$  RequestToNeu = FALSE  $\wedge$  RequestNoNeu = FALSE
inv7 : RequestToNeu = TRUE  $\Rightarrow$  RequestFromNeu = FALSE  $\wedge$  RequestNoNeu = FALSE
inv8 : RequestNoNeu = TRUE  $\Rightarrow$  RequestFromNeu = FALSE  $\wedge$  RequestToNeu = FALSE
inv9 : RequestNoNeu = TRUE  $\Rightarrow$  ToNeu = FALSE  $\wedge$  FromNeu = FALSE
inv10 : RequestToNeu = TRUE  $\Rightarrow$  FromNeu = FALSE  $\wedge$  NoNeu = FALSE
inv11 : RequestFromNeu = TRUE  $\Rightarrow$  ToNeu = FALSE  $\wedge$  NoNeu = FALSE
inv12 : NoNeu = TRUE  $\Rightarrow$  RequestNoNeu = TRUE
inv13 : FromNeu = TRUE  $\Rightarrow$  RequestFromNeu = TRUE
inv14 : ToNeu = TRUE  $\Rightarrow$  RequestToNeu = TRUE
inv15 : {RequestFromNeuT, RequestNoNeuT, RequestToNeuT}  $\subseteq \mathbb{N}$ 
inv16 : RequestFromNeu = TRUE  $\Rightarrow$  RequestFromNeuT = RequestT
inv17 : RequestNoNeu = TRUE  $\Rightarrow$  RequestNoNeuT = RequestT
inv18 : RequestToNeu = TRUE  $\Rightarrow$  RequestToNeuT = RequestT
inv19 : Error_FromNeu = TRUE  $\vee$  Error_NoNeu = TRUE  $\vee$  Error_ToNeu = TRUE  $\Rightarrow$  Error = TRUE
inv20 : Error_FromNeu = FALSE  $\wedge$  Error_NoNeu = FALSE  $\wedge$  Error_ToNeu = FALSE  $\Rightarrow$  Error = FALSE
inv21 : Error_FromNeu = TRUE  $\Rightarrow$  RequestFromNeu = TRUE
inv22 : Error_NoNeu = TRUE  $\Rightarrow$  RequestNoNeu = TRUE
inv23 : Error_ToNeu = TRUE  $\Rightarrow$  RequestToNeu = TRUE
inv24 : RequestFromNeu = TRUE  $\Rightarrow$  Error_NoNeu = FALSE  $\wedge$  Error_ToNeu = FALSE
inv25 : RequestNoNeu = TRUE  $\Rightarrow$  Error_FromNeu = FALSE  $\wedge$  Error_ToNeu = FALSE
inv26 : RequestToNeu = TRUE  $\Rightarrow$  Error_FromNeu = FALSE  $\wedge$  Error_NoNeu = FALSE
inv27 : FromNeu = TRUE  $\Rightarrow$  RequestFromNeu = TRUE
inv28 : NoNeu = TRUE  $\Rightarrow$  RequestNoNeu = TRUE
inv29 : ToNeu = TRUE  $\Rightarrow$  RequestToNeu = TRUE
inv30 : RequestFromNeu = TRUE  $\Rightarrow$  NoNeu = FALSE  $\wedge$  ToNeu = FALSE
inv31 : RequestNoNeu = TRUE  $\Rightarrow$  FromNeu = FALSE  $\wedge$  ToNeu = FALSE
inv32 : RequestToNeu = TRUE  $\Rightarrow$  FromNeu = FALSE  $\wedge$  NoNeu = FALSE
inv33 : FromNeu = TRUE  $\Rightarrow$  Error_FromNeu = FALSE
inv34 : NoNeu = TRUE  $\Rightarrow$  Error_NoNeu = FALSE
inv35 : ToNeu = TRUE  $\Rightarrow$  Error_ToNeu = FALSE
inv36 : FromNeu = TRUE  $\vee$  ToNeu = TRUE  $\vee$  NoNeu = TRUE  $\Rightarrow$  Error = FALSE
```

### EVENTS

```
INITIALISATION  $\triangleleft$ 
```

```
STATUS
```

```
ordinary
```

### BEGIN

```
act1 : RequestFromNeuT := 0
act2 : RequestNoNeuT := 0
act3 : RequestToNeuT := 0
act4 : time := 0
act5 : ToNeu := FALSE
act6 : FromNeu := FALSE
act7 : NoNeu := FALSE
```



## Gear Controller Case-study (Time Added Manually)

```
act8 :isNeu := TRUE
act9 :RequestNoNeu := FALSE
act10 :RequestToNeu := FALSE
act11 :RequestFromNeu := FALSE
act12 :Error_FromNeu := FALSE
act13 :Error_NoNeu := FALSE
act14 :Error_ToNeu := FALSE
END
```

### RequestFromNeu $\triangle$

```
STATUS
ordinary
REFINES
Request
WHEN
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = TRUE
THEN
act1 :RequestFromNeu := TRUE
act2 :RequestFromNeuT := time
END
```

### RequestNoNeu $\triangle$

```
STATUS
ordinary
REFINES
Request
WHEN
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = FALSE
THEN
act1 :RequestNoNeu := TRUE
act2 :RequestNoNeuT := time
END
```

### RequestToNeu $\triangle$

```
STATUS
ordinary
REFINES
Request
WHEN
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = FALSE
THEN
act1 :RequestToNeu := TRUE
act2 :RequestToNeuT := time
END
```

### FromNeu $\triangle$

```
STATUS
ordinary
REFINES
Response
WHEN
grd1 :RequestFromNeu = TRUE
grd2 :Error_FromNeu = FALSE
grd3 :FromNeu = FALSE
THEN
act1 :FromNeu := TRUE
act2 :isNeu := FALSE
END
```

### NoNeu $\triangle$

```
STATUS
ordinary
REFINES
Response
WHEN
grd1 :RequestNoNeu = TRUE
grd2 :Error_NoNeu = FALSE
grd3 :NoNeu = FALSE
THEN
act1 :NoNeu := TRUE
```

## Gear Controller Case-study (Time Added Manually)

END

**ToNeu**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Response

**WHEN**

grd1 :RequestToNeu = TRUE

grd2 :Error\_ToNeu = FALSE

grd3 :ToNeu = FALSE

**THEN**

act1 :ToNeu := TRUE

act2 :isNeu := TRUE

END

**Error\_FromNeu**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Error

**WHEN**

grd1 :Error\_FromNeu = FALSE

grd2 :RequestFromNeu = TRUE

grd3 :FromNeu = FALSE

**THEN**

act1 :Error\_FromNeu := TRUE

END

**Error\_NoNeu**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Error

**WHEN**

grd1 :Error\_NoNeu = FALSE

grd2 :RequestNoNeu = TRUE

grd3 :NoNeu = FALSE

**THEN**

act1 :Error\_NoNeu := TRUE

END

**Error\_ToNeu**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Error

**WHEN**

grd1 :Error\_ToNeu = FALSE

grd2 :RequestToNeu = TRUE

grd3 :ToNeu = FALSE

**THEN**

act1 :Error\_ToNeu := TRUE

END

**FINAL**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

FINAL

**WHEN**

grd1 :FromNeu = TRUE  $\vee$  ToNeu = TRUE  $\vee$  NoNeu = TRUE

**THEN**

act1 :RequestFromNeu := FALSE

act2 :RequestNoNeu := FALSE

act3 :RequestToNeu := FALSE

act4 :FromNeu := FALSE

act5 :ToNeu := FALSE

act6 :NoNeu := FALSE

END

**Tick\_Tock**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Tick\_Tock

**ANY**

tick

**WHERE**

## Gear Controller Case-study (Time Added Manually)

```
grd1 :tick > 0
grd2 :RequestFromNeu = TRUE  $\wedge$  FromNeu = FALSE  $\wedge$  Error_FromNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL + RequestFromNeuT
grd3 :RequestNoNeu = TRUE  $\wedge$  NoNeu = FALSE  $\wedge$  Error_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL + RequestNoNeuT
grd4 :RequestToNeu = TRUE  $\wedge$  ToNeu = FALSE  $\wedge$  Error_ToNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL + RequestToNeuT
THEN
  act1 :time := time + tick
END
END
```

## Machine m2

### MACHINE

```
m2 // Deadline(RequestFromNeu, FromNeuNoClutch  $\vee$  FromNeuClutch  $\vee$  Error_FromNeu, ChangingDL)
    // Deadline(RequestNoNeu, NoNeuNoClutch  $\vee$  NoNeuClutch  $\vee$  Error_NoNeu, ChangingDL)
    // Deadline(RequestToNeu, ToNeuNoClutch  $\vee$  ToNeuClutch  $\vee$  Error_ToNeu, ChangingDL)
```

### REFINES

m1

### SEES

c0

### VARIABLES

```
RequestFromNeu
RequestNoNeu
RequestToNeu
FromNeuNoClutch
NoNeuClutch // Flags
ToNeuNoClutch
NoNeuNoClutch
FromNeuClutch
ToNeuClutch // nextline
Error_FromNeu // Flags
Error_NoNeu // Flage
Error_ToNeu // Flags
isNeu // Gear Status
time
RequestFromNeuT
RequestNoNeuT
RequestToNeuT // Time
```

### INVARIANTS

```
inv1 :FromNeuClutch  $\in$  BOOL
inv2 :FromNeuNoClutch  $\in$  BOOL
inv3 :ToNeuNoClutch  $\in$  BOOL
inv4 :ToNeuClutch  $\in$  BOOL
inv5 :NoNeuNoClutch  $\in$  BOOL
inv6 :NoNeuClutch  $\in$  BOOL
inv7 :FromNeuNoClutch = TRUE  $\vee$  FromNeuClutch = TRUE  $\Leftrightarrow$  FromNeu = TRUE
inv8 :ToNeuNoClutch = TRUE  $\vee$  ToNeuClutch = TRUE  $\Leftrightarrow$  ToNeu = TRUE
inv9 :NoNeuNoClutch = TRUE  $\vee$  NoNeuClutch = TRUE  $\Leftrightarrow$  NoNeu = TRUE
inv10 :FromNeuNoClutch = FALSE  $\wedge$  FromNeuClutch = FALSE  $\Leftrightarrow$  FromNeu = FALSE
inv11 :ToNeuNoClutch = FALSE  $\wedge$  ToNeuClutch = FALSE  $\Leftrightarrow$  ToNeu = FALSE
inv12 :NoNeuNoClutch = FALSE  $\wedge$  NoNeuClutch = FALSE  $\Leftrightarrow$  NoNeu = FALSE
```

### EVENTS

#### INITIALISATION $\triangleq$

##### STATUS

ordinary

### BEGIN

```
act1 :time := 0
act2 :ToNeuNoClutch := FALSE
act3 :FromNeuNoClutch := FALSE
act4 :NoNeuNoClutch := FALSE
act5 :ToNeuClutch := FALSE
act6 :FromNeuClutch := FALSE
act7 :NoNeuClutch := FALSE
act8 :RequestNoNeu := FALSE
act9 :RequestToNeu := FALSE
act10 :RequestFromNeu := FALSE
act11 :RequestFromNeuT := 0
act12 :RequestNoNeuT := 0
act13 :RequestToNeuT := 0
act14 :isNeu := TRUE
act15 :Error_FromNeu := FALSE
act16 :Error_NoNeu := FALSE
act17 :Error_ToNeu := FALSE
```

### END

#### RequestFromNeu $\triangleq$

extended

##### STATUS

ordinary

### REFINES

RequestFromNeu

### WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = TRUE
```

## Gear Controller Case-study (Time Added Manually)

```
THEN
  act1 :RequestFromNeu := TRUE
  act2 :RequestFromNeuT := time
END
```

```
RequestNoNeu  $\triangleq$ 
  extended
```

```
  STATUS
```

```
  ordinary
```

```
REFINES
```

```
  RequestNoNeu
```

```
WHEN
```

```
  grd1 :RequestFromNeu = FALSE
```

```
  grd2 :RequestNoNeu = FALSE
```

```
  grd3 :RequestToNeu = FALSE
```

```
  grd4 :isNeu = FALSE
```

```
THEN
```

```
  act1 :RequestNoNeu := TRUE
```

```
  act2 :RequestNoNeuT := time
```

```
END
```

```
RequestToNeu  $\triangleq$ 
```

```
  extended
```

```
  STATUS
```

```
  ordinary
```

```
REFINES
```

```
  RequestToNeu
```

```
WHEN
```

```
  grd1 :RequestFromNeu = FALSE
```

```
  grd2 :RequestNoNeu = FALSE
```

```
  grd3 :RequestToNeu = FALSE
```

```
  grd4 :isNeu = FALSE
```

```
THEN
```

```
  act1 :RequestToNeu := TRUE
```

```
  act2 :RequestToNeuT := time
```

```
END
```

```
FromNeuNoClutch  $\triangleq$ 
```

```
  STATUS
```

```
  ordinary
```

```
REFINES
```

```
  FromNeu
```

```
WHEN
```

```
  grd1 :RequestFromNeu = TRUE
```

```
  grd2 :Error_FromNeu = FALSE
```

```
  grd3 :FromNeuNoClutch = FALSE
```

```
  grd4 :FromNeuClutch = FALSE
```

```
THEN
```

```
  act1 :FromNeuNoClutch := TRUE
```

```
  act2 :isNeu := FALSE
```

```
END
```

```
NoNeuNoClutch  $\triangleq$ 
```

```
  STATUS
```

```
  ordinary
```

```
REFINES
```

```
  NoNeu
```

```
WHEN
```

```
  grd1 :RequestNoNeu = TRUE
```

```
  grd2 :Error_NoNeu = FALSE
```

```
  grd3 :NoNeuNoClutch = FALSE
```

```
  grd4 :NoNeuClutch = FALSE
```

```
THEN
```

```
  act1 :NoNeuNoClutch := TRUE
```

```
END
```

```
ToNeuNoClutch  $\triangleq$ 
```

```
  STATUS
```

```
  ordinary
```

```
REFINES
```

```
  ToNeu
```

```
WHEN
```

```
  grd1 :RequestToNeu = TRUE
```

```
  grd2 :Error_ToNeu = FALSE
```

```
  grd3 :ToNeuNoClutch = FALSE
```

```
  grd4 :ToNeuClutch = FALSE
```

```
THEN
```

```
  act1 :ToNeuNoClutch := TRUE
```

```
  act2 :isNeu := TRUE
```

## Gear Controller Case-study (Time Added Manually)

END

**FromNeuClutch**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

FromNeu

**WHEN**

grd1 :RequestFromNeu = TRUE  
grd2 :Error\_FromNeu = FALSE  
grd3 :FromNeuClutch = FALSE  
grd4 :FromNeuNoClutch = FALSE

**THEN**

act1 :FromNeuClutch := TRUE  
act2 :isNeu := FALSE

END

**NoNeuClutch**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

NoNeu

**WHEN**

grd1 :RequestNoNeu = TRUE  
grd2 :Error\_NoNeu = FALSE  
grd3 :NoNeuClutch = FALSE  
grd4 :NoNeuNoClutch = FALSE

**THEN**

act1 :NoNeuClutch := TRUE

END

**ToNeuClutch**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

ToNeu

**WHEN**

grd1 :RequestToNeu = TRUE  
grd2 :Error\_ToNeu = FALSE  
grd3 :ToNeuClutch = FALSE  
grd4 :ToNeuNoClutch = FALSE

**THEN**

act1 :ToNeuClutch := TRUE  
act2 :isNeu := TRUE

END

**Error\_FromNeu**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

Error\_FromNeu

**WHEN**

grd1 :Error\_FromNeu = FALSE  
grd2 :RequestFromNeu = TRUE  
grd3 :FromNeuClutch = FALSE  
grd4 :FromNeuNoClutch = FALSE

**THEN**

act1 :Error\_FromNeu := TRUE

END

**Error\_NoNeu**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu

**WHEN**

grd1 :Error\_NoNeu = FALSE  
grd2 :RequestNoNeu = TRUE  
grd3 :NoNeuClutch = FALSE  
grd4 :NoNeuNoClutch = FALSE

**THEN**

act1 :Error\_NoNeu := TRUE

END

**Error\_ToNeu**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

Error\_ToNeu

## Gear Controller Case-study (Time Added Manually)

**WHEN**

grd1 :Error\_ToNeu = FALSE  
grd2 :RequestToNeu = TRUE  
grd3 :ToNeuClutch = FALSE  
grd4 :ToNeuNoClutch = FALSE

**THEN**

act1 :Error\_ToNeu := TRUE

**END**

**FINAL**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

FINAL

**WHEN**

grd1 : FromNeuNoClutch = TRUE  $\vee$  ToNeuNoClutch = TRUE  $\vee$  NoNeuNoClutch = TRUE  $\vee$   
FromNeuClutch = TRUE  $\vee$  ToNeuClutch = TRUE  $\vee$  NoNeuClutch = TRUE

**THEN**

act1 :RequestFromNeu := FALSE  
act2 :RequestNoNeu := FALSE  
act3 :RequestToNeu := FALSE  
act4 :FromNeuNoClutch := FALSE  
act5 :ToNeuNoClutch := FALSE  
act6 :NoNeuNoClutch := FALSE  
act7 :FromNeuClutch := FALSE  
act8 :ToNeuClutch := FALSE  
act9 :NoNeuClutch := FALSE

**END**

**Tick\_Tock**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

Tick\_Tock

**ANY**

tick

**WHERE**

grd1 :tick > 0  
grd2 :RequestFromNeu = TRUE  $\wedge$  FromNeuClutch = FALSE  $\wedge$  FromNeuNoClutch = FALSE  $\wedge$  Error\_FromNeu = FALSE  $\Rightarrow$  time+tick  $\leq$   
: ChangeDL + RequestFromNeuT  
grd3 :RequestNoNeu = TRUE  $\wedge$  NoNeuClutch = FALSE  $\wedge$  NoNeuNoClutch = FALSE  $\wedge$  Error\_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL +  
: RequestNoNeuT  
grd4 :RequestToNeu = TRUE  $\wedge$  ToNeuClutch = FALSE  $\wedge$  ToNeuNoClutch = FALSE  $\wedge$  Error\_ToNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL +  
: RequestToNeuT

**THEN**

act1 :time := time + tick

**END**

**END**

## Machine m3

### MACHINE

```

m3 // Deadline(RequestFromNeu, Setting_FromNeu_NoClutch  $\vee$  Setting_FromNeu_Clutch  $\vee$  Error_FromNeu, ChangingDL)
    // Deadline(RequestNoNeu, Setting_NoNeu_ReleaseClutch  $\vee$  Setting_NoNeu_NoClutch  $\vee$  Setting_NoNeu_Clutch
    // Error_Releasing_NoNeu  $\vee$  Error_Setting_NoNeu, ChangingDL)
    // Deadline(RequestToNeu, Releasing_ToNeu_NoClutch  $\vee$  Releasing_ToNeu_Clutch  $\vee$  Error_ToNeu, ChangingDL)

```

### REFINES

m2

### SEES

c0

### VARIABLES

```

time
RequestFromNeuT
RequestNoNeuT
RequestToNeuT // Time
isNeu // Gear Status
RequestFromNeu
RequestNoNeu
RequestToNeu
Setting_NoNeu_NoClutch // Flags
Setting_FromNeu_NoClutch
Releasing_ToNeu_NoClutch
Releasing_NoNeu_NoClutch // Flags
Setting_FromNeu_Clutch
Releasing_ToNeu_Clutch
Releasing_NoNeu_Clutch // Flags
Setting_NoNeu_Clutch
Setting_NoNeu_ReleaseClutch // Flags
Error_FromNeu // Flags
Error_Releasing_NoNeu // Flage
Error_Setting_NoNeu // Flage
Error_ToNeu // Flags

```

### INVARIANTS

```

{Setting_FromNeu_Clutch, Releasing_ToNeu_Clutch, Releasing_NoNeu_Clutch, Setting_NoNeu_Clutch,
inv1 :Setting_NoNeu_ReleaseClutch, Releasing_ToNeu_NoClutch, Releasing_NoNeu_NoClutch, Setting_NoNeu_NoClutch,
    Setting_FromNeu_NoClutch, Error_FromNeu ,Error_Releasing_NoNeu ,Error_Setting_NoNeu,Error_ToNeu}  $\in$   $\mathbb{P}$ (BOOL)
inv2 :Setting_FromNeu_NoClutch = TRUE  $\Leftrightarrow$  FromNeuNoClutch = TRUE
inv3 :Setting_NoNeu_NoClutch = TRUE  $\Leftrightarrow$  NoNeuNoClutch = TRUE
inv4 :Releasing_ToNeu_NoClutch = TRUE  $\Leftrightarrow$  ToNeuNoClutch = TRUE
inv5 :Setting_FromNeu_Clutch = TRUE  $\Leftrightarrow$  FromNeuClutch = TRUE
inv6 :Setting_NoNeu_Clutch = TRUE  $\vee$  Setting_NoNeu_ReleaseClutch = TRUE  $\Leftrightarrow$  NoNeuClutch = TRUE
inv7 :Releasing_ToNeu_Clutch = TRUE  $\Leftrightarrow$  ToNeuClutch = TRUE
inv8 :Releasing_NoNeu_NoClutch =TRUE  $\vee$  Releasing_NoNeu_Clutch =TRUE  $\Rightarrow$  RequestNoNeu = TRUE
inv9 :Releasing_NoNeu_NoClutch =TRUE  $\Rightarrow$  Releasing_NoNeu_Clutch =FALSE
inv10 :Releasing_NoNeu_Clutch =TRUE  $\Rightarrow$  Releasing_NoNeu_NoClutch =FALSE
inv11 :Setting_NoNeu_Clutch = TRUE  $\vee$  Setting_NoNeu_NoClutch = TRUE  $\Rightarrow$  Releasing_NoNeu_NoClutch = TRUE
inv12 :Setting_NoNeu_ReleaseClutch = TRUE  $\Rightarrow$  Releasing_NoNeu_Clutch = TRUE
inv13 :Error_Releasing_NoNeu = FALSE  $\wedge$  Error_Setting_NoNeu = FALSE  $\Rightarrow$  Error_NoNeu = FALSE
inv14 :Error_Releasing_NoNeu = TRUE  $\vee$  Error_Setting_NoNeu = TRUE  $\Rightarrow$  Error_NoNeu = TRUE
inv15 :Releasing_NoNeu_Clutch = TRUE  $\vee$  Releasing_NoNeu_NoClutch = TRUE  $\Rightarrow$  Error_Releasing_NoNeu = FALSE
inv16 :RequestNoNeu = TRUE  $\wedge$  Releasing_NoNeu_Clutch = FALSE  $\wedge$  Releasing_NoNeu_NoClutch = FALSE  $\Rightarrow$  Error_Setting_NoNeu =
: FALSE

```

### EVENTS

#### INITIALISATION $\triangleq$

#### STATUS

#### ordinary

### BEGIN

```

act1 :time := 0
act2 :isNeu := TRUE
act3 :RequestNoNeu := FALSE
act4 :RequestToNeu := FALSE
act5 :RequestFromNeu := FALSE
act6 :RequestFromNeuT := 0
act7 :RequestNoNeuT := 0
act8 :RequestToNeuT := 0
act9 :Releasing_ToNeu_NoClutch := FALSE
act10 :Setting_FromNeu_NoClutch := FALSE
act11 :Releasing_NoNeu_NoClutch := FALSE
act12 :Setting_NoNeu_NoClutch := FALSE
act13 :Releasing_ToNeu_Clutch := FALSE
act14 :Setting_FromNeu_Clutch := FALSE
act15 :Releasing_NoNeu_Clutch := FALSE
act16 :Setting_NoNeu_Clutch := FALSE
act17 :Setting_NoNeu_ReleaseClutch := FALSE

```



## Gear Controller Case-study (Time Added Manually)

```
act18 :Error_FromNeu := FALSE
act19 :Error_Releasing_NoNeu:= FALSE
act20 :Error_Setting_NoNeu:= FALSE
act21 :Error_ToNeu:= FALSE
END

RequestFromNeu  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  RequestFromNeu
WHEN
  grd1 :RequestFromNeu = FALSE
  grd2 :RequestNoNeu = FALSE
  grd3 :RequestToNeu = FALSE
  grd4 :isNeu = TRUE
THEN
  act1 :RequestFromNeu := TRUE
  act2 :RequestFromNeuT := time
END

RequestNoNeu  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  RequestNoNeu
WHEN
  grd1 :RequestFromNeu = FALSE
  grd2 :RequestNoNeu = FALSE
  grd3 :RequestToNeu = FALSE
  grd4 :isNeu = FALSE
THEN
  act1 :RequestNoNeu := TRUE
  act2 :RequestNoNeuT := time
END

RequestToNeu  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  RequestToNeu
WHEN
  grd1 :RequestFromNeu = FALSE
  grd2 :RequestNoNeu = FALSE
  grd3 :RequestToNeu = FALSE
  grd4 :isNeu = FALSE
THEN
  act1 :RequestToNeu := TRUE
  act2 :RequestToNeuT := time
END

Setting_FromNeu_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  FromNeuNoClutch
WHEN
  grd1 :RequestFromNeu = TRUE
  grd2 :Error_FromNeu = FALSE
  grd3 :Setting_FromNeu_NoClutch = FALSE
  grd4 :Setting_FromNeu_Clutch = FALSE
THEN
  act1 :Setting_FromNeu_NoClutch := TRUE
  act2 :isNeu := FALSE
END

Setting_FromNeu_Clutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  FromNeuClutch
WHEN
  grd1 :RequestFromNeu = TRUE
  grd2 :Error_FromNeu = FALSE
  grd3 :Setting_FromNeu_Clutch = FALSE
  grd4 :Setting_FromNeu_NoClutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
THEN
  act1 :Setting_FromNeu_Clutch := TRUE
  act2 :isNeu := FALSE
END

Releasing_NoNeu_NoClutch  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :Error_Releasing_NoNeu = FALSE
  grd3 :Releasing_NoNeu_NoClutch = FALSE
  grd4 :Releasing_NoNeu_Clutch = FALSE
THEN
  act1 :Releasing_NoNeu_NoClutch := TRUE
END

Releasing_NoNeu_Clutch  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :Error_Releasing_NoNeu = FALSE
  grd3 :Releasing_NoNeu_Clutch = FALSE
  grd4 :Releasing_NoNeu_NoClutch = FALSE
THEN
  act1 :Releasing_NoNeu_Clutch := TRUE
END

Setting_NoNeu_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  NoNeuNoClutch
WHEN
  grd1 :Releasing_NoNeu_NoClutch = TRUE
  grd2 :Error_Setting_NoNeu = FALSE
  grd3 :Setting_NoNeu_NoClutch = FALSE
  grd4 :Setting_NoNeu_Clutch = FALSE
THEN
  act1 :Setting_NoNeu_NoClutch := TRUE
END

Setting_NoNeu_Clutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  NoNeuClutch
WHEN
  grd1 :Releasing_NoNeu_NoClutch = TRUE
  grd2 :Error_Setting_NoNeu = FALSE
  grd3 :Setting_NoNeu_Clutch = FALSE
  grd4 :Setting_NoNeu_NoClutch = FALSE
THEN
  act1 :Setting_NoNeu_Clutch := TRUE
END

Setting_NoNeu_ReleaseClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  NoNeuClutch
WHEN
  grd1 :Releasing_NoNeu_Clutch = TRUE
  grd2 :Error_Setting_NoNeu = FALSE
  grd3 :Setting_NoNeu_ReleaseClutch = FALSE
THEN
  act1 :Setting_NoNeu_ReleaseClutch := TRUE
END

Releasing_ToNeu_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  ToNeuNoClutch
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :Error_ToNeu = FALSE
  grd3 :Releasing_ToNeu_NoClutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
    grd4 :Releasing_ToNeu_Clutch = FALSE
THEN
    act1 :Releasing_ToNeu_NoClutch := TRUE
    act2 :isNeu := TRUE
END

    Releasing_ToNeu_Clutch  $\triangle$ 
    STATUS
    ordinary
REFINES
    ToNeuClutch
WHEN
    grd1 :RequestToNeu = TRUE
    grd2 :Error_ToNeu = FALSE
    grd3 :Releasing_ToNeu_Clutch = FALSE
    grd4 :Releasing_ToNeu_NoClutch = FALSE
THEN
    act1 :Releasing_ToNeu_Clutch := TRUE
    act2 :isNeu := TRUE
END

    Error_ToNeu  $\triangle$ 
    STATUS
    ordinary
REFINES
    Error_ToNeu
WHEN
    grd1 :Error_ToNeu = FALSE
    grd2 :RequestToNeu = TRUE
    grd3 :Releasing_ToNeu_NoClutch = FALSE
    grd4 :Releasing_ToNeu_Clutch = FALSE
THEN
    act1 :Error_ToNeu := TRUE
END

    Error_Releasing_NoNeu  $\triangle$ 
    STATUS
    ordinary
REFINES
    Error_NoNeu
WHEN
    grd1 :Error_Releasing_NoNeu = FALSE
    grd2 :RequestNoNeu = TRUE
    grd3 :Releasing_NoNeu_Clutch = FALSE
    grd4 :Releasing_NoNeu_NoClutch = FALSE
THEN
    act1 :Error_Releasing_NoNeu := TRUE
END

    Error_Setting_NoNeu  $\triangle$ 
    STATUS
    ordinary
REFINES
    Error_NoNeu
WHEN
    grd1 :Error_Setting_NoNeu = FALSE
    grd2 :Releasing_NoNeu_Clutch = TRUE  $\vee$  Releasing_NoNeu_NoClutch = TRUE
    grd3 :Setting_NoNeu_NoClutch = FALSE
    grd4 :Setting_NoNeu_Clutch = FALSE
    grd5 :Setting_NoNeu_ReleaseClutch = FALSE
THEN
    act1 :Error_Setting_NoNeu := TRUE
END

    Error_FromNeu  $\triangle$ 
    STATUS
    ordinary
REFINES
    Error_FromNeu
WHEN
    grd1 :Error_FromNeu = FALSE
    grd2 :RequestFromNeu = TRUE
    grd3 :Setting_FromNeu_NoClutch = FALSE
    grd4 :Setting_FromNeu_Clutch = FALSE
THEN
    act1 :Error_FromNeu := TRUE
END

    FINAL  $\triangle$ 
```

## Gear Controller Case-study (Time Added Manually)

```
STATUS
ordinary
REFINES
FINAL
WHEN
  grd1 : Setting_FromNeu_NoClutch = TRUE  $\vee$  Setting_NoNeu_NoClutch = TRUE  $\vee$  Releasing_ToNeu_NoClutch = TRUE  $\vee$ 
  : Setting_FromNeu_Clutch = TRUE  $\vee$  Setting_NoNeu_Clutch = TRUE  $\vee$  Setting_NoNeu_ReleaseClutch = TRUE  $\vee$ 
  : Releasing_ToNeu_Clutch = TRUE
THEN
  act1 : RequestFromNeu := FALSE
  act2 : RequestNoNeu := FALSE
  act3 : RequestToNeu := FALSE
  act4 : Releasing_ToNeu_NoClutch := FALSE
  act5 : Setting_NoNeu_NoClutch := FALSE
  act6 : Setting_FromNeu_NoClutch := FALSE
  act7 : Releasing_NoNeu_NoClutch := FALSE
  act8 : Releasing_ToNeu_Clutch := FALSE
  act9 : Setting_NoNeu_Clutch := FALSE
  act10 : Setting_NoNeu_ReleaseClutch := FALSE
  act11 : Setting_FromNeu_Clutch := FALSE
  act12 : Releasing_NoNeu_Clutch := FALSE
END

Tick_Tock  $\triangleq$ 
STATUS
ordinary
REFINES
Tick_Tock
ANY
tick
WHERE
  grd1 : tick > 0
  grd2 : RequestFromNeu = TRUE  $\wedge$  Setting_FromNeu_Clutch = FALSE  $\wedge$ 
  : Setting_FromNeu_NoClutch = FALSE  $\wedge$  Error_FromNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL + RequestFromNeuT
  : RequestNoNeu = TRUE  $\wedge$  Setting_NoNeu_Clutch = FALSE  $\wedge$ 
  : Setting_NoNeu_ReleaseClutch = FALSE  $\wedge$  Setting_NoNeu_NoClutch = FALSE  $\wedge$ 
  : Error_Releasing_NoNeu = FALSE  $\wedge$  Error_Setting_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL + RequestNoNeuT
  : RequestToNeu = TRUE  $\wedge$  Releasing_ToNeu_Clutch = FALSE  $\wedge$ 
  : Releasing_ToNeu_NoClutch = FALSE  $\wedge$  Error_ToNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  ChangeDL + RequestToNeuT
THEN
  act1 : time := time + tick
END
END
```

## Machine m4

### MACHINE

```

// Deadline(RequestFromNeu, Setting_FromNeu_NoClutch V Setting_FromNeu_Clutch V Error_FromNeu, S_FN)
// Deadline(RequestNoNeu, Releasing_NoNeu_Clutch V Releasing_NoNeu_NoClutch V Error_Releasing_NoNeu, R_NN)
m4 // Deadline(Releasing_NoNeu_NoClutch, Setting_NoNeu_NoClutch V Setting_NoNeu_Clutch V Error_Setting_NoNeu, S_NN)
// Deadline(Releasing_NoNeu_Clutch, Setting_NoNeu_ReleaseClutch V Error_Setting_NoNeu, S_NN_RC)
// Expiry(RequestNoNeu, Releasing_NoNeu_NoClutch, R_NN_NC_EX)
// Deadline(RequestToNeu, Releasing_ToNeu_NoClutch V Releasing_ToNeu_Clutch V Error_ToNeu, R_TN)

```

### REFINES

m3

### SEES

c1

### VARIABLES

```

time
RequestFromNeuT
RequestNoNeuT
RequestToNeuT
Releasing_NoNeu_ClutchT
Releasing_NoNeu_NoClutchT // Time
isNeu // Gear Status
Setting_FromNeu_NoClutch
Releasing_ToNeu_NoClutch
Releasing_NoNeu_NoClutch // Flags
Setting_NoNeu_NoClutch
RequestFromNeu
RequestNoNeu
RequestToNeu
Setting_FromNeu_Clutch
Releasing_ToNeu_Clutch
Releasing_NoNeu_Clutch
Setting_NoNeu_Clutch
Setting_NoNeu_ReleaseClutch
Error_FromNeu // Flags
Error_Releasing_NoNeu // Flage
Error_Setting_NoNeu // Flage
Error_ToNeu // Flags

```

### INVARIANTS

```

inv1 : {Releasing_NoNeu_ClutchT, Releasing_NoNeu_NoClutchT} ⊆ ℕ
inv2 : Releasing_NoNeu_Clutch = TRUE ⇒ Releasing_NoNeu_ClutchT ≤ RequestNoNeuT + R_NN
inv3 : Releasing_NoNeu_NoClutch = TRUE ⇒ Releasing_NoNeu_NoClutchT ≤ RequestNoNeuT + R_NN_NC_EX
inv4 : RequestNoNeu = TRUE ∧ Releasing_NoNeu_Clutch = FALSE ∧
      Releasing_NoNeu_NoClutch = FALSE ∧ Error_Releasing_NoNeu = FALSE ⇒ time ≤ R_NN + RequestNoNeuT

```

### EVENTS

#### INITIALISATION ≙

extended

STATUS

ordinary

#### BEGIN

```

act1 : time := 0
act2 : isNeu := TRUE
act3 : RequestNoNeu := FALSE
act4 : RequestToNeu := FALSE
act5 : RequestFromNeu := FALSE
act6 : RequestFromNeuT := 0
act7 : RequestNoNeuT := 0
act8 : RequestToNeuT := 0
act9 : Releasing_ToNeu_NoClutch := FALSE
act10 : Setting_FromNeu_NoClutch := FALSE
act11 : Releasing_NoNeu_NoClutch := FALSE
act12 : Setting_NoNeu_NoClutch := FALSE
act13 : Releasing_ToNeu_Clutch := FALSE
act14 : Setting_FromNeu_Clutch := FALSE
act15 : Releasing_NoNeu_Clutch := FALSE
act16 : Setting_NoNeu_Clutch := FALSE
act17 : Setting_NoNeu_ReleaseClutch := FALSE
act18 : Error_FromNeu := FALSE
act19 : Error_Releasing_NoNeu := FALSE
act20 : Error_Setting_NoNeu := FALSE
act21 : Error_ToNeu := FALSE
act22 : Releasing_NoNeu_ClutchT := 0
act23 : Releasing_NoNeu_NoClutchT := 0

```

#### END

RequestFromNeu ≙

## Gear Controller Case-study (Time Added Manually)

```
    extended
      STATUS
    ordinary
  REFINES
    RequestFromNeu
  WHEN
    grd1 :RequestFromNeu = FALSE
    grd2 :RequestNoNeu = FALSE
    grd3 :RequestToNeu = FALSE
    grd4 :isNeu = TRUE
  THEN
    act1 :RequestFromNeu := TRUE
    act2 :RequestFromNeuT := time
  END

  RequestNoNeu  $\triangle$ 
    extended
      STATUS
    ordinary
  REFINES
    RequestNoNeu
  WHEN
    grd1 :RequestFromNeu = FALSE
    grd2 :RequestNoNeu = FALSE
    grd3 :RequestToNeu = FALSE
    grd4 :isNeu = FALSE
  THEN
    act1 :RequestNoNeu := TRUE
    act2 :RequestNoNeuT := time
  END

  RequestToNeu  $\triangle$ 
    extended
      STATUS
    ordinary
  REFINES
    RequestToNeu
  WHEN
    grd1 :RequestFromNeu = FALSE
    grd2 :RequestNoNeu = FALSE
    grd3 :RequestToNeu = FALSE
    grd4 :isNeu = FALSE
  THEN
    act1 :RequestToNeu := TRUE
    act2 :RequestToNeuT := time
  END

  Setting_FromNeu_NoClutch  $\triangle$ 
    extended
      STATUS
    ordinary
  REFINES
    Setting_FromNeu_NoClutch
  WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :Error_FromNeu = FALSE
    grd3 :Setting_FromNeu_NoClutch = FALSE
    grd4 :Setting_FromNeu_Clutch = FALSE
  THEN
    act1 :Setting_FromNeu_NoClutch := TRUE
    act2 :isNeu := FALSE
  END

  Setting_FromNeu_Clutch  $\triangle$ 
    extended
      STATUS
    ordinary
  REFINES
    Setting_FromNeu_Clutch
  WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :Error_FromNeu = FALSE
    grd3 :Setting_FromNeu_Clutch = FALSE
    grd4 :Setting_FromNeu_NoClutch = FALSE
  THEN
    act1 :Setting_FromNeu_Clutch := TRUE
    act2 :isNeu := FALSE
  END
```

## Gear Controller Case-study (Time Added Manually)

```
Releasing_NoNeu_NoClutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Releasing_NoNeu_NoClutch  
WHEN  
  grd1 :RequestNoNeu = TRUE  
  grd2 :Error_Releasing_NoNeu = FALSE  
  grd3 :Releasing_NoNeu_NoClutch = FALSE  
  grd4 :Releasing_NoNeu_Clutch = FALSE  
  grd5 :time  $\leq$  RequestNoNeuT + R_NN_NC_EX  
THEN  
  act1 :Releasing_NoNeu_NoClutch := TRUE  
  act2 :Releasing_NoNeu_NoClutchT := time  
END
```

```
Releasing_NoNeu_Clutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Releasing_NoNeu_Clutch  
WHEN  
  grd1 :RequestNoNeu = TRUE  
  grd2 :Error_Releasing_NoNeu = FALSE  
  grd3 :Releasing_NoNeu_Clutch = FALSE  
  grd4 :Releasing_NoNeu_NoClutch = FALSE  
THEN  
  act1 :Releasing_NoNeu_Clutch := TRUE  
  act2 :Releasing_NoNeu_ClutchT := time  
END
```

```
Setting_NoNeu_NoClutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Setting_NoNeu_NoClutch  
WHEN  
  grd1 :Releasing_NoNeu_NoClutch = TRUE  
  grd2 :Error_Setting_NoNeu = FALSE  
  grd3 :Setting_NoNeu_NoClutch = FALSE  
  grd4 :Setting_NoNeu_Clutch = FALSE  
THEN  
  act1 :Setting_NoNeu_NoClutch := TRUE  
END
```

```
Setting_NoNeu_Clutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Setting_NoNeu_Clutch  
WHEN  
  grd1 :Releasing_NoNeu_NoClutch = TRUE  
  grd2 :Error_Setting_NoNeu = FALSE  
  grd3 :Setting_NoNeu_Clutch = FALSE  
  grd4 :Setting_NoNeu_NoClutch = FALSE  
THEN  
  act1 :Setting_NoNeu_Clutch := TRUE  
END
```

```
Setting_NoNeu_ReleaseClutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Setting_NoNeu_ReleaseClutch  
WHEN  
  grd1 :Releasing_NoNeu_Clutch = TRUE  
  grd2 :Error_Setting_NoNeu = FALSE  
  grd3 :Setting_NoNeu_ReleaseClutch = FALSE  
THEN  
  act1 :Setting_NoNeu_ReleaseClutch := TRUE  
END
```

```
Releasing_ToNeu_NoClutch  $\triangle$   
  extended
```

## Gear Controller Case-study (Time Added Manually)

```

    STATUS
ordinary
REFINES
Releasing_ToNeu_NoClutch
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :Error_ToNeu = FALSE
  grd3 :Releasing_ToNeu_NoClutch = FALSE
  grd4 :Releasing_ToNeu_Clutch = FALSE
THEN
  act1 :Releasing_ToNeu_NoClutch := TRUE
  act2 :isNeu := TRUE
END

Releasing_ToNeu_Clutch ≙
extended
STATUS
ordinary
REFINES
Releasing_ToNeu_Clutch
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :Error_ToNeu = FALSE
  grd3 :Releasing_ToNeu_Clutch = FALSE
  grd4 :Releasing_ToNeu_NoClutch = FALSE
THEN
  act1 :Releasing_ToNeu_Clutch := TRUE
  act2 :isNeu := TRUE
END

Error_ToNeu ≙
extended
STATUS
ordinary
REFINES
Error_ToNeu
WHEN
  grd1 :Error_ToNeu = FALSE
  grd2 :RequestToNeu = TRUE
  grd3 :Releasing_ToNeu_NoClutch = FALSE
  grd4 :Releasing_ToNeu_Clutch = FALSE
THEN
  act1 :Error_ToNeu := TRUE
END

Error_Releasing_NoNeu ≙
extended
STATUS
ordinary
REFINES
Error_Releasing_NoNeu
WHEN
  grd1 :Error_Releasing_NoNeu = FALSE
  grd2 :RequestNoNeu = TRUE
  grd3 :Releasing_NoNeu_Clutch = FALSE
  grd4 :Releasing_NoNeu_NoClutch = FALSE
THEN
  act1 :Error_Releasing_NoNeu := TRUE
END

Error_Setting_NoNeu ≙
extended
STATUS
ordinary
REFINES
Error_Setting_NoNeu
WHEN
  grd1 :Error_Setting_NoNeu = FALSE
  grd2 :Releasing_NoNeu_Clutch = TRUE ∨ Releasing_NoNeu_NoClutch = TRUE
  grd3 :Setting_NoNeu_NoClutch = FALSE
  grd4 :Setting_NoNeu_Clutch = FALSE
  grd5 :Setting_NoNeu_ReleaseClutch = FALSE
THEN
  act1 :Error_Setting_NoNeu := TRUE
END

Error_FromNeu ≙
extended
STATUS
```



## Gear Controller Case-study (Time Added Manually)

```
ordinary
REFINES
  Error_FromNeu
WHEN
  grd1 :Error_FromNeu = FALSE
  grd2 :RequestFromNeu = TRUE
  grd3 :Setting_FromNeu_NoClutch = FALSE
  grd4 :Setting_FromNeu_Clutch = FALSE
THEN
  act1 :Error_FromNeu := TRUE
END

FINAL  $\triangle$ 
extended
  STATUS
ordinary
REFINES
  FINAL
WHEN
  : Setting_FromNeu_NoClutch = TRUE  $\vee$  Setting_NoNeu_NoClutch = TRUE  $\vee$  Releasing_ToNeu_NoClutch = TRUE  $\vee$ 
  : Setting_FromNeu_Clutch = TRUE  $\vee$  Setting_NoNeu_Clutch = TRUE  $\vee$  Setting_NoNeu_ReleaseClutch = TRUE  $\vee$ 
  : Releasing_ToNeu_Clutch = TRUE
THEN
  act1 :RequestFromNeu := FALSE
  act2 :RequestNoNeu := FALSE
  act3 :RequestToNeu := FALSE
  act4 :Releasing_ToNeu_NoClutch := FALSE
  act5 :Setting_NoNeu_NoClutch := FALSE
  act6 :Setting_FromNeu_NoClutch := FALSE
  act7 :Releasing_NoNeu_NoClutch := FALSE
  act8 :Releasing_ToNeu_Clutch := FALSE
  act9 :Setting_NoNeu_Clutch := FALSE
  act10 :Setting_NoNeu_ReleaseClutch := FALSE
  act11 :Setting_FromNeu_Clutch := FALSE
  act12 :Releasing_NoNeu_Clutch := FALSE
END

Tick_Tock  $\triangle$ 
  STATUS
ordinary
REFINES
  Tick_Tock
ANY
  tick
WHERE
  grd1 :tick > 0
  grd2 :RequestFromNeu = TRUE  $\wedge$  Setting_FromNeu_Clutch = FALSE  $\wedge$ 
  : Setting_FromNeu_NoClutch = FALSE  $\wedge$  Error_FromNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  S_FN+RequestFromNeuT
  : RequestToNeu = TRUE  $\wedge$  Releasing_ToNeu_Clutch = FALSE  $\wedge$ 
  : Releasing_ToNeu_NoClutch = FALSE  $\wedge$  Error_ToNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  R_TN+RequestToNeuT
  : RequestNoNeu = TRUE  $\wedge$  Releasing_NoNeu_Clutch = FALSE  $\wedge$ 
  : Releasing_NoNeu_NoClutch = FALSE  $\wedge$  Error_Releasing_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  R_NN+RequestNoNeuT
  : Releasing_NoNeu_NoClutch = TRUE  $\wedge$  Setting_NoNeu_Clutch = FALSE  $\wedge$ 
  : Setting_NoNeu_NoClutch = FALSE  $\wedge$  Error_Setting_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  S_NN+ Releasing_NoNeu_NoClutchT
  : Releasing_NoNeu_Clutch = TRUE  $\wedge$  Setting_NoNeu_ReleaseClutch = FALSE  $\wedge$ 
  : Error_Setting_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  S_NN_RC+ Releasing_NoNeu_ClutchT
THEN
  act1 :time := time + tick
END

END
```

# Gear Controller Case-study (Time Added Manually)

## Machine m5

### MACHINE

```
// Deadline(RequestFromNeu, FromNeu_SyncSpeed  $\vee$  FromNeu_OpenClutch  $\vee$  Error_FromNeu_OpenClutch, SyncOpen_DL)
// Expiry(RequestFromNeu, FromNeu_SyncSpeed, Sync_EX)
// Deadline(FromNeu_SyncSpeed, FromNeu_SetGear_NoClutch  $\vee$  Error_FromNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(FromNeu_OpenClutch, FromNeu_SetGear_Clutch  $\vee$  Error_FromNeu_SetGear_Clutch, SetGear_DL)
// Deadline(FromNeu_SetGear_Clutch, FromNeu_CloseClutch  $\vee$  Error_FromNeu_CloseClutch, CloseClutch_DL)
//
m5
// Deadline(RequestNoNeu, Releasing_NoNeu_Clutch  $\vee$  Releasing_NoNeu_NoClutch  $\vee$  Error_Releasing_NoNeu, R_NN)
// Deadline(Releasing_NoNeu_NoClutch, Setting_NoNeu_NoClutch  $\vee$  Setting_NoNeu_Clutch  $\vee$  Error_Setting_NoNeu, S_NN)
// Deadline(Releasing_NoNeu_Clutch, Setting_NoNeu_ReleaseClutch  $\vee$  Error_Setting_NoNeu, S_NN_RC)
// Expiry(RequestNoNeu, Releasing_NoNeu_NoClutch, R_NN_NC_EX)
//
// Deadline(RequestToNeu, Releasing_ToNeu_NoClutch  $\vee$  Releasing_ToNeu_Clutch  $\vee$  Error_ToNeu, R_TN)
```

### REFINES

m4

### SEES

c2

### VARIABLES

```
time // Time
RequestFromNeuT // Time
RequestNoNeuT // Time
RequestToNeuT // Time
Releasing_NoNeu_ClutchT // Time
Releasing_NoNeu_NoClutchT // Time
isNeu // Gear Status
Releasing_ToNeu_NoClutch
Releasing_NoNeu_NoClutch // Flags
Setting_NoNeu_NoClutch
RequestFromNeu // Flags
RequestNoNeu // Flags
RequestToNeu // Flags
Releasing_ToNeu_Clutch // Flags
Releasing_NoNeu_Clutch // Flags
Setting_NoNeu_Clutch // Flags
Setting_NoNeu_ReleaseClutch // Flags
Error_Releasing_NoNeu // Flage
Error_Setting_NoNeu // Flage
Error_ToNeu // Flags
FromNeu_SyncSpeed // Scenario1
FromNeu_OpenClutch // Flage
FromNeu_SetGear_NoClutch // Flage
FromNeu_SetGear_Clutch // Flage
FromNeu_CloseClutch // Flage
Error_FromNeu_OpenClutch // Flage
Error_FromNeu_SetGear_NoClutch // Flage
Error_FromNeu_SetGear_Clutch // Flage
Error_FromNeu_CloseClutch // Scenario1
FromNeu_OpenClutchT // TIME
FromNeu_SyncSpeedT // TIME
FromNeu_SetGear_ClutchT // TIME
```

### INVARIANTS

```
{FromNeu_SyncSpeed, FromNeu_OpenClutch, FromNeu_SetGear_NoClutch, FromNeu_SetGear_Clutch,
inv1 : FromNeu_CloseClutch, Error_FromNeu_OpenClutch, Error_FromNeu_SetGear_NoClutch,
      Error_FromNeu_SetGear_Clutch, Error_FromNeu_CloseClutch}  $\in \mathbb{P}(\text{BOOL})$ 
inv2 : {FromNeu_OpenClutchT, FromNeu_SyncSpeedT, FromNeu_SetGear_ClutchT}  $\subseteq \mathbb{N}$ 
inv3 : FromNeu_SetGear_NoClutch = Setting_FromNeu_NoClutch
inv4 : FromNeu_CloseClutch = Setting_FromNeu_Clutch
inv5 : FromNeu_SyncSpeed = TRUE  $\vee$  FromNeu_OpenClutch = TRUE  $\Rightarrow$  RequestFromNeu = TRUE
inv6 : FromNeu_SetGear_Clutch = TRUE  $\Rightarrow$  FromNeu_OpenClutch = TRUE
inv7 : FromNeu_SetGear_NoClutch = TRUE  $\Rightarrow$  FromNeu_SyncSpeed = TRUE
inv8 : FromNeu_SyncSpeed = TRUE  $\Rightarrow$  FromNeu_OpenClutch = FALSE  $\wedge$  Error_FromNeu_OpenClutch = FALSE
inv9 : FromNeu_CloseClutch = TRUE  $\Rightarrow$  FromNeu_SetGear_Clutch = TRUE
inv10 : FromNeu_OpenClutch = FALSE  $\Rightarrow$  FromNeu_CloseClutch = FALSE
      Error_FromNeu_OpenClutch = FALSE  $\wedge$ 
      Error_FromNeu_SetGear_NoClutch = FALSE  $\wedge$ 
inv11 : Error_FromNeu_SetGear_Clutch = FALSE  $\wedge$ 
      Error_FromNeu_CloseClutch = FALSE  $\Rightarrow$  Error_FromNeu = FALSE
      Error_FromNeu_OpenClutch = TRUE  $\vee$ 
inv12 : Error_FromNeu_SetGear_NoClutch = TRUE  $\vee$ 
      Error_FromNeu_SetGear_Clutch = TRUE  $\vee$ 
      Error_FromNeu_CloseClutch = TRUE  $\Rightarrow$  Error_FromNeu = TRUE
inv13 : FromNeu_SetGear_Clutch = TRUE  $\Rightarrow$  Error_FromNeu_SetGear_Clutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
inv14 :FromNeu_SetGear_NoClutch = TRUE ⇒ Error_FromNeu_SetGear_NoClutch = FALSE
inv15 :FromNeu_CloseClutch = TRUE ⇒ Error_FromNeu_CloseClutch = FALSE
inv16 :FromNeu_OpenClutch = TRUE ⇒ Error_FromNeu_OpenClutch = FALSE
inv17 :RequestFromNeu = TRUE ∧ Error_FromNeu_SetGear_Clutch = TRUE ⇒ FromNeu_OpenClutch = TRUE
inv18 :RequestFromNeu = TRUE ∧ Error_FromNeu_SetGear_NoClutch = TRUE ⇒ FromNeu_SyncSpeed = TRUE
inv19 :RequestFromNeu = TRUE ∧ Error_FromNeu_CloseClutch = TRUE ⇒ FromNeu_SetGear_Clutch = TRUE
inv20 :FromNeu_SyncSpeed = TRUE ⇒ FromNeu_SyncSpeedT ≤ RequestFromNeuT + SyncOpen_DL
inv21 :FromNeu_OpenClutch = TRUE ⇒ FromNeu_OpenClutchT ≤ RequestFromNeuT + SyncOpen_DL
inv22 :FromNeu_SetGear_Clutch = TRUE ⇒ FromNeu_SetGear_ClutchT ≤ FromNeu_OpenClutchT + SetGear_DL
inv23 :RequestFromNeu = TRUE ∧ FromNeu_SyncSpeed= FALSE ∧
      FromNeu_OpenClutch = FALSE ∧ Error_FromNeu_OpenClutch = FALSE ⇒ time ≤ SyncOpen_DL+RequestFromNeuT
inv24 :FromNeu_OpenClutch = TRUE ∧ FromNeu_SetGear_Clutch= FALSE ∧
      Error_FromNeu_SetGear_Clutch = FALSE ⇒ time ≤ SetGear_DL+FromNeu_OpenClutchT
```

### EVENTS

#### INITIALISATION ≙

##### STATUS

###### ordinary

### BEGIN

```
act1 :time := 0
act2 :isNeu := TRUE
act3 :RequestNoNeu := FALSE
act4 :RequestToNeu := FALSE
act5 :RequestFromNeu := FALSE
act6 :RequestFromNeuT := 0
act7 :RequestNoNeuT := 0
act8 :RequestToNeuT := 0
act9 :Releasing_ToNeu_NoClutch := FALSE
act10 :Releasing_NoNeu_NoClutch := FALSE
act11 :Setting_NoNeu_NoClutch := FALSE
act12 :Releasing_ToNeu_Clutch := FALSE
act13 :Releasing_NoNeu_Clutch := FALSE
act14 :Setting_NoNeu_Clutch := FALSE
act15 :Setting_NoNeu_ReleaseClutch := FALSE
act16 :Error_Releasing_NoNeu := FALSE
act17 :Error_Setting_NoNeu := FALSE
act18 :Error_ToNeu := FALSE
act19 :Releasing_NoNeu_ClutchT := 0
act20 :Releasing_NoNeu_NoClutchT := 0
act21 :FromNeu_SyncSpeed := FALSE
act22 :FromNeu_OpenClutch := FALSE
act23 :FromNeu_SetGear_NoClutch := FALSE
act24 :FromNeu_SetGear_Clutch := FALSE
act25 :FromNeu_CloseClutch := FALSE
act26 :Error_FromNeu_OpenClutch := FALSE
act27 :Error_FromNeu_SetGear_NoClutch := FALSE
act28 :Error_FromNeu_SetGear_Clutch := FALSE
act29 :Error_FromNeu_CloseClutch := FALSE
act30 :FromNeu_OpenClutchT := 0
act31 :FromNeu_SyncSpeedT := 0
act32 :FromNeu_SetGear_ClutchT := 0
```

### END

#### RequestFromNeu ≙

##### extended

##### STATUS

###### ordinary

### REFINES

RequestFromNeu

### WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = TRUE
```

### THEN

```
act1 :RequestFromNeu := TRUE
act2 :RequestFromNeuT := time
```

### END

#### RequestNoNeu ≙

##### extended

##### STATUS

###### ordinary

### REFINES

RequestNoNeu

### WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
    grd4 :isNeu = FALSE
THEN
    act1 :RequestNoNeu := TRUE
    act2 :RequestNoNeuT := time
END

RequestToNeu  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    RequestToNeu
WHEN
    grd1 :RequestFromNeu = FALSE
    grd2 :RequestNoNeu = FALSE
    grd3 :RequestToNeu = FALSE
    grd4 :isNeu = FALSE
THEN
    act1 :RequestToNeu := TRUE
    act2 :RequestToNeuT := time
END

FromNeu_SyncSpeed  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :FromNeu_SyncSpeed = FALSE
    grd3 :FromNeu_OpenClutch = FALSE
    grd4 :Error_FromNeu_OpenClutch = FALSE
    grd5 :time  $\leq$  RequestFromNeuT + Sync_EX
THEN
    act1 :FromNeu_SyncSpeed := TRUE
    act2 :FromNeu_SyncSpeedT := time
END

FromNeu_OpenClutch  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :Error_FromNeu_OpenClutch = FALSE
    grd3 :FromNeu_SyncSpeed = FALSE
    grd4 :FromNeu_OpenClutch = FALSE
THEN
    act1 :FromNeu_OpenClutch := TRUE
    act2 :FromNeu_OpenClutchT := time
END

Error_FromNeu_OpenClutch  $\triangle$ 
    STATUS
    ordinary
REFINES
    Error_FromNeu
WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :Error_FromNeu_OpenClutch = FALSE
    grd3 :FromNeu_SyncSpeed = FALSE
    grd4 :FromNeu_OpenClutch = FALSE
THEN
    act1 :Error_FromNeu_OpenClutch := TRUE
END

FromNeu_SetGear_NoClutch  $\triangle$ 
    STATUS
    ordinary
REFINES
    Setting_FromNeu_NoClutch
WHEN
    grd1 :FromNeu_SyncSpeed = TRUE
    grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
    grd3 :FromNeu_SetGear_NoClutch = FALSE
THEN
    act1 :FromNeu_SetGear_NoClutch := TRUE
    act2 :isNeu := FALSE
END

Error_FromNeu_SetGear_NoClutch  $\triangle$ 
    STATUS
```

## Gear Controller Case-study (Time Added Manually)

```
ordinary
REFINES
  Error_FromNeu
WHEN
  grd1 :FromNeu_SyncSpeed = TRUE
  grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
  grd3 :FromNeu_SetGear_NoClutch = FALSE
THEN
  act1 :Error_FromNeu_SetGear_NoClutch := TRUE
END
```

### FromNeu\_SetGear\_Clutch $\triangle$

```
STATUS
ordinary
WHEN
  grd1 :FromNeu_OpenClutch = TRUE
  grd2 :Error_FromNeu_SetGear_Clutch = FALSE
  grd3 :FromNeu_SetGear_Clutch = FALSE
THEN
  act1 :FromNeu_SetGear_Clutch := TRUE
  act2 :FromNeu_SetGear_ClutchT := time
END
```

### Error\_FromNeu\_SetGear\_Clutch $\triangle$

```
STATUS
ordinary
REFINES
  Error_FromNeu
WHEN
  grd1 :FromNeu_OpenClutch = TRUE
  grd2 :Error_FromNeu_SetGear_Clutch = FALSE
  grd3 :FromNeu_SetGear_Clutch = FALSE
THEN
  act1 :Error_FromNeu_SetGear_Clutch := TRUE
END
```

### FromNeu\_CloseClutch $\triangle$

```
STATUS
ordinary
REFINES
  Setting_FromNeu_Clutch
WHEN
  grd1 :FromNeu_SetGear_Clutch = TRUE
  grd2 :Error_FromNeu_CloseClutch = FALSE
  grd3 :FromNeu_CloseClutch = FALSE
THEN
  act1 :FromNeu_CloseClutch := TRUE
  act2 :isNeu := FALSE
END
```

### Error\_FromNeu\_CloseClutch $\triangle$

```
STATUS
ordinary
REFINES
  Error_FromNeu
WHEN
  grd1 :FromNeu_SetGear_Clutch = TRUE
  grd2 :Error_FromNeu_CloseClutch = FALSE
  grd3 :FromNeu_CloseClutch = FALSE
THEN
  act1 :Error_FromNeu_CloseClutch := TRUE
END
```

### Releasing\_NoNeu\_NoClutch $\triangle$

```
extended
STATUS
ordinary
REFINES
  Releasing_NoNeu_NoClutch
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :Error_Releasing_NoNeu = FALSE
  grd3 :Releasing_NoNeu_NoClutch = FALSE
  grd4 :Releasing_NoNeu_Clutch = FALSE
  grd5 :time  $\leq$  RequestNoNeuT + R_NN_NC_EX
THEN
  act1 :Releasing_NoNeu_NoClutch := TRUE
  act2 :Releasing_NoNeu_NoClutchT := time
END
```

## Gear Controller Case-study (Time Added Manually)

```
Releasing_NoNeu_Clutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Releasing_NoNeu_Clutch  
WHEN  
  grd1 :RequestNoNeu = TRUE  
  grd2 :Error_Releasing_NoNeu = FALSE  
  grd3 :Releasing_NoNeu_Clutch = FALSE  
  grd4 :Releasing_NoNeu_NoClutch = FALSE  
THEN  
  act1 :Releasing_NoNeu_Clutch := TRUE  
  act2 :Releasing_NoNeu_ClutchT := time  
END
```

```
Setting_NoNeu_NoClutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Setting_NoNeu_NoClutch  
WHEN  
  grd1 :Releasing_NoNeu_NoClutch = TRUE  
  grd2 :Error_Setting_NoNeu = FALSE  
  grd3 :Setting_NoNeu_NoClutch = FALSE  
  grd4 :Setting_NoNeu_Clutch = FALSE  
THEN  
  act1 :Setting_NoNeu_NoClutch := TRUE  
END
```

```
Setting_NoNeu_Clutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Setting_NoNeu_Clutch  
WHEN  
  grd1 :Releasing_NoNeu_NoClutch = TRUE  
  grd2 :Error_Setting_NoNeu = FALSE  
  grd3 :Setting_NoNeu_Clutch = FALSE  
  grd4 :Setting_NoNeu_NoClutch = FALSE  
THEN  
  act1 :Setting_NoNeu_Clutch := TRUE  
END
```

```
Setting_NoNeu_ReleaseClutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Setting_NoNeu_ReleaseClutch  
WHEN  
  grd1 :Releasing_NoNeu_Clutch = TRUE  
  grd2 :Error_Setting_NoNeu = FALSE  
  grd3 :Setting_NoNeu_ReleaseClutch = FALSE  
THEN  
  act1 :Setting_NoNeu_ReleaseClutch := TRUE  
END
```

```
Releasing_ToNeu_NoClutch  $\triangle$   
  extended  
  STATUS  
  ordinary  
REFINES  
  Releasing_ToNeu_NoClutch  
WHEN  
  grd1 :RequestToNeu = TRUE  
  grd2 :Error_ToNeu = FALSE  
  grd3 :Releasing_ToNeu_NoClutch = FALSE  
  grd4 :Releasing_ToNeu_Clutch = FALSE  
THEN  
  act1 :Releasing_ToNeu_NoClutch := TRUE  
  act2 :isNeu := TRUE  
END
```

```
Releasing_ToNeu_Clutch  $\triangle$   
  extended  
  STATUS
```

## Gear Controller Case-study (Time Added Manually)

```
ordinary
REFINES
  Releasing_ToNeu_Clutch
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :Error_ToNeu = FALSE
  grd3 :Releasing_ToNeu_Clutch = FALSE
  grd4 :Releasing_ToNeu_NoClutch = FALSE
THEN
  act1 :Releasing_ToNeu_Clutch := TRUE
  act2 :isNeu := TRUE
END

Error_Releasing_NoNeu  $\triangle$ 
extended
  STATUS
ordinary
REFINES
  Error_Releasing_NoNeu
WHEN
  grd1 :Error_Releasing_NoNeu = FALSE
  grd2 :RequestNoNeu = TRUE
  grd3 :Releasing_NoNeu_Clutch = FALSE
  grd4 :Releasing_NoNeu_NoClutch = FALSE
THEN
  act1 :Error_Releasing_NoNeu := TRUE
END

Error_Setting_NoNeu  $\triangle$ 
extended
  STATUS
ordinary
REFINES
  Error_Setting_NoNeu
WHEN
  grd1 :Error_Setting_NoNeu = FALSE
  grd2 :Releasing_NoNeu_Clutch = TRUE  $\vee$  Releasing_NoNeu_NoClutch = TRUE
  grd3 :Setting_NoNeu_NoClutch = FALSE
  grd4 :Setting_NoNeu_Clutch = FALSE
  grd5 :Setting_NoNeu_ReleaseClutch = FALSE
THEN
  act1 :Error_Setting_NoNeu := TRUE
END

Error_ToNeu  $\triangle$ 
extended
  STATUS
ordinary
REFINES
  Error_ToNeu
WHEN
  grd1 :Error_ToNeu = FALSE
  grd2 :RequestToNeu = TRUE
  grd3 :Releasing_ToNeu_NoClutch = FALSE
  grd4 :Releasing_ToNeu_Clutch = FALSE
THEN
  act1 :Error_ToNeu := TRUE
END

FINAL  $\triangle$ 
  STATUS
ordinary
REFINES
  FINAL
WHEN
  grd1 FromNeu_SetGear_NoClutch = TRUE  $\vee$  Setting_NoNeu_NoClutch = TRUE  $\vee$  Releasing_ToNeu_NoClutch = TRUE  $\vee$ 
  : FromNeu_CloseClutch = TRUE  $\vee$  Setting_NoNeu_Clutch = TRUE  $\vee$  Setting_NoNeu_ReleaseClutch = TRUE  $\vee$ 
  : Releasing_ToNeu_Clutch = TRUE
THEN
  act1 :RequestFromNeu := FALSE
  act2 :RequestNoNeu := FALSE
  act3 :RequestToNeu := FALSE
  act4 :Releasing_ToNeu_NoClutch := FALSE
  act5 :Setting_NoNeu_NoClutch := FALSE
  act6 :Releasing_NoNeu_NoClutch := FALSE
  act7 :Releasing_ToNeu_Clutch := FALSE
  act8 :Setting_NoNeu_Clutch := FALSE
  act9 :Setting_NoNeu_ReleaseClutch := FALSE
  act10 :Releasing_NoNeu_Clutch := FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
act11 :FromNeu_SyncSpeed := FALSE
act12 :FromNeu_OpenClutch := FALSE
act13 :FromNeu_SetGear_NoClutch := FALSE
act14 :FromNeu_SetGear_Clutch := FALSE
act15 :FromNeu_CloseClutch := FALSE
END

Tick_Tock  $\triangle$ 
  STATUS
  ordinary
REFINES
  Tick_Tock
ANY
  tick
WHERE
  grd1 :tick > 0
  grd2 :RequestFromNeu = TRUE  $\wedge$  FromNeu_SyncSpeed= FALSE  $\wedge$ 
        FromNeu_OpenClutch = FALSE  $\wedge$  Error_FromNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SyncOpen_DL+RequestFromNeuT
  grd3 :FromNeu_OpenClutch = TRUE  $\wedge$  FromNeu_SetGear_Clutch= FALSE  $\wedge$ 
        Error_FromNeu_SetGear_Clutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_OpenClutchT
  grd4 :FromNeu_SyncSpeed = TRUE  $\wedge$  FromNeu_SetGear_NoClutch= FALSE  $\wedge$ 
        Error_FromNeu_SetGear_NoClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_SyncSpeedT
  grd5 :FromNeu_SetGear_Clutch = TRUE  $\wedge$  FromNeu_CloseClutch= FALSE  $\wedge$ 
        Error_FromNeu_CloseClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+FromNeu_SetGear_ClutchT
  grd6 :RequestToNeu = TRUE  $\wedge$ Releasing_ToNeu_Clutch= FALSE  $\wedge$ 
        Releasing_ToNeu_NoClutch= FALSE  $\wedge$  Error_ToNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  R_TN+RequestToNeuT
  grd7 :RequestNoNeu = TRUE  $\wedge$ Releasing_NoNeu_Clutch= FALSE  $\wedge$ 
        Releasing_NoNeu_NoClutch= FALSE  $\wedge$  Error_Releasing_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  R_NN+RequestNoNeuT
  grd8 :Releasing_NoNeu_NoClutch = TRUE  $\wedge$ Setting_NoNeu_Clutch= FALSE  $\wedge$ 
        Setting_NoNeu_NoClutch= FALSE  $\wedge$  Error_Setting_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  S_NN+ Releasing_NoNeu_NoClutchT
  grd9 :Releasing_NoNeu_Clutch = TRUE  $\wedge$ Setting_NoNeu_ReleaseClutch= FALSE  $\wedge$ 
        Error_Setting_NoNeu = FALSE  $\Rightarrow$  time+tick  $\leq$  S_NN_RC+ Releasing_NoNeu_ClutchT
THEN
  act1 :time := time + tick
END

END
```



# Gear Controller Case-study (Time Added Manually)

## Machine m6

### MACHINE

```
// Deadline(RequestFromNeu, FromNeu_SyncSpeed ∨ FromNeu_OpenClutch ∨ Error_FromNeu_OpenClutch, SyncOpen_DL)
// Expiry(RequestFromNeu, FromNeu_SyncSpeed, Sync_EX)
// Deadline(FromNeu_SyncSpeed, FromNeu_SetGear_NoClutch ∨ Error_FromNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(FromNeu_OpenClutch, FromNeu_SetGear_Clutch ∨ Error_FromNeu_SetGear_Clutch, SetGear_DL)
// Deadline(FromNeu_SetGear_Clutch, FromNeu_CloseClutch ∨ Error_FromNeu_CloseClutch, CloseClutch_DL)
//
// Deadline(RequestNoNeu, Releasing_NoNeu_Clutch ∨ Releasing_NoNeu_NoClutch ∨ Error_Releasing_NoNeu, R_NN)
m6 // Deadline(Releasing_NoNeu_NoClutch, Setting_NoNeu_NoClutch ∨ Setting_NoNeu_Clutch ∨ Error_Setting_NoNeu, S_NN)
// Deadline(Releasing_NoNeu_Clutch, Setting_NoNeu_ReleaseClutch ∨ Error_Setting_NoNeu, S_NN_RC)
// Expiry(RequestNoNeu, Releasing_NoNeu_NoClutch, R_NN_NC_EX)
//
// Deadline(RequestToNeu, ToNeu_ZeroTorque ∨ ToNeu_OpenClutch ∨ Error_ToNeu_OpenClutch, ZeroOpen_DL)
// Expiry(RequestToNeu, ToNeu_ZeroTorque, Zero_EX)
// Deadline(ToNeu_ZeroTorque, ToNeu_Release_NoClutch ∨ Error_ToNeu_Release_NoClutch, Release_DL)
// Deadline(ToNeu_OpenClutch, ToNeu_Release_Clutch ∨ Error_ToNeu_Release_Clutch, Release_DL)
// Deadline(ToNeu_Release_Clutch, ToNeu_CloseClutch ∨ Error_ToNeu_CloseClutch, CloseClutch_DL)
```

### REFINES

m5

### SEES

c3

### VARIABLES

```
time // Time
RequestFromNeuT // Time
RequestNoNeuT // Time
RequestToNeuT // Time
Releasing_NoNeu_ClutchT // Time
Releasing_NoNeu_NoClutchT // Time
isNeu // Gear Status
Releasing_NoNeu_NoClutch // Flags
Setting_NoNeu_NoClutch
RequestFromNeu // Flags
RequestNoNeu // Flags
RequestToNeu // Flags
Releasing_NoNeu_Clutch // Flags
Setting_NoNeu_Clutch // Flags
Setting_NoNeu_ReleaseClutch // Flags
Error_Releasing_NoNeu // Flage
Error_Setting_NoNeu // Flage
FromNeu_SyncSpeed // Senario1
FromNeu_OpenClutch // Flage
FromNeu_SetGear_NoClutch // Flage
FromNeu_SetGear_Clutch // Flage
FromNeu_CloseClutch // Flage
Error_FromNeu_OpenClutch // Flage
Error_FromNeu_SetGear_NoClutch // Flage
Error_FromNeu_SetGear_Clutch // Flage
Error_FromNeu_CloseClutch // Senario1
FromNeu_OpenClutchT // TIME
FromNeu_SyncSpeedT // TIME
FromNeu_SetGear_ClutchT // TIME
ToNeu_ZeroTorque // Senario3 Flage
ToNeu_OpenClutch // Senario3 Flage
Error_ToNeu_OpenClutch // Senario3 Flage
ToNeu_Release_NoClutch // Senario3 Flage
Error_ToNeu_Release_NoClutch // Senario3 Flage
ToNeu_Release_Clutch // Senario3 Flage
Error_ToNeu_Release_Clutch // Senario3 Flage
ToNeu_CloseClutch // Senario3 Flage
Error_ToNeu_CloseClutch // Senario3 Flage
ToNeu_ZeroTorqueT // TIME
ToNeu_OpenClutchT // TIME
ToNeu_Release_ClutchT // TIME
```

### INVARIANTS

```
inv1 : {ToNeu_ZeroTorque, ToNeu_OpenClutch, Error_ToNeu_OpenClutch, ToNeu_Release_NoClutch, Error_ToNeu_Release_NoClutch,
ToNeu_Release_Clutch, Error_ToNeu_Release_Clutch, ToNeu_CloseClutch, Error_ToNeu_CloseClutch} ∈ ℙ(BOOL)
inv2 : {ToNeu_ZeroTorqueT, ToNeu_OpenClutchT, ToNeu_Release_ClutchT} ⊆ ℕ
inv3 : ToNeu_Release_NoClutch = Releasing_ToNeu_NoClutch
inv4 : ToNeu_CloseClutch = Releasing_ToNeu_Clutch
inv5 : ToNeu_ZeroTorque = TRUE ∨ ToNeu_OpenClutch = TRUE ⇒ RequestToNeu = TRUE
inv6 : ToNeu_Release_NoClutch = TRUE ⇒ ToNeu_ZeroTorque = TRUE
inv7 : ToNeu_Release_Clutch = TRUE ⇒ ToNeu_OpenClutch = TRUE
```

## Gear Controller Case-study (Time Added Manually)

```
inv8 :ToNeu_ZeroTorque = TRUE ⇒ ToNeu_OpenClutch = FALSE ∧ Error_ToNeu_OpenClutch = FALSE
inv9 :ToNeu_CloseClutch = TRUE ⇒ ToNeu_Release_Clutch = TRUE
inv10 :ToNeu_OpenClutch=FALSE ⇒ ToNeu_CloseClutch = FALSE
      Error_ToNeu_OpenClutch = FALSE ∧
inv11 :Error_ToNeu_Release_NoClutch = FALSE ∧
      Error_ToNeu_Release_Clutch = FALSE ∧
      Error_ToNeu_CloseClutch= FALSE ⇒ Error_ToNeu = FALSE
      Error_ToNeu_OpenClutch = TRUE ∨
inv12 :Error_ToNeu_Release_NoClutch = TRUE ∨
      Error_ToNeu_Release_Clutch = TRUE ∨
      Error_ToNeu_CloseClutch= TRUE ⇒ Error_ToNeu = TRUE
inv13 :ToNeu_Release_Clutch = TRUE ⇒ Error_ToNeu_Release_Clutch = FALSE
inv14 :ToNeu_Release_NoClutch = TRUE ⇒ Error_ToNeu_Release_NoClutch = FALSE
inv15 :ToNeu_CloseClutch = TRUE ⇒ Error_ToNeu_CloseClutch = FALSE
inv16 :ToNeu_OpenClutch = TRUE ⇒ Error_ToNeu_OpenClutch = FALSE
inv17 :RequestToNeu = TRUE ∧ Error_ToNeu_Release_Clutch = TRUE ⇒ ToNeu_OpenClutch = TRUE
inv18 :RequestToNeu = TRUE ∧ Error_ToNeu_Release_NoClutch = TRUE ⇒ ToNeu_ZeroTorque = TRUE
inv19 :RequestToNeu = TRUE ∧ Error_ToNeu_CloseClutch = TRUE ⇒ ToNeu_Release_Clutch = TRUE
inv20 :ToNeu_ZeroTorque = TRUE ⇒ ToNeu_ZeroTorqueT ≤ RequestToNeuT + ZeroOpen_DL
inv21 :ToNeu_OpenClutch = TRUE ⇒ ToNeu_OpenClutchT ≤ RequestToNeuT + ZeroOpen_DL
inv22 :ToNeu_Release_Clutch = TRUE ⇒ ToNeu_Release_ClutchT ≤ ToNeu_OpenClutchT + Release_DL
inv23 :RequestToNeu = TRUE ∧ ToNeu_ZeroTorque= FALSE ∧
      ToNeu_OpenClutch = FALSE ∧ Error_ToNeu_OpenClutch = FALSE ⇒ time ≤ ZeroOpen_DL+RequestToNeuT
inv24 :ToNeu_OpenClutch = TRUE ∧ ToNeu_Release_Clutch= FALSE ∧
      Error_ToNeu_Release_Clutch = FALSE ⇒ time ≤ Release_DL+ToNeu_OpenClutchT
```

### EVENTS

#### INITIALISATION ≙

##### STATUS

###### ordinary

### BEGIN

```
act1 :time := 0
act2 :isNeu := TRUE
act3 :RequestNoNeu := FALSE
act4 :RequestToNeu := FALSE
act5 :RequestFromNeu := FALSE
act6 :RequestFromNeuT := 0
act7 :RequestNoNeuT := 0
act8 :RequestToNeuT := 0
act9 :Releasing_NoNeu_NoClutch := FALSE
act10 :Setting_NoNeu_NoClutch := FALSE
act11 :Releasing_NoNeu_Clutch := FALSE
act12 :Setting_NoNeu_Clutch := FALSE
act13 :Setting_NoNeu_ReleaseClutch := FALSE
act14 :Error_Releasing_NoNeu:= FALSE
act15 :Error_Setting_NoNeu:= FALSE
act16 :Releasing_NoNeu_ClutchT := 0
act17 :Releasing_NoNeu_NoClutchT := 0
act18 :FromNeu_SyncSpeed := FALSE
act19 :FromNeu_OpenClutch := FALSE
act20 :FromNeu_SetGear_NoClutch := FALSE
act21 :FromNeu_SetGear_Clutch := FALSE
act22 :FromNeu_CloseClutch := FALSE
act23 :Error_FromNeu_OpenClutch := FALSE
act24 :Error_FromNeu_SetGear_NoClutch := FALSE
act25 :Error_FromNeu_SetGear_Clutch := FALSE
act26 :Error_FromNeu_CloseClutch := FALSE
act27 :FromNeu_OpenClutchT := 0
act28 :FromNeu_SyncSpeedT := 0
act29 :FromNeu_SetGear_ClutchT := 0
act30 :ToNeu_ZeroTorque:= FALSE // Scenario3 Flage
act31 :ToNeu_OpenClutch := FALSE // Scenario3 Flage
act32 :Error_ToNeu_OpenClutch := FALSE // Scenario3 Flage
act33 :ToNeu_Release_NoClutch:= FALSE // Scenario3 Flage
act34 :Error_ToNeu_Release_NoClutch:= FALSE // Scenario3 Flage
act35 :ToNeu_Release_Clutch:= FALSE // Scenario3 Flage
act36 :Error_ToNeu_Release_Clutch := FALSE // Scenario3 Flage
act37 :ToNeu_CloseClutch:= FALSE // Scenario3 Flage
act38 :Error_ToNeu_CloseClutch:= FALSE // Scenario3 Flage
act39 :ToNeu_ZeroTorqueT := 0 //TIME
act40 :ToNeu_OpenClutchT := 0 //TIME
act41 :ToNeu_Release_ClutchT:= 0 //TIME
```

### END

#### RequestFromNeu ≙

##### extended

##### STATUS

###### ordinary

## Gear Controller Case-study (Time Added Manually)

### REFINES

RequestFromNeu

### WHEN

*grd1* :RequestFromNeu = FALSE  
*grd2* :RequestNoNeu = FALSE  
*grd3* :RequestToNeu = FALSE  
*grd4* :isNeu = TRUE

### THEN

*act1* :RequestFromNeu := TRUE  
*act2* :RequestFromNeuT := time

### END

### RequestNoNeu $\triangleq$

extended

STATUS

ordinary

### REFINES

RequestNoNeu

### WHEN

*grd1* :RequestFromNeu = FALSE  
*grd2* :RequestNoNeu = FALSE  
*grd3* :RequestToNeu = FALSE  
*grd4* :isNeu = FALSE

### THEN

*act1* :RequestNoNeu := TRUE  
*act2* :RequestNoNeuT := time

### END

### RequestToNeu $\triangleq$

extended

STATUS

ordinary

### REFINES

RequestToNeu

### WHEN

*grd1* :RequestFromNeu = FALSE  
*grd2* :RequestNoNeu = FALSE  
*grd3* :RequestToNeu = FALSE  
*grd4* :isNeu = FALSE

### THEN

*act1* :RequestToNeu := TRUE  
*act2* :RequestToNeuT := time

### END

### FromNeu\_SyncSpeed $\triangleq$

extended

STATUS

ordinary

### REFINES

FromNeu\_SyncSpeed

### WHEN

*grd1* :RequestFromNeu = TRUE  
*grd2* :FromNeu\_SyncSpeed = FALSE  
*grd3* :FromNeu\_OpenClutch = FALSE  
*grd4* :Error\_FromNeu\_OpenClutch = FALSE  
*grd5* :time  $\leq$  RequestFromNeuT + Sync\_EX

### THEN

*act1* :FromNeu\_SyncSpeed := TRUE  
*act2* :FromNeu\_SyncSpeedT := time

### END

### FromNeu\_OpenClutch $\triangleq$

extended

STATUS

ordinary

### REFINES

FromNeu\_OpenClutch

### WHEN

*grd1* :RequestFromNeu = TRUE  
*grd2* :Error\_FromNeu\_OpenClutch = FALSE  
*grd3* :FromNeu\_SyncSpeed = FALSE  
*grd4* :FromNeu\_OpenClutch = FALSE

### THEN

*act1* :FromNeu\_OpenClutch := TRUE  
*act2* :FromNeu\_OpenClutchT := time

### END

### Error\_FromNeu\_OpenClutch $\triangleq$

extended

## Gear Controller Case-study (Time Added Manually)

```

    STATUS
    ordinary
REFINES
    Error_FromNeu_OpenClutch
WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :Error_FromNeu_OpenClutch = FALSE
    grd3 :FromNeu_SyncSpeed = FALSE
    grd4 :FromNeu_OpenClutch = FALSE
THEN
    act1 :Error_FromNeu_OpenClutch := TRUE
END

FromNeu_SetGear_NoClutch ≙
    extended
    STATUS
    ordinary
REFINES
    FromNeu_SetGear_NoClutch
WHEN
    grd1 :FromNeu_SyncSpeed = TRUE
    grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
    grd3 :FromNeu_SetGear_NoClutch = FALSE
THEN
    act1 :FromNeu_SetGear_NoClutch := TRUE
    act2 :isNeu := FALSE
END

Error_FromNeu_SetGear_NoClutch ≙
    extended
    STATUS
    ordinary
REFINES
    Error_FromNeu_SetGear_NoClutch
WHEN
    grd1 :FromNeu_SyncSpeed = TRUE
    grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
    grd3 :FromNeu_SetGear_NoClutch = FALSE
THEN
    act1 :Error_FromNeu_SetGear_NoClutch := TRUE
END

FromNeu_SetGear_Clutch ≙
    extended
    STATUS
    ordinary
REFINES
    FromNeu_SetGear_Clutch
WHEN
    grd1 :FromNeu_OpenClutch = TRUE
    grd2 :Error_FromNeu_SetGear_Clutch = FALSE
    grd3 :FromNeu_SetGear_Clutch = FALSE
THEN
    act1 :FromNeu_SetGear_Clutch := TRUE
    act2 :FromNeu_SetGear_ClutchT := time
END

Error_FromNeu_SetGear_Clutch ≙
    extended
    STATUS
    ordinary
REFINES
    Error_FromNeu_SetGear_Clutch
WHEN
    grd1 :FromNeu_OpenClutch = TRUE
    grd2 :Error_FromNeu_SetGear_Clutch = FALSE
    grd3 :FromNeu_SetGear_Clutch = FALSE
THEN
    act1 :Error_FromNeu_SetGear_Clutch := TRUE
END

FromNeu_CloseClutch ≙
    extended
    STATUS
    ordinary
REFINES
    FromNeu_CloseClutch
WHEN
    grd1 :FromNeu_SetGear_Clutch = TRUE
```

## Gear Controller Case-study (Time Added Manually)

```
    grd2 :Error_FromNeu_CloseClutch = FALSE
    grd3 :FromNeu_CloseClutch = FALSE
THEN
    act1 :FromNeu_CloseClutch := TRUE
    act2 :isNeu := FALSE
END
```

### Error\_FromNeu\_CloseClutch $\triangle$

```
    extended
    STATUS
    ordinary
REFINES
    Error_FromNeu_CloseClutch
WHEN
    grd1 :FromNeu_SetGear_Clutch = TRUE
    grd2 :Error_FromNeu_CloseClutch = FALSE
    grd3 :FromNeu_CloseClutch = FALSE
THEN
    act1 :Error_FromNeu_CloseClutch := TRUE
END
```

### Releasing\_NoNeu\_NoClutch $\triangle$

```
    extended
    STATUS
    ordinary
REFINES
    Releasing_NoNeu_NoClutch
WHEN
    grd1 :RequestNoNeu = TRUE
    grd2 :Error_Releasing_NoNeu = FALSE
    grd3 :Releasing_NoNeu_NoClutch = FALSE
    grd4 :Releasing_NoNeu_Clutch = FALSE
    grd5 :time  $\leq$  RequestNoNeuT + R_NN_NC_EX
THEN
    act1 :Releasing_NoNeu_NoClutch := TRUE
    act2 :Releasing_NoNeu_NoClutchT := time
END
```

### Releasing\_NoNeu\_Clutch $\triangle$

```
    extended
    STATUS
    ordinary
REFINES
    Releasing_NoNeu_Clutch
WHEN
    grd1 :RequestNoNeu = TRUE
    grd2 :Error_Releasing_NoNeu = FALSE
    grd3 :Releasing_NoNeu_Clutch = FALSE
    grd4 :Releasing_NoNeu_NoClutch = FALSE
THEN
    act1 :Releasing_NoNeu_Clutch := TRUE
    act2 :Releasing_NoNeu_ClutchT := time
END
```

### Setting\_NoNeu\_NoClutch $\triangle$

```
    extended
    STATUS
    ordinary
REFINES
    Setting_NoNeu_NoClutch
WHEN
    grd1 :Releasing_NoNeu_NoClutch = TRUE
    grd2 :Error_Setting_NoNeu = FALSE
    grd3 :Setting_NoNeu_NoClutch = FALSE
    grd4 :Setting_NoNeu_Clutch = FALSE
THEN
    act1 :Setting_NoNeu_NoClutch := TRUE
END
```

### Setting\_NoNeu\_Clutch $\triangle$

```
    extended
    STATUS
    ordinary
REFINES
    Setting_NoNeu_Clutch
WHEN
    grd1 :Releasing_NoNeu_NoClutch = TRUE
    grd2 :Error_Setting_NoNeu = FALSE
    grd3 :Setting_NoNeu_Clutch = FALSE
    grd4 :Setting_NoNeu_NoClutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
THEN
  act1 :Setting_NoNeu_Clutch := TRUE
END

Setting_NoNeu_ReleaseClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  Setting_NoNeu_ReleaseClutch
WHEN
  grd1 :Releasing_NoNeu_Clutch = TRUE
  grd2 :Error_Setting_NoNeu = FALSE
  grd3 :Setting_NoNeu_ReleaseClutch = FALSE
THEN
  act1 :Setting_NoNeu_ReleaseClutch := TRUE
END

ToNeu_ZeroTorque  $\triangle$  // First Event of Senarion3
  STATUS
  ordinary
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :ToNeu_ZeroTorque = FALSE
  grd3 :ToNeu_OpenClutch = FALSE
  grd4 :Error_ToNeu_OpenClutch = FALSE
  grd5 :time  $\leq$  RequestToNeuT + Zero_EX
THEN
  act1 :ToNeu_ZeroTorque := TRUE
  act2 :ToNeu_ZeroTorqueT := time
END

ToNeu_OpenClutch  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :ToNeu_ZeroTorque = FALSE
  grd3 :ToNeu_OpenClutch = FALSE
  grd4 :Error_ToNeu_OpenClutch = FALSE
THEN
  act1 :ToNeu_OpenClutch := TRUE
  act2 :ToNeu_OpenClutchT := time
END

Error_ToNeu_OpenClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_ToNeu
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :ToNeu_ZeroTorque = FALSE
  grd3 :ToNeu_OpenClutch = FALSE
  grd4 :Error_ToNeu_OpenClutch = FALSE
THEN
  act1 :Error_ToNeu_OpenClutch := TRUE
END

ToNeu_Release_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Releasing_ToNeu_NoClutch
WHEN
  grd1 :ToNeu_ZeroTorque = TRUE
  grd2 :ToNeu_Release_NoClutch = FALSE
  grd3 :Error_ToNeu_Release_NoClutch = FALSE
THEN
  act1 :ToNeu_Release_NoClutch := TRUE
  act2 :isNeu := TRUE
END

Error_ToNeu_Release_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_ToNeu
WHEN
```

## Gear Controller Case-study (Time Added Manually)

```
    grd1 :ToNeu_ZeroTorque = TRUE
    grd2 :ToNeu_Release_NoClutch = FALSE
    grd3 :Error_ToNeu_Release_NoClutch = FALSE
THEN
    act1 :Error_ToNeu_Release_NoClutch := TRUE
END

ToNeu_Release_Clutch  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :ToNeu_OpenClutch = TRUE
    grd2 :ToNeu_Release_Clutch = FALSE
    grd3 :Error_ToNeu_Release_Clutch = FALSE
THEN
    act1 :ToNeu_Release_Clutch := TRUE
    act2 :ToNeu_Release_ClutchT := time
END

Error_ToNeu_Release_Clutch  $\triangle$ 
    STATUS
    ordinary
REFINES
    Error_ToNeu
WHEN
    grd1 :ToNeu_OpenClutch = TRUE
    grd2 :ToNeu_Release_Clutch = FALSE
    grd3 :Error_ToNeu_Release_Clutch = FALSE
THEN
    act1 :Error_ToNeu_Release_Clutch := TRUE
END

ToNeu_CloseClutch  $\triangle$ 
    STATUS
    ordinary
REFINES
    Releasing_ToNeu_Clutch
WHEN
    grd1 :ToNeu_Release_Clutch = TRUE
    grd2 :ToNeu_CloseClutch = FALSE
    grd3 :Error_ToNeu_CloseClutch = FALSE
THEN
    act1 :ToNeu_CloseClutch := TRUE
    act2 :isNeu := TRUE
END

Error_ToNeu_CloseClutch  $\triangle$  // Last Event of Senarion3
    STATUS
    ordinary
REFINES
    Error_ToNeu
WHEN
    grd1 :ToNeu_Release_Clutch = TRUE
    grd2 :ToNeu_CloseClutch = FALSE
    grd3 :Error_ToNeu_CloseClutch = FALSE
THEN
    act1 :Error_ToNeu_CloseClutch := TRUE
END

Error_Releasing_NoNeu  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    Error_Releasing_NoNeu
WHEN
    grd1 :Error_Releasing_NoNeu = FALSE
    grd2 :RequestNoNeu = TRUE
    grd3 :Releasing_NoNeu_Clutch = FALSE
    grd4 :Releasing_NoNeu_NoClutch = FALSE
THEN
    act1 :Error_Releasing_NoNeu := TRUE
END

Error_Setting_NoNeu  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
```

## Gear Controller Case-study (Time Added Manually)

```

Error_Setting_NoNeu
WHEN
  grd1 :Error_Setting_NoNeu = FALSE
  grd2 :Releasing_NoNeu_Clutch = TRUE ∨ Releasing_NoNeu_NoClutch = TRUE
  grd3 :Setting_NoNeu_NoClutch = FALSE
  grd4 :Setting_NoNeu_Clutch = FALSE
  grd5 :Setting_NoNeu_ReleaseClutch = FALSE
THEN
  act1 :Error_Setting_NoNeu := TRUE
END

FINAL  $\triangle$ 
STATUS
  ordinary
REFINES
  FINAL
WHEN
  FromNeu_SetGear_NoClutch = TRUE ∨ Setting_NoNeu_NoClutch = TRUE ∨
  ToNeu_Release_NoClutch = TRUE ∨ FromNeu_CloseClutch = TRUE ∨
  Setting_NoNeu_Clutch = TRUE ∨ Setting_NoNeu_ReleaseClutch = TRUE ∨
  ToNeu_CloseClutch = TRUE
THEN
  act1 :RequestFromNeu := FALSE
  act2 :RequestNoNeu := FALSE
  act3 :RequestToNeu := FALSE
  act4 :Setting_NoNeu_NoClutch := FALSE
  act5 :Releasing_NoNeu_NoClutch := FALSE
  act6 :Setting_NoNeu_Clutch := FALSE
  act7 :Setting_NoNeu_ReleaseClutch := FALSE
  act8 :Releasing_NoNeu_Clutch := FALSE
  act9 :FromNeu_SyncSpeed := FALSE
  act10 :FromNeu_OpenClutch := FALSE
  act11 :FromNeu_SetGear_NoClutch := FALSE
  act12 :FromNeu_SetGear_Clutch := FALSE
  act13 :FromNeu_CloseClutch := FALSE
  act14 :ToNeu_Release_NoClutch := FALSE
  act15 :ToNeu_CloseClutch := FALSE
  act16 :ToNeu_ZeroTorque := FALSE // Scenario3 Flage
  act17 :ToNeu_OpenClutch := FALSE // Scenario3 Flage
  act18 :ToNeu_Release_Clutch := FALSE // Scenario3 Flage
END

Tick_Tock  $\triangle$ 
STATUS
  ordinary
REFINES
  Tick_Tock
ANY
  tick
WHERE
  grd1 :tick > 0
  grd2 :RequestFromNeu = TRUE ∧ FromNeu_SyncSpeed = FALSE ∧ // Scenario1
  FromNeu_OpenClutch = FALSE ∧ Error_FromNeu_OpenClutch = FALSE ⇒ time+tick ≤ SyncOpen_DL
  :
  +RequestFromNeuT
  grd3 :FromNeu_OpenClutch = TRUE ∧ FromNeu_SetGear_Clutch = FALSE ∧
  Error_FromNeu_SetGear_Clutch = FALSE ⇒ time+tick ≤ SetGear_DL+FromNeu_OpenClutchT
  grd4 :FromNeu_SyncSpeed = TRUE ∧ FromNeu_SetGear_NoClutch = FALSE ∧
  Error_FromNeu_SetGear_NoClutch = FALSE ⇒ time+tick ≤ SetGear_DL+FromNeu_SyncSpeedT
  grd5 :FromNeu_SetGear_Clutch = TRUE ∧ FromNeu_CloseClutch = FALSE ∧ // Scenario1
  Error_FromNeu_CloseClutch = FALSE ⇒ time+tick ≤ CloseClutch_DL+FromNeu_SetGear_ClutchT
  grd6 :RequestToNeu = TRUE ∧ ToNeu_OpenClutch = FALSE ∧ // Scenario3
  ToNeu_ZeroTorque = FALSE ∧ Error_ToNeu_OpenClutch = FALSE ⇒ time+tick ≤ ZeroOpen_DL+RequestToNeuT
  grd7 :ToNeu_ZeroTorque = TRUE ∧ ToNeu_Release_NoClutch = FALSE ∧
  Error_ToNeu_Release_NoClutch = FALSE ⇒ time+tick ≤ Release_DL+ToNeu_ZeroTorqueT
  grd8 :ToNeu_OpenClutch = TRUE ∧ ToNeu_Release_Clutch = FALSE ∧
  Error_ToNeu_Release_Clutch = FALSE ⇒ time+tick ≤ Release_DL+ToNeu_OpenClutchT
  grd9 :ToNeu_Release_Clutch = TRUE ∧ ToNeu_CloseClutch = FALSE ∧ // Scenario3
  Error_ToNeu_CloseClutch = FALSE ⇒ time+tick ≤ CloseClutch_DL+ToNeu_Release_ClutchT
  grd10 :RequestNoNeu = TRUE ∧ Releasing_NoNeu_Clutch = FALSE ∧
  Releasing_NoNeu_NoClutch = FALSE ∧ Error_Releasing_NoNeu = FALSE ⇒ time+tick ≤ R_NN+RequestNoNeuT
  grd11 :Releasing_NoNeu_NoClutch = TRUE ∧ Setting_NoNeu_Clutch = FALSE ∧
  Setting_NoNeu_NoClutch = FALSE ∧ Error_Setting_NoNeu = FALSE ⇒ time+tick ≤ S_NN+ Releasing_NoNeu_NoClutchT
  grd12 :Releasing_NoNeu_Clutch = TRUE ∧ Setting_NoNeu_ReleaseClutch = FALSE ∧
  Error_Setting_NoNeu = FALSE ⇒ time+tick ≤ S_NN_RC+ Releasing_NoNeu_ClutchT
THEN
  act1 :time := time + tick

```



## | Gear Controller Case-study (Time Added Manually)

END

END

## Machine m7

### MACHINE

```

// Deadline(RequestFromNeu, FromNeu_SyncSpeed v FromNeu_OpenClutch v Error_FromNeu_OpenClutch, SyncOpen_DL)
// Expiry(RequestFromNeu, FromNeu_SyncSpeed, Sync_EX)
// Deadline(FromNeu_SyncSpeed, FromNeu_SetGear_NoClutch v Error_FromNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(FromNeu_OpenClutch, FromNeu_SetGear_Clutch v Error_FromNeu_SetGear_Clutch, SetGear_DL)
// Deadline(FromNeu_SetGear_Clutch, FromNeu_CloseClutch v Error_FromNeu_CloseClutch, CloseClutch_DL)
// Deadline(RequestNoNeu, NoNeu_ZeroTorque v NoNeu_OpenClutch_Releasing v Error_NoNeu_OpenClutch_Releasing,
ZeroOpen_DL)
// Expiry(RequestNoNeu, NoNeu_ZeroTorque, Zero_EX)
// Deadline(NoNeu_ZeroTorque, NoNeu_Release_NoClutch v Error_NoNeu_Release_NoClutch, Release_DL)
// Deadline(NoNeu_OpenClutch_Releasing, NoNeu_Release_Clutch v Error_NoNeu_Release_Clutch, Release_DL)
// Deadline(NoNeu_Release_NoClutch, NoNeu_SyncSpeed v NoNeu_OpenClutch_Setting v Error_NoNeu_OpenClutch_Setting,
SyncOpen_DL)
m7 // Expiry(NoNeu_Release_NoClutch, NoNeu_SyncSpeed, Sync_EX)
// Deadline(NoNeu_SyncSpeed, NoNeu_SetGear_NoClutch v Error_NoNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(NoNeu_OpenClutch_Setting, NoNeu_SetGear_SettingClutch v Error_NoNeu_SetGear_SettingClutch, SetGear_DL)
// Deadline(NoNeu_SetGear_SettingClutch, NoNeu_CloseClutch_Setting v Error_NoNeu_CloseClutch_Setting, CloseClutch_DL)
// Deadline(NoNeu_Release_Clutch, NoNeu_SetGear_ReleasingClutch v Error_NoNeu_SetGear_ReleasingClutch, SetGear_DL)
// Deadline(NoNeu_SetGear_ReleasingClutch, NoNeu_CloseClutch_Releasing v Error_NoNeu_CloseClutch_Releasing,
CloseClutch_DL)
// Deadline(RequestToNeu, ToNeu_ZeroTorque v ToNeu_OpenClutch v Error_ToNeu_OpenClutch, ZeroOpen_DL)
// Expiry(RequestToNeu, ToNeu_ZeroTorque, Zero_EX)
// Deadline(ToNeu_ZeroTorque, ToNeu_Release_NoClutch v Error_ToNeu_Release_NoClutch, Release_DL)
// Deadline(ToNeu_OpenClutch, ToNeu_Release_Clutch v Error_ToNeu_Release_Clutch, Release_DL)
// Deadline(ToNeu_Release_Clutch, ToNeu_CloseClutch v Error_ToNeu_CloseClutch, CloseClutch_DL)

```

### REFINES

m6

### SEES

c4

### VARIABLES

```

time // Time
RequestFromNeuT // Time
RequestNoNeuT // Time
RequestToNeuT // Time
isNeu // Gear Status
RequestFromNeu // Flags
RequestNoNeu // Flags
RequestToNeu // Flags
FromNeu_SyncSpeed // Scenario1
FromNeu_OpenClutch // Flage
FromNeu_SetGear_NoClutch // Flage
FromNeu_SetGear_Clutch // Flage
FromNeu_CloseClutch // Flage
Error_FromNeu_OpenClutch // Flage
Error_FromNeu_SetGear_NoClutch // Flage
Error_FromNeu_SetGear_Clutch // Flage
Error_FromNeu_CloseClutch // Scenario1
FromNeu_OpenClutchT // TIME
FromNeu_SyncSpeedT // TIME
FromNeu_SetGear_ClutchT // TIME
ToNeu_ZeroTorque // Scenario3 Flage
ToNeu_OpenClutch // Scenario3 Flage
Error_ToNeu_OpenClutch // Scenario3 Flage
ToNeu_Release_NoClutch // Scenario3 Flage
Error_ToNeu_Release_NoClutch // Scenario3 Flage
ToNeu_Release_Clutch // Scenario3 Flage
Error_ToNeu_Release_Clutch // Scenario3 Flage
ToNeu_CloseClutch // Scenario3 Flage
Error_ToNeu_CloseClutch // Scenario3 Flage
ToNeu_ZeroTorqueT // TIME
ToNeu_OpenClutchT // TIME
ToNeu_Release_ClutchT // TIME
NoNeu_ZeroTorque // Scenario2 Flage
NoNeu_Release_NoClutch // Scenario2 Flage
NoNeu_OpenClutch_Releasing // Scenario2 Flage
NoNeu_Release_Clutch // Scenario2 Flage
NoNeu_SyncSpeed // Scenario2 Flage
NoNeu_OpenClutch_Setting // Scenario2 Flage
NoNeu_SetGear_NoClutch // Scenario2 Flage
NoNeu_SetGear_ReleasingClutch // Scenario2 Flage
NoNeu_SetGear_SettingClutch // Scenario2 Flage
NoNeu_CloseClutch_Releasing // Scenario2 Flage

```

## Gear Controller Case-study (Time Added Manually)

```
NoNeu_CloseClutch_Setting // Scenario2 Flage
Error_NoNeu_OpenClutch_Releasing // Scenario2 Flage
Error_NoNeu_Release_Clutch // Scenario2 Flage
Error_NoNeu_Release_NoClutch // Scenario2 Flage
Error_NoNeu_OpenClutch_Setting // Scenario2 Flage
Error_NoNeu_SetGear_NoClutch // Scenario2 Flage
Error_NoNeu_SetGear_ReleasingClutch // Scenario2 Flage
Error_NoNeu_SetGear_SettingClutch // Scenario2 Flage
Error_NoNeu_CloseClutch_Releasing // Scenario2 Flage
Error_NoNeu_CloseClutch_Setting // Scenario2 Flage
NoNeu_ZeroTorqueT // Scenario2 Time
NoNeu_Release_NoClutchT // Scenario2 Time
NoNeu_OpenClutch_ReleasingT // Scenario2 Time
NoNeu_Release_ClutchT // Scenario2 Time
NoNeu_SetGear_ReleasingClutchT // Scenario2 Time
NoNeu_SetGear_SettingClutchT // Scenario2 Time
NoNeu_SyncSpeedT // Scenario2 Time
NoNeu_OpenClutch_SettingT // Scenario2 Time
```

### INVARIANTS

```
{NoNeu_ZeroTorque, NoNeu_OpenClutch_Releasing, Error_NoNeu_OpenClutch_Releasing, NoNeu_Release_NoClutch,
Error_NoNeu_Release_NoClutch, NoNeu_Release_Clutch, Error_NoNeu_Release_Clutch,
NoNeu_SyncSpeed, NoNeu_OpenClutch_Setting, Error_NoNeu_OpenClutch_Setting,
inv1 :NoNeu_SetGear_NoClutch, Error_NoNeu_SetGear_NoClutch, NoNeu_SetGear_ReleasingClutch,
NoNeu_SetGear_SettingClutch, Error_NoNeu_SetGear_ReleasingClutch, Error_NoNeu_SetGear_SettingClutch,
NoNeu_CloseClutch_Setting, Error_NoNeu_CloseClutch_Releasing, Error_NoNeu_CloseClutch_Setting,
NoNeu_CloseClutch_Releasing} ∈ ℙ(BOOL)
{NoNeu_ZeroTorqueT, NoNeu_Release_NoClutchT,
NoNeu_OpenClutch_ReleasingT, NoNeu_Release_ClutchT,
inv2 :NoNeu_SyncSpeedT, NoNeu_OpenClutch_SettingT,
NoNeu_SetGear_ReleasingClutchT, NoNeu_SetGear_SettingClutchT,
NoNeu_OpenClutch_ReleasingT, NoNeu_OpenClutch_SettingT} ⊆ ℕ
inv3 :NoNeu_Release_NoClutch = Releasing_NoNeu_NoClutch
inv4 :NoNeu_Release_Clutch = Releasing_NoNeu_Clutch
inv5 :NoNeu_SetGear_NoClutch = Setting_NoNeu_NoClutch
inv6 :NoNeu_CloseClutch_Releasing = Setting_NoNeu_ReleaseClutch
inv7 :NoNeu_CloseClutch_Setting = Setting_NoNeu_Clutch
inv8 :NoNeu_ZeroTorque = TRUE ∨ NoNeu_OpenClutch_Releasing = TRUE ⇒ RequestNoNeu = TRUE
inv9 :NoNeu_Release_NoClutch = TRUE ⇒ NoNeu_ZeroTorque = TRUE
inv10 :NoNeu_Release_Clutch = TRUE ⇒ NoNeu_OpenClutch_Releasing = TRUE
inv11 :NoNeu_ZeroTorque = TRUE ⇒ NoNeu_OpenClutch_Releasing = FALSE ∧ Error_NoNeu_OpenClutch_Releasing = FALSE
Error_NoNeu_OpenClutch_Releasing = FALSE ∧
Error_NoNeu_Release_NoClutch = FALSE ∧
inv12 :Error_NoNeu_Release_Clutch = FALSE
⇒ Error_Releasing_NoNeu = FALSE
Error_NoNeu_OpenClutch_Releasing = TRUE ∨
inv13 :Error_NoNeu_Release_NoClutch = TRUE ∨
Error_NoNeu_Release_Clutch = TRUE
⇒ Error_Releasing_NoNeu = TRUE
inv14 :NoNeu_Release_Clutch = TRUE ⇒ Error_NoNeu_Release_Clutch = FALSE
inv15 :NoNeu_Release_NoClutch = TRUE ⇒ Error_NoNeu_Release_NoClutch = FALSE
inv16 :NoNeu_OpenClutch_Releasing = TRUE ⇒ Error_NoNeu_OpenClutch_Releasing = FALSE
inv17 :RequestNoNeu = TRUE ∧ Error_NoNeu_Release_Clutch = TRUE ⇒ NoNeu_OpenClutch_Releasing = TRUE
inv18 :RequestNoNeu = TRUE ∧ Error_NoNeu_Release_NoClutch = TRUE ⇒ NoNeu_ZeroTorque = TRUE
inv19 :NoNeu_SyncSpeed = TRUE ∨ NoNeu_OpenClutch_Setting = TRUE ⇒ NoNeu_Release_NoClutch = TRUE
inv20 :NoNeu_SetGear_ReleasingClutch = TRUE ⇒ NoNeu_Release_Clutch = TRUE
inv21 :NoNeu_SetGear_SettingClutch = TRUE ⇒ NoNeu_OpenClutch_Setting = TRUE
inv22 :NoNeu_SetGear_NoClutch = TRUE ⇒ NoNeu_SyncSpeed = TRUE
inv23 :NoNeu_SyncSpeed = TRUE ⇒ NoNeu_OpenClutch_Setting = FALSE ∧ Error_NoNeu_OpenClutch_Setting = FALSE
inv24 :NoNeu_CloseClutch_Releasing = TRUE ⇒ NoNeu_SetGear_ReleasingClutch = TRUE
inv25 :NoNeu_CloseClutch_Setting = TRUE ⇒ NoNeu_SetGear_SettingClutch = TRUE
Error_NoNeu_OpenClutch_Setting = FALSE ∧
Error_NoNeu_SetGear_NoClutch = FALSE ∧
Error_NoNeu_SetGear_ReleasingClutch = FALSE ∧
inv26 :Error_NoNeu_SetGear_SettingClutch = FALSE ∧
Error_NoNeu_CloseClutch_Releasing = FALSE ∧
Error_NoNeu_CloseClutch_Setting = FALSE
⇒ Error_Setting_NoNeu = FALSE
Error_NoNeu_OpenClutch_Setting = TRUE ∨
Error_NoNeu_SetGear_NoClutch = TRUE ∨
Error_NoNeu_SetGear_ReleasingClutch = TRUE ∨
inv27 :Error_NoNeu_SetGear_SettingClutch = TRUE ∨
Error_NoNeu_CloseClutch_Releasing = TRUE ∨
Error_NoNeu_CloseClutch_Setting = TRUE
⇒ Error_Setting_NoNeu = TRUE
inv28 :NoNeu_SetGear_ReleasingClutch = TRUE ⇒ Error_NoNeu_SetGear_ReleasingClutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
inv29 :NoNeu_SetGear_SettingClutch = TRUE ⇒ Error_NoNeu_SetGear_SettingClutch = FALSE
inv30 :NoNeu_SetGear_NoClutch = TRUE ⇒ Error_NoNeu_SetGear_NoClutch = FALSE
inv31 :NoNeu_CloseClutch_Releasing = TRUE ⇒ Error_NoNeu_CloseClutch_Releasing = FALSE
inv32 :NoNeu_CloseClutch_Setting = TRUE ⇒ Error_NoNeu_CloseClutch_Setting = FALSE
inv33 :NoNeu_OpenClutch_Releasing = TRUE ⇒ Error_NoNeu_OpenClutch_Releasing = FALSE
inv34 :NoNeu_OpenClutch_Setting = TRUE ⇒ Error_NoNeu_OpenClutch_Setting = FALSE
inv35 :RequestNoNeu = TRUE ∧ Error_NoNeu_SetGear_ReleasingClutch = TRUE ⇒ NoNeu_Release_Clutch = TRUE
inv36 :RequestNoNeu = TRUE ∧ Error_NoNeu_SetGear_SettingClutch = TRUE ⇒ NoNeu_OpenClutch_Setting = TRUE
inv37 :RequestNoNeu = TRUE ∧ Error_NoNeu_SetGear_NoClutch = TRUE ⇒ NoNeu_SyncSpeed = TRUE
inv38 :RequestNoNeu = TRUE ∧ Error_NoNeu_CloseClutch_Releasing = TRUE ⇒ NoNeu_SetGear_ReleasingClutch = TRUE
inv39 :RequestNoNeu = TRUE ∧ Error_NoNeu_CloseClutch_Setting = TRUE ⇒ NoNeu_SetGear_SettingClutch = TRUE
inv40 :RequestNoNeu = TRUE ∧ Error_NoNeu_OpenClutch_Setting = TRUE ⇒ NoNeu_Release_NoClutch = TRUE
inv41 :NoNeu_Release_Clutch = TRUE ⇒ NoNeu_SyncSpeed = FALSE ∧ NoNeu_OpenClutch_Setting = FALSE
inv42 :NoNeu_ZeroTorque = TRUE ⇒ NoNeu_ZeroTorqueT ≤ RequestNoNeuT + Zero_EX
inv43 :NoNeu_OpenClutch_Releasing = TRUE ⇒ NoNeu_OpenClutch_ReleasingT ≤ RequestNoNeuT + ZeroOpen_DL
inv44 :NoNeu_SyncSpeed = TRUE ⇒ NoNeu_SyncSpeedT ≤ NoNeu_Release_NoClutchT + Sync_EX
inv45 :NoNeu_OpenClutch_Setting = TRUE ⇒ NoNeu_OpenClutch_SettingT ≤ NoNeu_Release_NoClutchT + SyncOpen_DL
inv46 :NoNeu_SetGear_ReleasingClutch = TRUE ⇒ NoNeu_SetGear_ReleasingClutchT ≤ NoNeu_Release_ClutchT + SetGear_DL
inv47 :NoNeu_SetGear_SettingClutch = TRUE ⇒ NoNeu_SetGear_SettingClutchT ≤ NoNeu_OpenClutch_SettingT + SetGear_DL
inv48 :RequestNoNeu = TRUE ∧ NoNeu_ZeroTorque = FALSE ∧
  NoNeu_OpenClutch_Releasing = FALSE ∧ Error_NoNeu_OpenClutch_Releasing = FALSE ⇒ time ≤ ZeroOpen_DL+RequestNoNeuT
inv49 :NoNeu_Release_NoClutch = TRUE ∧ NoNeu_SyncSpeed = FALSE ∧ NoNeu_OpenClutch_Setting = FALSE ∧
  Error_NoNeu_OpenClutch_Setting = FALSE ⇒ time ≤ SyncOpen_DL+NoNeu_Release_NoClutchT
inv50 :NoNeu_Release_Clutch = TRUE ∧ NoNeu_SetGear_ReleasingClutch = FALSE ∧
  Error_NoNeu_SetGear_ReleasingClutch = FALSE ⇒ time ≤ SetGear_DL+NoNeu_Release_ClutchT
inv51 :NoNeu_OpenClutch_Setting = TRUE ∧ NoNeu_SetGear_SettingClutch = FALSE ∧
  Error_NoNeu_SetGear_SettingClutch = FALSE ⇒ time ≤ SetGear_DL+NoNeu_OpenClutch_SettingT
inv52 :NoNeu_ZeroTorque = TRUE ∧ NoNeu_Release_NoClutch = FALSE ∧ // Added for Expiry
  Error_NoNeu_Release_NoClutch = FALSE ⇒ time ≤ Release_DL+NoNeu_ZeroTorqueT
inv53 :NoNeu_Release_NoClutchT = Releasing_NoNeu_NoClutchT
inv54 :NoNeu_Release_ClutchT = Releasing_NoNeu_ClutchT
inv55 :NoNeu_Release_NoClutch = TRUE ⇒ NoNeu_Release_NoClutchT ≤ NoNeu_ZeroTorqueT + Release_DL
inv56 :NoNeu_ZeroTorque = TRUE ∧ NoNeu_Release_NoClutch = FALSE ∧
  Error_NoNeu_Release_NoClutch = FALSE ⇒ time ≤ Release_DL+NoNeu_ZeroTorqueT
```

### EVENTS

#### INITIALISATION $\triangle$

##### STATUS

##### ordinary

#### BEGIN

```
act1 :time := 0
act2 :isNeu := TRUE
act3 :RequestNoNeu := FALSE
act4 :RequestToNeu := FALSE
act5 :RequestFromNeu := FALSE
act6 :RequestFromNeuT := 0
act7 :RequestNoNeuT := 0
act8 :RequestToNeuT := 0
act9 :FromNeu_SyncSpeed := FALSE
act10 :FromNeu_OpenClutch := FALSE
act11 :FromNeu_SetGear_NoClutch := FALSE
act12 :FromNeu_SetGear_Clutch := FALSE
act13 :FromNeu_CloseClutch := FALSE
act14 :Error_FromNeu_OpenClutch := FALSE
act15 :Error_FromNeu_SetGear_NoClutch := FALSE
act16 :Error_FromNeu_SetGear_Clutch := FALSE
act17 :Error_FromNeu_CloseClutch := FALSE
act18 :FromNeu_OpenClutchT := 0
act19 :FromNeu_SyncSpeedT := 0
act20 :FromNeu_SetGear_ClutchT := 0
act21 :ToNeu_ZeroTorque := FALSE // Senario3 Flage
act22 :ToNeu_OpenClutch := FALSE // Senario3 Flage
act23 :Error_ToNeu_OpenClutch := FALSE // Senario3 Flage
act24 :ToNeu_Release_NoClutch := FALSE // Senario3 Flage
act25 :Error_ToNeu_Release_NoClutch := FALSE // Senario3 Flage
act26 :ToNeu_Release_Clutch := FALSE // Senario3 Flage
act27 :Error_ToNeu_Release_Clutch := FALSE // Senario3 Flage
act28 :ToNeu_CloseClutch := FALSE // Senario3 Flage
act29 :Error_ToNeu_CloseClutch := FALSE // Senario3 Flage
act30 :ToNeu_ZeroTorqueT := 0 // TIME
act31 :ToNeu_OpenClutchT := 0 // TIME
act32 :ToNeu_Release_ClutchT := 0 // TIME
act33 :NoNeu_ZeroTorque := FALSE // Senario2 Flage
act34 :NoNeu_OpenClutch_Releasing := FALSE // Senario2 Flage
act35 :NoNeu_Release_NoClutch := FALSE // Senario2 Flage
act36 :NoNeu_Release_Clutch := FALSE // Senario2 Flage
act37 :NoNeu_SyncSpeed := FALSE // Senario2 Flage
act38 :NoNeu_OpenClutch_Setting := FALSE // Senario2 Flage
```

## Gear Controller Case-study (Time Added Manually)

```
act39 :NoNeu_SetGear_NoClutch:= FALSE // Senario2 Flage
act40 :NoNeu_SetGear_ReleasingClutch:= FALSE // Senario2 Flage
act41 :NoNeu_SetGear_SettingClutch:= FALSE // Senario2 Flage
act42 :NoNeu_CloseClutch_Releasing:= FALSE // Senario2 Flage
act43 :NoNeu_CloseClutch_Setting:= FALSE // Senario2 Flage
act44 :Error_NoNeu_OpenClutch_Releasing:= FALSE // Senario2 Flage
act45 :Error_NoNeu_Release_NoClutch:= FALSE // Senario2 Flage
act46 :Error_NoNeu_Release_Clutch:= FALSE // Senario2 Flage
act47 :Error_NoNeu_OpenClutch_Setting := FALSE // Senario2 Flage
act48 :Error_NoNeu_SetGear_NoClutch:= FALSE // Senario2 Flage
act49 :Error_NoNeu_SetGear_ReleasingClutch:= FALSE // Senario2 Flage
act50 :Error_NoNeu_SetGear_SettingClutch:= FALSE // Senario2 Flage
act51 :Error_NoNeu_CloseClutch_Releasing := FALSE // Senario2 Flage
act52 :Error_NoNeu_CloseClutch_Setting := FALSE // Senario2 Flage
act53 :NoNeu_ZeroTorqueT:= 0 // Senario2 Time
act54 :NoNeu_Release_NoClutchT := 0 // Senario2 Time
act55 :NoNeu_OpenClutch_ReleasingT:= 0 // Senario2 Time
act56 :NoNeu_Release_ClutchT := 0 // Senario2 Time
act57 :NoNeu_SyncSpeedT := 0 // Senario2 Time
act58 :NoNeu_OpenClutch_SettingT:= 0 // Senario2 Time
act59 :NoNeu_SetGear_ReleasingClutchT := 0 // Senario2 Time
act60 :NoNeu_SetGear_SettingClutchT := 0 // Senario2 Time
```

END

**RequestFromNeu**  $\triangle$

extended

STATUS

ordinary

REFINES

RequestFromNeu

WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = TRUE
```

THEN

```
act1 :RequestFromNeu := TRUE
act2 :RequestFromNeuT := time
```

END

**RequestNoNeu**  $\triangle$

extended

STATUS

ordinary

REFINES

RequestNoNeu

WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = FALSE
```

THEN

```
act1 :RequestNoNeu := TRUE
act2 :RequestNoNeuT := time
```

END

**RequestToNeu**  $\triangle$

extended

STATUS

ordinary

REFINES

RequestToNeu

WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = FALSE
```

THEN

```
act1 :RequestToNeu := TRUE
act2 :RequestToNeuT := time
```

END

**FromNeu\_SyncSpeed**  $\triangle$

extended

STATUS

ordinary

REFINES

FromNeu\_SyncSpeed

WHEN

## Gear Controller Case-study (Time Added Manually)

```
    grd1 :RequestFromNeu = TRUE
    grd2 :FromNeu_SyncSpeed = FALSE
    grd3 :FromNeu_OpenClutch = FALSE
    grd4 :Error_FromNeu_OpenClutch = FALSE
    grd5 :time ≤ RequestFromNeuT + Sync_EX
THEN
    act1 :FromNeu_SyncSpeed := TRUE
    act2 :FromNeu_SyncSpeedT := time
END

FromNeu_OpenClutch  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    FromNeu_OpenClutch
WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :Error_FromNeu_OpenClutch = FALSE
    grd3 :FromNeu_SyncSpeed = FALSE
    grd4 :FromNeu_OpenClutch = FALSE
THEN
    act1 :FromNeu_OpenClutch := TRUE
    act2 :FromNeu_OpenClutchT := time
END

Error_FromNeu_OpenClutch  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    Error_FromNeu_OpenClutch
WHEN
    grd1 :RequestFromNeu = TRUE
    grd2 :Error_FromNeu_OpenClutch = FALSE
    grd3 :FromNeu_SyncSpeed = FALSE
    grd4 :FromNeu_OpenClutch = FALSE
THEN
    act1 :Error_FromNeu_OpenClutch := TRUE
END

FromNeu_SetGear_NoClutch  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    FromNeu_SetGear_NoClutch
WHEN
    grd1 :FromNeu_SyncSpeed = TRUE
    grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
    grd3 :FromNeu_SetGear_NoClutch = FALSE
THEN
    act1 :FromNeu_SetGear_NoClutch := TRUE
    act2 :isNeu := FALSE
END

Error_FromNeu_SetGear_NoClutch  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    Error_FromNeu_SetGear_NoClutch
WHEN
    grd1 :FromNeu_SyncSpeed = TRUE
    grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
    grd3 :FromNeu_SetGear_NoClutch = FALSE
THEN
    act1 :Error_FromNeu_SetGear_NoClutch := TRUE
END

FromNeu_SetGear_Clutch  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    FromNeu_SetGear_Clutch
WHEN
    grd1 :FromNeu_OpenClutch = TRUE
    grd2 :Error_FromNeu_SetGear_Clutch = FALSE
    grd3 :FromNeu_SetGear_Clutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
THEN
  act1 :FromNeu_SetGear_Clutch := TRUE
  act2 :FromNeu_SetGear_ClutchT := time
END

Error_FromNeu_SetGear_Clutch ≙
  extended
  STATUS
  ordinary
REFINES
  Error_FromNeu_SetGear_Clutch
WHEN
  grd1 :FromNeu_OpenClutch = TRUE
  grd2 :Error_FromNeu_SetGear_Clutch = FALSE
  grd3 :FromNeu_SetGear_Clutch = FALSE
THEN
  act1 :Error_FromNeu_SetGear_Clutch := TRUE
END

FromNeu_CloseClutch ≙
  extended
  STATUS
  ordinary
REFINES
  FromNeu_CloseClutch
WHEN
  grd1 :FromNeu_SetGear_Clutch = TRUE
  grd2 :Error_FromNeu_CloseClutch = FALSE
  grd3 :FromNeu_CloseClutch = FALSE
THEN
  act1 :FromNeu_CloseClutch := TRUE
  act2 :isNeu := FALSE
END

Error_FromNeu_CloseClutch ≙
  extended
  STATUS
  ordinary
REFINES
  Error_FromNeu_CloseClutch
WHEN
  grd1 :FromNeu_SetGear_Clutch = TRUE
  grd2 :Error_FromNeu_CloseClutch = FALSE
  grd3 :FromNeu_CloseClutch = FALSE
THEN
  act1 :Error_FromNeu_CloseClutch := TRUE
END

ToNeu_ZeroTorque ≙ // First Event of Senarion3
  extended
  STATUS
  ordinary
REFINES
  ToNeu_ZeroTorque
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :ToNeu_ZeroTorque = FALSE
  grd3 :ToNeu_OpenClutch = FALSE
  grd4 :Error_ToNeu_OpenClutch = FALSE
  grd5 :time ≤ RequestToNeuT + Zero_EX
THEN
  act1 :ToNeu_ZeroTorque := TRUE
  act2 :ToNeu_ZeroTorqueT := time
END

ToNeu_OpenClutch ≙
  extended
  STATUS
  ordinary
REFINES
  ToNeu_OpenClutch
WHEN
  grd1 :RequestToNeu = TRUE
  grd2 :ToNeu_ZeroTorque = FALSE
  grd3 :ToNeu_OpenClutch = FALSE
  grd4 :Error_ToNeu_OpenClutch = FALSE
THEN
  act1 :ToNeu_OpenClutch := TRUE
  act2 :ToNeu_OpenClutchT := time
```

## Gear Controller Case-study (Time Added Manually)

END

**Error\_ToNeu\_OpenClutch**  $\triangle$

extended

STATUS

ordinary

REFINES

Error\_ToNeu\_OpenClutch

WHEN

*grd1* :RequestToNeu = TRUE

*grd2* :ToNeu\_ZeroTorque = FALSE

*grd3* :ToNeu\_OpenClutch = FALSE

*grd4* :Error\_ToNeu\_OpenClutch = FALSE

THEN

*act1* :Error\_ToNeu\_OpenClutch := TRUE

END

**ToNeu\_Release\_NoClutch**  $\triangle$

extended

STATUS

ordinary

REFINES

ToNeu\_Release\_NoClutch

WHEN

*grd1* :ToNeu\_ZeroTorque = TRUE

*grd2* :ToNeu\_Release\_NoClutch = FALSE

*grd3* :Error\_ToNeu\_Release\_NoClutch = FALSE

THEN

*act1* :ToNeu\_Release\_NoClutch := TRUE

*act2* :isNeu := TRUE

END

**Error\_ToNeu\_Release\_NoClutch**  $\triangle$

extended

STATUS

ordinary

REFINES

Error\_ToNeu\_Release\_NoClutch

WHEN

*grd1* :ToNeu\_ZeroTorque = TRUE

*grd2* :ToNeu\_Release\_NoClutch = FALSE

*grd3* :Error\_ToNeu\_Release\_NoClutch = FALSE

THEN

*act1* :Error\_ToNeu\_Release\_NoClutch := TRUE

END

**ToNeu\_Release\_Clutch**  $\triangle$

extended

STATUS

ordinary

REFINES

ToNeu\_Release\_Clutch

WHEN

*grd1* :ToNeu\_OpenClutch = TRUE

*grd2* :ToNeu\_Release\_Clutch = FALSE

*grd3* :Error\_ToNeu\_Release\_Clutch = FALSE

THEN

*act1* :ToNeu\_Release\_Clutch := TRUE

*act2* :ToNeu\_Release\_ClutchT := time

END

**Error\_ToNeu\_Release\_Clutch**  $\triangle$

extended

STATUS

ordinary

REFINES

Error\_ToNeu\_Release\_Clutch

WHEN

*grd1* :ToNeu\_OpenClutch = TRUE

*grd2* :ToNeu\_Release\_Clutch = FALSE

*grd3* :Error\_ToNeu\_Release\_Clutch = FALSE

THEN

*act1* :Error\_ToNeu\_Release\_Clutch := TRUE

END

**ToNeu\_CloseClutch**  $\triangle$

extended

STATUS

ordinary



## Gear Controller Case-study (Time Added Manually)

```
REFINES
  ToNeu_CloseClutch
WHEN
  grd1 :ToNeu_Release_Clutch = TRUE
  grd2 :ToNeu_CloseClutch = FALSE
  grd3 :Error_ToNeu_CloseClutch = FALSE
THEN
  act1 :ToNeu_CloseClutch := TRUE
  act2 :isNeu := TRUE
END

Error_ToNeu_CloseClutch  $\triangle$  // Last Event of Senarion3
  extended
  STATUS
  ordinary
REFINES
  Error_ToNeu_CloseClutch
WHEN
  grd1 :ToNeu_Release_Clutch = TRUE
  grd2 :ToNeu_CloseClutch = FALSE
  grd3 :Error_ToNeu_CloseClutch = FALSE
THEN
  act1 :Error_ToNeu_CloseClutch := TRUE
END

NoNeu_ZeroTorque  $\triangle$  // First Event of Senarion2
  STATUS
  ordinary
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :NoNeu_ZeroTorque = FALSE
  grd3 :NoNeu_OpenClutch_Releasing = FALSE
  grd4 :Error_NoNeu_OpenClutch_Releasing = FALSE
  grd5 :time  $\leq$  RequestNoNeuT + Zero_EX
THEN
  act1 :NoNeu_ZeroTorque := TRUE
  act2 :NoNeu_ZeroTorqueT := time
END

NoNeu_OpenClutch_Releasing  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :NoNeu_ZeroTorque = FALSE
  grd3 :NoNeu_OpenClutch_Releasing = FALSE
  grd4 :Error_NoNeu_OpenClutch_Releasing = FALSE
THEN
  act1 :NoNeu_OpenClutch_Releasing := TRUE
  act2 :NoNeu_OpenClutch_ReleasingT := time
END

Error_NoNeu_OpenClutch_Releasing  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Releasing_NoNeu
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :NoNeu_ZeroTorque = FALSE
  grd3 :NoNeu_OpenClutch_Releasing = FALSE
  grd4 :Error_NoNeu_OpenClutch_Releasing = FALSE
THEN
  act1 :Error_NoNeu_OpenClutch_Releasing := TRUE
END

NoNeu_Release_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Releasing_NoNeu_NoClutch
WHEN
  grd1 :NoNeu_ZeroTorque = TRUE
  grd2 :NoNeu_Release_NoClutch = FALSE
  grd3 :Error_NoNeu_Release_NoClutch = FALSE
THEN
  act1 :NoNeu_Release_NoClutch := TRUE
  act2 :NoNeu_Release_NoClutchT := time
END
```

## Gear Controller Case-study (Time Added Manually)

```
Error_NoNeu_Release_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Releasing_NoNeu
WHEN
  grd1 :NoNeu_ZeroTorque = TRUE
  grd2 :NoNeu_Release_NoClutch = FALSE
  grd3 :Error_NoNeu_Release_NoClutch = FALSE
THEN
  act1 :Error_NoNeu_Release_NoClutch := TRUE
END

NoNeu_Release_Clutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Releasing_NoNeu_Clutch
WHEN
  grd1 :NoNeu_OpenClutch_Releasing = TRUE
  grd2 :NoNeu_Release_Clutch = FALSE
  grd3 :Error_NoNeu_Release_Clutch = FALSE
THEN
  act1 :NoNeu_Release_Clutch := TRUE
  act2 :NoNeu_Release_ClutchT := time
END

Error_NoNeu_Release_Clutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Releasing_NoNeu
WHEN
  grd1 :NoNeu_OpenClutch_Releasing = TRUE
  grd2 :NoNeu_Release_Clutch = FALSE
  grd3 :Error_NoNeu_Release_Clutch = FALSE
THEN
  act1 :Error_NoNeu_Release_Clutch := TRUE
END

NoNeu_SyncSpeed  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :NoNeu_Release_NoClutch = TRUE
  grd2 :NoNeu_SyncSpeed = FALSE
  grd3 :NoNeu_OpenClutch_Setting = FALSE
  grd4 :Error_NoNeu_OpenClutch_Setting = FALSE
  grd5 :time  $\leq$  NoNeu_Release_NoClutchT + Sync_EX
THEN
  act1 :NoNeu_SyncSpeed := TRUE
  act2 :NoNeu_SyncSpeedT := time
END

NoNeu_OpenClutch_Setting  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :NoNeu_Release_NoClutch = TRUE
  grd2 :Error_NoNeu_OpenClutch_Setting = FALSE
  grd3 :NoNeu_SyncSpeed = FALSE
  grd4 :NoNeu_OpenClutch_Setting = FALSE
THEN
  act1 :NoNeu_OpenClutch_Setting := TRUE
  act2 :NoNeu_OpenClutch_SettingT := time
END

Error_NoNeu_OpenClutch_Setting  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Setting_NoNeu
WHEN
  grd1 :NoNeu_Release_NoClutch = TRUE
  grd2 :Error_NoNeu_OpenClutch_Setting = FALSE
  grd3 :NoNeu_SyncSpeed = FALSE
  grd4 :NoNeu_OpenClutch_Setting = FALSE
THEN
```

## Gear Controller Case-study (Time Added Manually)

```
act1 :Error_NoNeu_OpenClutch_Setting := TRUE
END

NoNeu_SetGear_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Setting_NoNeu_NoClutch
WHEN
  grd1 :NoNeu_SyncSpeed = TRUE
  grd2 :Error_NoNeu_SetGear_NoClutch = FALSE
  grd3 :NoNeu_SetGear_NoClutch = FALSE
THEN
  act1 :NoNeu_SetGear_NoClutch := TRUE
END

Error_NoNeu_SetGear_NoClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Setting_NoNeu
WHEN
  grd1 :NoNeu_SyncSpeed = TRUE
  grd2 :Error_NoNeu_SetGear_NoClutch = FALSE
  grd3 :NoNeu_SetGear_NoClutch = FALSE
THEN
  act1 :Error_NoNeu_SetGear_NoClutch := TRUE
END

NoNeu_SetGear_ReleasingClutch  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :NoNeu_Release_Clutch = TRUE
  grd2 :Error_NoNeu_SetGear_ReleasingClutch = FALSE
  grd3 :NoNeu_SetGear_ReleasingClutch = FALSE
THEN
  act1 :NoNeu_SetGear_ReleasingClutch := TRUE
  act2 :NoNeu_SetGear_ReleasingClutchT := time
END

Error_NoNeu_SetGear_ReleasingClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Setting_NoNeu
WHEN
  grd1 :NoNeu_Release_Clutch = TRUE
  grd2 :Error_NoNeu_SetGear_ReleasingClutch = FALSE
  grd3 :NoNeu_SetGear_ReleasingClutch = FALSE
THEN
  act1 :Error_NoNeu_SetGear_ReleasingClutch := TRUE
END

NoNeu_SetGear_SettingClutch  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :NoNeu_OpenClutch_Setting = TRUE
  grd2 :Error_NoNeu_SetGear_SettingClutch = FALSE
  grd3 :NoNeu_SetGear_SettingClutch = FALSE
THEN
  act1 :NoNeu_SetGear_SettingClutch := TRUE
  act2 :NoNeu_SetGear_SettingClutchT := time
END

Error_NoNeu_SetGear_SettingClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Setting_NoNeu
WHEN
  grd1 :NoNeu_OpenClutch_Setting = TRUE
  grd2 :Error_NoNeu_SetGear_SettingClutch = FALSE
  grd3 :NoNeu_SetGear_SettingClutch = FALSE
THEN
  act1 :Error_NoNeu_SetGear_SettingClutch := TRUE
END
```

## Gear Controller Case-study (Time Added Manually)

```
NoNeu_CloseClutch_Setting  $\triangle$ 
  STATUS
  ordinary
REFINES
  Setting_NoNeu_Clutch
WHEN
  grd1 :NoNeu_SetGear_SettingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Setting = FALSE
  grd3 :NoNeu_CloseClutch_Setting = FALSE
THEN
  act1 :NoNeu_CloseClutch_Setting := TRUE
END

Error_NoNeu_CloseClutch_Setting  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Setting_NoNeu
WHEN
  grd1 :NoNeu_SetGear_SettingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Setting = FALSE
  grd3 :NoNeu_CloseClutch_Setting = FALSE
THEN
  act1 :Error_NoNeu_CloseClutch_Setting := TRUE
END

NoNeu_CloseClutch_Releasing  $\triangle$ 
  STATUS
  ordinary
REFINES
  Setting_NoNeu_ReleaseClutch
WHEN
  grd1 :NoNeu_SetGear_ReleasingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Releasing = FALSE
  grd3 :NoNeu_CloseClutch_Releasing = FALSE
THEN
  act1 :NoNeu_CloseClutch_Releasing := TRUE
END

Error_NoNeu_CloseClutch_Releasing  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_Setting_NoNeu
WHEN
  grd1 :NoNeu_SetGear_ReleasingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Releasing = FALSE
  grd3 :NoNeu_CloseClutch_Releasing = FALSE
THEN
  act1 :Error_NoNeu_CloseClutch_Releasing := TRUE
END

FINAL  $\triangle$ 
  STATUS
  ordinary
REFINES
  FINAL
WHEN
  FromNeu_SetGear_NoClutch = TRUE  $\vee$  NoNeu_SetGear_NoClutch = TRUE  $\vee$ 
  ToNeu_Release_NoClutch = TRUE  $\vee$  FromNeu_CloseClutch = TRUE  $\vee$ 
  NoNeu_CloseClutch_Setting = TRUE  $\vee$  NoNeu_CloseClutch_Releasing = TRUE  $\vee$ 
  ToNeu_CloseClutch = TRUE
THEN
  act1 :RequestFromNeu := FALSE
  act2 :RequestNoNeu := FALSE
  act3 :RequestToNeu := FALSE
  act4 :FromNeu_SyncSpeed := FALSE
  act5 :FromNeu_OpenClutch := FALSE
  act6 :FromNeu_SetGear_NoClutch := FALSE
  act7 :FromNeu_SetGear_Clutch := FALSE
  act8 :FromNeu_CloseClutch := FALSE
  act9 :ToNeu_Release_NoClutch := FALSE
  act10 :ToNeu_CloseClutch := FALSE
  act11 :ToNeu_ZeroTorque := FALSE // Scenario3 Flage
  act12 :ToNeu_OpenClutch := FALSE // Scenario3 Flage
  act13 :ToNeu_Release_Clutch := FALSE // Scenario3 Flage
  act14 :NoNeu_ZeroTorque := FALSE // Scenario2 Flage
  act15 :NoNeu_OpenClutch_Releasing := FALSE
  act16 :NoNeu_Release_NoClutch := FALSE // Scenario2 Flage
```

## Gear Controller Case-study (Time Added Manually)

```

act17 :NoNeu_Release_Clutch:= FALSE // Senario2 Flage
act18 :NoNeu_SyncSpeed := FALSE // Senario2 Flage
act19 :NoNeu_OpenClutch_Setting := FALSE // Senario2 Flage
act20 :NoNeu_SetGear_NoClutch:= FALSE // Senario2 Flage
act21 :NoNeu_SetGear_ReleasingClutch:= FALSE // Senario2 Flage
act22 :NoNeu_SetGear_SettingClutch:= FALSE // Senario2 Flage
act23 :NoNeu_CloseClutch_Setting:= FALSE // Senario2 Flage
act24 :NoNeu_CloseClutch_Releasing:= FALSE // Senario2 Flage
END

Tick_Tock  $\triangle$ 
STATUS
ordinary
REFINES
Tick_Tock
ANY
tick
WHERE
grd1 :tick > 0
grd2 :RequestFromNeu = TRUE  $\wedge$  FromNeu_SyncSpeed= FALSE  $\wedge$  // Senario1
      :FromNeu_OpenClutch = FALSE  $\wedge$  Error_FromNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SyncOpen_DL
      :+RequestFromNeuT
grd3 :FromNeu_OpenClutch = TRUE  $\wedge$  FromNeu_SetGear_Clutch= FALSE  $\wedge$ 
      :Error_FromNeu_SetGear_Clutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_OpenClutchT
grd4 :FromNeu_SyncSpeed = TRUE  $\wedge$  FromNeu_SetGear_NoClutch= FALSE  $\wedge$ 
      :Error_FromNeu_SetGear_NoClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_SyncSpeedT
grd5 :FromNeu_SetGear_Clutch = TRUE  $\wedge$  FromNeu_CloseClutch= FALSE  $\wedge$  // Senario1
      :Error_FromNeu_CloseClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+FromNeu_SetGear_ClutchT
grd6 :RequestToNeu = TRUE  $\wedge$  ToNeu_OpenClutch= FALSE  $\wedge$  // Senario3
      :ToNeu_ZeroTorque= FALSE  $\wedge$  Error_ToNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  ZeroOpen_DL+RequestToNeuT
grd7 :ToNeu_ZeroTorque = TRUE  $\wedge$  ToNeu_Release_NoClutch= FALSE  $\wedge$ 
      :Error_ToNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_ZeroTorqueT
grd8 :ToNeu_OpenClutch = TRUE  $\wedge$  ToNeu_Release_Clutch= FALSE  $\wedge$ 
      :Error_ToNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_OpenClutchT
grd9 :ToNeu_Release_Clutch = TRUE  $\wedge$  ToNeu_CloseClutch= FALSE  $\wedge$  // Senario3
      :Error_ToNeu_CloseClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+ToNeu_Release_ClutchT
grd10 :RequestNoNeu = TRUE  $\wedge$  NoNeu_ZeroTorque = FALSE  $\wedge$  // Senario2
      :NoNeu_OpenClutch_Releasing = FALSE  $\wedge$  Error_NoNeu_OpenClutch_Releasing = FALSE  $\Rightarrow$  time+tick  $\leq$ 
      :ZeroOpen_DL+RequestNoNeuT
grd11 :NoNeu_ZeroTorque = TRUE  $\wedge$  NoNeu_Release_NoClutch= FALSE  $\wedge$ 
      :Error_NoNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_ZeroTorqueT
grd12 :NoNeu_Release_NoClutch = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$  NoNeu_OpenClutch_Setting = FALSE  $\wedge$ 
      :Error_NoNeu_OpenClutch_Setting= FALSE  $\Rightarrow$  time+tick  $\leq$  SyncOpen_DL+NoNeu_Release_NoClutchT
grd13 :NoNeu_SyncSpeed = TRUE  $\wedge$  NoNeu_SetGear_NoClutch= FALSE  $\wedge$  // Senario2_1
      :Error_NoNeu_SetGear_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_SyncSpeedT
grd14 :NoNeu_OpenClutch_Setting = TRUE  $\wedge$  NoNeu_SetGear_SettingClutch= FALSE  $\wedge$ 
      :Error_NoNeu_SetGear_SettingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_OpenClutch_SettingT
grd15 :NoNeu_SetGear_SettingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Setting= FALSE  $\wedge$  // Senario2_2
      :Error_NoNeu_CloseClutch_Setting= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNeu_SetGear_SettingClutchT
grd16 :NoNeu_OpenClutch_Releasing = TRUE  $\wedge$  NoNeu_Release_Clutch= FALSE  $\wedge$ 
      :Error_NoNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_OpenClutch_ReleasingT
grd17 :NoNeu_Release_Clutch = TRUE  $\wedge$  NoNeu_SetGear_ReleasingClutch= FALSE  $\wedge$ 
      :Error_NoNeu_SetGear_ReleasingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_Release_ClutchT
grd18 :NoNeu_SetGear_ReleasingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Releasing= FALSE  $\wedge$  // Senario2_3
      :Error_NoNeu_CloseClutch_Releasing= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNeu_SetGear_ReleasingClutchT
THEN
act1 :time := time + tick
END
END

```

## Machine m8

### MACHINE

```
// Deadline(RequestFromNeu, FromNeu_SyncSpeed v FromNeu_RequestOpenClutch, Sync_DL)
// Expiry(RequestFromNeu, FromNeu_SyncSpeed, Sync_EX)
// Delay(RequestFromNeu, FromNeu_RequestOpenClutch, OpenClutch_Sync_DE)
// Deadline(FromNeu_RequestOpenClutch, FromNeu_RequestOpenClutch v FromNeu_OpenClutch v Error_FromNeu_OpenClutch,
OpenClutch_DL)
// Deadline(FromNeu_SyncSpeed, FromNeu_SetGear_NoClutch v Error_FromNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(FromNeu_OpenClutch, FromNeu_SetGear_Clutch v Error_FromNeu_SetGear_Clutch, SetGear_DL)
// Deadline(FromNeu_SetGear_Clutch, FromNeu_CloseClutch v Error_FromNeu_CloseClutch, CloseClutch_DL)
//
// Deadline(RequestNoNeu, NoNeu_ZeroTorque v NoNeu_RequestOpenClutch_Releasing, Zero_DL)
// Expiry(RequestNoNeu, NoNeu_ZeroTorque, Zero_EX)
// Delay(RequestNoNeu, NoNeu_RequestOpenClutch_Releasing, OpenClutch_Zero_DE)
// Deadline(NoNeu_RequestOpenClutch_Releasing, NoNeu_OpenClutch_Releasing v Error_NoNeu_OpenClutch_Releasing,
OpenClutch_DL)
// Deadline(NoNeu_ZeroTorque, NoNeu_Release_NoClutch v Error_NoNeu_Release_NoClutch, Release_DL)
// Deadline(NoNeu_OpenClutch_Releasing, NoNeu_Release_Clutch v Error_NoNeu_Release_Clutch, Release_DL)
// Deadline(NoNeu_Release_NoClutch, NoNeu_SyncSpeed v NoNeu_RequestOpenClutch_Setting, Sync_DL)
// Expiry(NoNeu_Release_NoClutch, NoNeu_SyncSpeed, Sync_EX)
// Delay(NoNeu_Release_NoClutch, NoNeu_RequestOpenClutch_Setting, OpenClutch_Sync_DE)
// Deadline(NoNeu_RequestOpenClutch_Setting, NoNeu_OpenClutch_Setting v Error_NoNeu_OpenClutch_Setting, OpenClutch_DL)
// Deadline(NoNeu_SyncSpeed, NoNeu_SetGear_NoClutch v Error_NoNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(NoNeu_OpenClutch_Setting, NoNeu_SetGear_SettingClutch v Error_NoNeu_SetGear_SettingClutch, SetGear_DL)
// Deadline(NoNeu_SetGear_SettingClutch, NoNeu_CloseClutch_Setting v Error_NoNeu_CloseClutch_Setting, CloseClutch_DL)
// Deadline(NoNeu_Release_Clutch, NoNeu_SetGear_ReleasingClutch v Error_NoNeu_SetGear_ReleasingClutch, SetGear_DL)
// Deadline(NoNeu_SetGear_ReleasingClutch, NoNeu_CloseClutch_Releasing v Error_NoNeu_CloseClutch_Releasing,
CloseClutch_DL)
//
// Deadline(RequestToNeu, ToNeu_ZeroTorque v ToNeu_RequestOpenClutch, Zero_DL)
// Expiry(RequestToNeu, ToNeu_ZeroTorque, Zero_EX)
// Delay(RequestToNeu, ToNeu_RequestOpenClutch, OpenClutch_Zero_DE)
// Deadline(ToNeu_RequestOpenClutch, ToNeu_OpenClutch v Error_ToNeu_OpenClutch, OpenClutch_DL)
// Deadline(ToNeu_ZeroTorque, ToNeu_Release_NoClutch v Error_ToNeu_Release_NoClutch, Release_DL)
// Deadline(ToNeu_OpenClutch, ToNeu_Release_Clutch v Error_ToNeu_Release_Clutch, Release_DL)
// Deadline(ToNeu_Release_Clutch, ToNeu_CloseClutch v Error_ToNeu_CloseClutch, CloseClutch_DL)
//
//
```

m8

### REFINES

m7

### SEES

c5

### VARIABLES

```
time // Time
RequestFromNeuT // Time
RequestNoNeuT // Time
RequestToNeuT // Time
isNeu // Gear Status
RequestFromNeu // Flags
RequestNoNeu // Flags
RequestToNeu // Flags
FromNeu_SyncSpeed // Scenario1
FromNeu_OpenClutch // Flage
FromNeu_SetGear_NoClutch // Flage
FromNeu_SetGear_Clutch // Flage
FromNeu_CloseClutch // Flage
Error_FromNeu_OpenClutch // Flage
Error_FromNeu_SetGear_NoClutch // Flage
Error_FromNeu_SetGear_Clutch // Flage
Error_FromNeu_CloseClutch // Scenario1
FromNeu_OpenClutchT // TIME
FromNeu_SyncSpeedT // TIME
FromNeu_SetGear_ClutchT // TIME
ToNeu_ZeroTorque // Scenario3 Flage
ToNeu_OpenClutch // Scenario3 Flage
Error_ToNeu_OpenClutch // Scenario3 Flage
ToNeu_Release_NoClutch // Scenario3 Flage
Error_ToNeu_Release_NoClutch // Scenario3 Flage
ToNeu_Release_Clutch // Scenario3 Flage
Error_ToNeu_Release_Clutch // Scenario3 Flage
ToNeu_CloseClutch // Scenario3 Flage
Error_ToNeu_CloseClutch // Scenario3 Flage
```

## Gear Controller Case-study (Time Added Manually)

```

ToNeu_ZeroTorqueT //TIME
ToNeu_OpenClutchT //TIME
ToNeu_Release_ClutchT //TIME
NoNeu_ZeroTorque //Scenario2 Flage
NoNeu_Release_NoClutch //Scenario2 Flage
NoNeu_OpenClutch_Releasing //Scenario2 Flage
NoNeu_Release_Clutch //Scenario2 Flage
NoNeu_SyncSpeed //Scenario2 Flage
NoNeu_OpenClutch_Setting //Scenario2 Flage
NoNeu_SetGear_NoClutch //Scenario2 Flage
NoNeu_SetGear_ReleasingClutch //Scenario2 Flage
NoNeu_SetGear_SettingClutch //Scenario2 Flage
NoNeu_CloseClutch_Releasing //Scenario2 Flage
NoNeu_CloseClutch_Setting //Scenario2 Flage
Error_NoNeu_OpenClutch_Releasing //Scenario2 Flage
Error_NoNeu_Release_Clutch //Scenario2 Flage
Error_NoNeu_Release_NoClutch //Scenario2 Flage
Error_NoNeu_OpenClutch_Setting //Scenario2 Flage
Error_NoNeu_SetGear_NoClutch //Scenario2 Flage
Error_NoNeu_SetGear_ReleasingClutch //Scenario2 Flage
Error_NoNeu_SetGear_SettingClutch //Scenario2 Flage
Error_NoNeu_CloseClutch_Releasing //Scenario2 Flage
Error_NoNeu_CloseClutch_Setting //Scenario2 Flage
NoNeu_ZeroTorqueT //Scenario2 Time
NoNeu_Release_NoClutchT //Scenario2 Time
NoNeu_OpenClutch_ReleasingT //Scenario2 Time
NoNeu_Release_ClutchT //Scenario2 Time
NoNeu_SetGear_ReleasingClutchT //Scenario2 Time
NoNeu_SetGear_SettingClutchT //Scenario2 Time
NoNeu_SyncSpeedT //Scenario2 Time
NoNeu_OpenClutch_SettingT //Scenario2 Time
Engine_SyncSpeed //Engine Flgas
Engine_WaitForSyncClutch //Engine Flgas
Engine_ZeroTorque //Engine Flgas
Engine_WaitForZeroClutch //Engine Flgas
Clutch_Open //Clutch Flgas
Error_Clutch_Open //Clutch Flgas
Clutch_Close //Clutch Flgas
Error_Clutch_Close //Clutch Flgas
Gear_Release //Gear Flgas
Error_Gear_Release //Gear Flgas
Gear_Set //Gear Flgas
Error_Gear_Set //Gear Flgas
FromNeu_RequestOpenClutch //Scenario1 Flag
ToNeu_RequestOpenClutch //Scenario3 Flag
NoNeu_RequestOpenClutch_Releasing //Scenario2 Flag
NoNeu_RequestOpenClutch_Setting //Scenario2 Flag
FromNeu_RequestOpenClutchT //Scenario1 Time
ToNeu_RequestOpenClutchT //Scenario3 Time
NoNeu_RequestOpenClutch_ReleasingT //Scenario2 Time
NoNeu_RequestOpenClutch_SettingT //Scenario2 Time

```

### INVARIANTS

```

{Engine_SyncSpeed ,
 Engine_WaitForSyncClutch ,Engine_ZeroTorque,
 Engine_WaitForZeroClutch, Clutch_Open, Error_Clutch_Open,
inv1 :Clutch_Close, Error_Clutch_Close, Gear_Release,
 Error_Gear_Release, Gear_Set, Error_Gear_Set, FromNeu_RequestOpenClutch,
 ToNeu_RequestOpenClutch ,NoNeu_RequestOpenClutch_Releasing,
 NoNeu_RequestOpenClutch_Setting} ∈ ℙ(BOOL)
inv2 :Engine_SyncSpeed= TRUE ⇒ RequestFromNeu = TRUE ∨ NoNeu_Release_NoClutch = TRUE
inv3 :Engine_ZeroTorque = TRUE ⇒ RequestToNeu = TRUE ∨ RequestNoNeu = TRUE
inv4 :{FromNeu_RequestOpenClutchT, ToNeu_RequestOpenClutchT,
 NoNeu_RequestOpenClutch_ReleasingT, NoNeu_RequestOpenClutch_SettingT} ⊆ ℕ
inv5 :FromNeu_RequestOpenClutch = TRUE ⇒ FromNeu_SyncSpeed = FALSE ∧ RequestFromNeu = TRUE
inv6 :FromNeu_RequestOpenClutch = FALSE ⇒ FromNeu_OpenClutch = FALSE ∧ Error_FromNeu_OpenClutch = FALSE
inv7 :ToNeu_RequestOpenClutch = TRUE ⇒ ToNeu_ZeroTorque = FALSE ∧ RequestToNeu = TRUE
inv8 :ToNeu_RequestOpenClutch = FALSE ⇒ ToNeu_OpenClutch = FALSE ∧ Error_ToNeu_OpenClutch = FALSE
inv9 :NoNeu_RequestOpenClutch_Releasing = TRUE ⇒ NoNeu_ZeroTorque = FALSE ∧ RequestNoNeu = TRUE
inv10 :NoNeu_RequestOpenClutch_Releasing = FALSE ⇒ NoNeu_OpenClutch_Releasing = FALSE ∧ Error_NoNeu_OpenClutch_Releasing
 : = FALSE
inv11 :NoNeu_RequestOpenClutch_Setting = TRUE ⇒ NoNeu_SyncSpeed = FALSE ∧ NoNeu_Release_NoClutch = TRUE
inv12 :NoNeu_RequestOpenClutch_Setting = FALSE ⇒ NoNeu_OpenClutch_Setting = FALSE ∧ Error_NoNeu_OpenClutch_Setting =
 : FALSE
inv13 :FromNeu_RequestOpenClutch = TRUE ⇒ FromNeu_RequestOpenClutchT ≤ RequestFromNeuT + Sync_DL
inv14 :ToNeu_RequestOpenClutch = TRUE ⇒ ToNeu_RequestOpenClutchT ≤ RequestToNeuT + Zero_DL
inv15 :NoNeu_RequestOpenClutch_Releasing = TRUE ⇒ NoNeu_RequestOpenClutch_ReleasingT ≤ RequestNoNeuT +Zero_DL
inv16 :NoNeu_RequestOpenClutch_Setting = TRUE ⇒ NoNeu_RequestOpenClutch_SettingT ≤ NoNeu_Release_NoClutchT + Sync_DL
inv17 :RequestFromNeu = TRUE ∧ FromNeu_RequestOpenClutch= FALSE ∧
 FromNeu_SyncSpeed = FALSE ⇒ time ≤ Sync_DL+RequestFromNeuT

```



## Gear Controller Case-study (Time Added Manually)

```
inv18 : RequestToNeu = TRUE  $\wedge$  ToNeu_RequestOpenClutch= FALSE  $\wedge$   
       ToNeu_ZeroTorque= FALSE  $\Rightarrow$  time  $\leq$  Zero_DL+RequestToNeuT  
       RequestNoNeu = TRUE  $\wedge$  NoNeu_ZeroTorque = FALSE  $\wedge$   
inv19 : NoNeu_RequestOpenClutch_Releasing = FALSE  
        $\Rightarrow$  time  $\leq$  Zero_DL+RequestNoNeuT  
       NoNeu_Release_NoClutch = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$   
inv20 : NoNeu_RequestOpenClutch_Setting = FALSE  
        $\Rightarrow$  time  $\leq$  Sync_DL+NoNeu_Release_NoClutchT
```

### EVENTS

#### INITIALISATION $\triangle$

extended

STATUS

ordinary

#### BEGIN

```
act1 : time := 0  
act2 : isNeu := TRUE  
act3 : RequestNoNeu := FALSE  
act4 : RequestToNeu := FALSE  
act5 : RequestFromNeu := FALSE  
act6 : RequestFromNeuT := 0  
act7 : RequestNoNeuT := 0  
act8 : RequestToNeuT := 0  
act9 : FromNeu_SyncSpeed := FALSE  
act10 : FromNeu_OpenClutch := FALSE  
act11 : FromNeu_SetGear_NoClutch := FALSE  
act12 : FromNeu_SetGear_Clutch := FALSE  
act13 : FromNeu_CloseClutch := FALSE  
act14 : Error_FromNeu_OpenClutch := FALSE  
act15 : Error_FromNeu_SetGear_NoClutch := FALSE  
act16 : Error_FromNeu_SetGear_Clutch := FALSE  
act17 : Error_FromNeu_CloseClutch := FALSE  
act18 : FromNeu_OpenClutchT := 0  
act19 : FromNeu_SyncSpeedT := 0  
act20 : FromNeu_SetGear_ClutchT := 0  
act21 : ToNeu_ZeroTorque := FALSE // Senario3 Flage  
act22 : ToNeu_OpenClutch := FALSE // Senario3 Flage  
act23 : Error_ToNeu_OpenClutch := FALSE // Senario3 Flage  
act24 : ToNeu_Release_NoClutch := FALSE // Senario3 Flage  
act25 : Error_ToNeu_Release_NoClutch := FALSE // Senario3 Flage  
act26 : ToNeu_Release_Clutch := FALSE // Senario3 Flage  
act27 : Error_ToNeu_Release_Clutch := FALSE // Senario3 Flage  
act28 : ToNeu_CloseClutch := FALSE // Senario3 Flage  
act29 : Error_ToNeu_CloseClutch := FALSE // Senario3 Flage  
act30 : ToNeu_ZeroTorqueT := 0 // TIME  
act31 : ToNeu_OpenClutchT := 0 // TIME  
act32 : ToNeu_Release_ClutchT := 0 // TIME  
act33 : NoNeu_ZeroTorque := FALSE // Senario2 Flage  
act34 : NoNeu_OpenClutch_Releasing := FALSE // Senario2 Flage  
act35 : NoNeu_Release_NoClutch := FALSE // Senario2 Flage  
act36 : NoNeu_Release_Clutch := FALSE // Senario2 Flage  
act37 : NoNeu_SyncSpeed := FALSE // Senario2 Flage  
act38 : NoNeu_OpenClutch_Setting := FALSE // Senario2 Flage  
act39 : NoNeu_SetGear_NoClutch := FALSE // Senario2 Flage  
act40 : NoNeu_SetGear_ReleasingClutch := FALSE // Senario2 Flage  
act41 : NoNeu_SetGear_SettingClutch := FALSE // Senario2 Flage  
act42 : NoNeu_CloseClutch_Releasing := FALSE // Senario2 Flage  
act43 : NoNeu_CloseClutch_Setting := FALSE // Senario2 Flage  
act44 : Error_NoNeu_OpenClutch_Releasing := FALSE // Senario2 Flage  
act45 : Error_NoNeu_Release_NoClutch := FALSE // Senario2 Flage  
act46 : Error_NoNeu_Release_Clutch := FALSE // Senario2 Flage  
act47 : Error_NoNeu_OpenClutch_Setting := FALSE // Senario2 Flage  
act48 : Error_NoNeu_SetGear_NoClutch := FALSE // Senario2 Flage  
act49 : Error_NoNeu_SetGear_ReleasingClutch := FALSE // Senario2 Flage  
act50 : Error_NoNeu_SetGear_SettingClutch := FALSE // Senario2 Flage  
act51 : Error_NoNeu_CloseClutch_Releasing := FALSE // Senario2 Flage  
act52 : Error_NoNeu_CloseClutch_Setting := FALSE // Senario2 Flage  
act53 : NoNeu_ZeroTorqueT := 0 // Senario2 Time  
act54 : NoNeu_Release_NoClutchT := 0 // Senario2 Time  
act55 : NoNeu_OpenClutch_ReleasingT := 0 // Senario2 Time  
act56 : NoNeu_Release_ClutchT := 0 // Senario2 Time  
act57 : NoNeu_SyncSpeedT := 0 // Senario2 Time  
act58 : NoNeu_OpenClutch_SettingT := 0 // Senario2 Time  
act59 : NoNeu_SetGear_ReleasingClutchT := 0 // Senario2 Time  
act60 : NoNeu_SetGear_SettingClutchT := 0 // Senario2 Time  
act61 : Engine_SyncSpeed := FALSE  
act62 : Engine_WaitForSyncClutch := FALSE  
act63 : Engine_ZeroTorque := FALSE  
act64 : Engine_WaitForZeroClutch := FALSE
```



## Gear Controller Case-study (Time Added Manually)

```
act65 :Clutch_Open := FALSE // Clutch Flags
act66 :Error_Clutch_Open := FALSE // Clutch Flags
act67 :Clutch_Close := FALSE // Clutch Flags
act68 :Error_Clutch_Close := FALSE // Clutch Flags
act69 :Gear_Release := FALSE // Gear Flags
act70 :Error_Gear_Release := FALSE // Gear Flags
act71 :Gear_Set := FALSE // Gear Flags
act72 :Error_Gear_Set := FALSE // Gear Flags
act73 :FromNeu_RequestOpenClutch := FALSE // Scenario1 Flag
act74 :ToNeu_RequestOpenClutch := FALSE // Scenario3 Flag
act75 :NoNeu_RequestOpenClutch_Releasing := FALSE // Scenario2 Flag
act76 :NoNeu_RequestOpenClutch_Setting := FALSE // Scenario2 Flag
act77 :FromNeu_RequestOpenClutchT := 0 // Scenario1 Time
act78 :ToNeu_RequestOpenClutchT := 0 // Scenario3 Time
act79 :NoNeu_RequestOpenClutch_ReleasingT := 0 // Scenario2 Time
act80 :NoNeu_RequestOpenClutch_SettingT := 0
```

END

**RequestFromNeu**  $\triangle$

extended

STATUS

ordinary

REFINES

RequestFromNeu

WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = TRUE
```

THEN

```
act1 :RequestFromNeu := TRUE
act2 :RequestFromNeuT := time
```

END

**RequestNoNeu**  $\triangle$

extended

STATUS

ordinary

REFINES

RequestNoNeu

WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = FALSE
```

THEN

```
act1 :RequestNoNeu := TRUE
act2 :RequestNoNeuT := time
```

END

**RequestToNeu**  $\triangle$

extended

STATUS

ordinary

REFINES

RequestToNeu

WHEN

```
grd1 :RequestFromNeu = FALSE
grd2 :RequestNoNeu = FALSE
grd3 :RequestToNeu = FALSE
grd4 :isNeu = FALSE
```

THEN

```
act1 :RequestToNeu := TRUE
act2 :RequestToNeuT := time
```

END

**FromNeu\_SyncSpeed**  $\triangle$

STATUS

ordinary

REFINES

FromNeu\_SyncSpeed

WHEN

```
grd1 :RequestFromNeu = TRUE
grd2 :FromNeu_SyncSpeed = FALSE
grd3 :FromNeu_RequestOpenClutch = FALSE
grd4 :Engine_SyncSpeed = TRUE
grd5 :time ≤ RequestFromNeuT + Sync_EX
```

THEN

```
act1 :FromNeu_SyncSpeed := TRUE
```

## Gear Controller Case-study (Time Added Manually)

```
act2 :FromNeu_SyncSpeedT := time
END

FromNeu_RequestOpenClutch  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestFromNeu = TRUE
  grd2 :FromNeu_SyncSpeed = FALSE
  grd3 :FromNeu_RequestOpenClutch = FALSE
  grd4 :time  $\geq$  RequestFromNeuT + OpenClutch_Zero_DE
THEN
  act1 :FromNeu_RequestOpenClutch := TRUE
  act2 :FromNeu_RequestOpenClutchT := time
END

FromNeu_OpenClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  FromNeu_OpenClutch
WHEN
  grd1 :FromNeu_RequestOpenClutch = TRUE
  grd2 :Error_FromNeu_OpenClutch = FALSE
  grd3 :FromNeu_OpenClutch = FALSE
  grd4 :Clutch_Open = TRUE
THEN
  act1 :FromNeu_OpenClutch := TRUE
  act2 :FromNeu_OpenClutchT := time
END

Error_FromNeu_OpenClutch  $\triangle$ 
  STATUS
  ordinary
REFINES
  Error_FromNeu_OpenClutch
WHEN
  grd1 :FromNeu_RequestOpenClutch = TRUE
  grd2 :Error_FromNeu_OpenClutch = FALSE
  grd3 :FromNeu_OpenClutch = FALSE
THEN
  act1 :Error_FromNeu_OpenClutch := TRUE
END

FromNeu_SetGear_NoClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  FromNeu_SetGear_NoClutch
WHEN
  grd1 :FromNeu_SyncSpeed = TRUE
  grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
  grd3 :FromNeu_SetGear_NoClutch = FALSE
  grd4 :Gear_Set = TRUE
THEN
  act1 :FromNeu_SetGear_NoClutch := TRUE
  act2 :isNeu := FALSE
END

Error_FromNeu_SetGear_NoClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  Error_FromNeu_SetGear_NoClutch
WHEN
  grd1 :FromNeu_SyncSpeed = TRUE
  grd2 :Error_FromNeu_SetGear_NoClutch = FALSE
  grd3 :FromNeu_SetGear_NoClutch = FALSE
  grd4 :Gear_Set = TRUE
THEN
  act1 :Error_FromNeu_SetGear_NoClutch := TRUE
END

FromNeu_SetGear_Clutch  $\triangle$ 
  extended
  STATUS
  ordinary
```

## Gear Controller Case-study (Time Added Manually)

### REFINES

FromNeu\_SetGear\_Clutch

### WHEN

grd1 :FromNeu\_OpenClutch = TRUE  
grd2 :Error\_FromNeu\_SetGear\_Clutch = FALSE  
grd3 :FromNeu\_SetGear\_Clutch = FALSE  
grd4 :Gear\_Set= TRUE

### THEN

act1 :FromNeu\_SetGear\_Clutch := TRUE  
act2 :FromNeu\_SetGear\_ClutchT := time

### END

**Error\_FromNeu\_SetGear\_Clutch**  $\triangle$

extended

STATUS

ordinary

### REFINES

Error\_FromNeu\_SetGear\_Clutch

### WHEN

grd1 :FromNeu\_OpenClutch = TRUE  
grd2 :Error\_FromNeu\_SetGear\_Clutch = FALSE  
grd3 :FromNeu\_SetGear\_Clutch = FALSE

### THEN

act1 :Error\_FromNeu\_SetGear\_Clutch := TRUE

### END

**FromNeu\_CloseClutch**  $\triangle$

extended

STATUS

ordinary

### REFINES

FromNeu\_CloseClutch

### WHEN

grd1 :FromNeu\_SetGear\_Clutch = TRUE  
grd2 :Error\_FromNeu\_CloseClutch = FALSE  
grd3 :FromNeu\_CloseClutch = FALSE  
grd4 :Clutch\_Close = TRUE

### THEN

act1 :FromNeu\_CloseClutch := TRUE  
act2 :isNeu := FALSE

### END

**Error\_FromNeu\_CloseClutch**  $\triangle$

extended

STATUS

ordinary

### REFINES

Error\_FromNeu\_CloseClutch

### WHEN

grd1 :FromNeu\_SetGear\_Clutch = TRUE  
grd2 :Error\_FromNeu\_CloseClutch = FALSE  
grd3 :FromNeu\_CloseClutch = FALSE

### THEN

act1 :Error\_FromNeu\_CloseClutch := TRUE

### END

**ToNeu\_ZeroTorque**  $\triangle$  // First Event of Senarion3

STATUS

ordinary

### REFINES

ToNeu\_ZeroTorque

### WHEN

grd1 :RequestToNeu = TRUE  
grd2 :ToNeu\_ZeroTorque = FALSE  
grd3 :ToNeu\_RequestOpenClutch = FALSE  
grd4 :Engine\_ZeroTorque = TRUE  
grd5 :time  $\leq$  RequestToNeuT + Zero\_EX

### THEN

act1 :ToNeu\_ZeroTorque := TRUE  
act2 :ToNeu\_ZeroTorqueT := time

### END

**ToNeu\_RequestOpenClutch**  $\triangle$

STATUS

ordinary

### WHEN

grd1 :RequestToNeu = TRUE  
grd2 :ToNeu\_ZeroTorque = FALSE  
grd3 :ToNeu\_RequestOpenClutch = FALSE  
grd4 :time  $\geq$  RequestToNeuT + OpenClutch\_Zero\_DE

## Gear Controller Case-study (Time Added Manually)

```
THEN
  act1 :ToNeu_RequestOpenClutch := TRUE
  act2 :ToNeu_RequestOpenClutchT := time
END

ToNeu_OpenClutch ≙
  STATUS
  ordinary
REFINES
  ToNeu_OpenClutch
WHEN
  grd1 :ToNeu_RequestOpenClutch = TRUE
  grd2 :ToNeu_OpenClutch = FALSE
  grd3 :Error_ToNeu_OpenClutch = FALSE
  grd4 :Clutch_Open = TRUE
THEN
  act1 :ToNeu_OpenClutch := TRUE
  act2 :ToNeu_OpenClutchT := time
END

Error_ToNeu_OpenClutch ≙
  STATUS
  ordinary
REFINES
  Error_ToNeu_OpenClutch
WHEN
  grd1 :ToNeu_RequestOpenClutch = TRUE
  grd2 :ToNeu_OpenClutch = FALSE
  grd3 :Error_ToNeu_OpenClutch = FALSE
THEN
  act1 :Error_ToNeu_OpenClutch := TRUE
END

ToNeu_Release_NoClutch ≙
  extended
  STATUS
  ordinary
REFINES
  ToNeu_Release_NoClutch
WHEN
  grd1 :ToNeu_ZeroTorque = TRUE
  grd2 :ToNeu_Release_NoClutch = FALSE
  grd3 :Error_ToNeu_Release_NoClutch = FALSE
  grd4 :Gear_Release = TRUE
THEN
  act1 :ToNeu_Release_NoClutch := TRUE
  act2 :isNeu := TRUE
END

Error_ToNeu_Release_NoClutch ≙
  extended
  STATUS
  ordinary
REFINES
  Error_ToNeu_Release_NoClutch
WHEN
  grd1 :ToNeu_ZeroTorque = TRUE
  grd2 :ToNeu_Release_NoClutch = FALSE
  grd3 :Error_ToNeu_Release_NoClutch = FALSE
THEN
  act1 :Error_ToNeu_Release_NoClutch := TRUE
END

ToNeu_Release_Clutch ≙
  extended
  STATUS
  ordinary
REFINES
  ToNeu_Release_Clutch
WHEN
  grd1 :ToNeu_OpenClutch = TRUE
  grd2 :ToNeu_Release_Clutch = FALSE
  grd3 :Error_ToNeu_Release_Clutch = FALSE
  grd4 :Gear_Release = TRUE
THEN
  act1 :ToNeu_Release_Clutch := TRUE
  act2 :ToNeu_Release_ClutchT := time
END
```

## Gear Controller Case-study (Time Added Manually)

```
Error_ToNeu_Release_Clutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  Error_ToNeu_Release_Clutch
WHEN
  grd1 :ToNeu_OpenClutch = TRUE
  grd2 :ToNeu_Release_Clutch = FALSE
  grd3 :Error_ToNeu_Release_Clutch = FALSE
THEN
  act1 :Error_ToNeu_Release_Clutch := TRUE
END

ToNeu_CloseClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  ToNeu_CloseClutch
WHEN
  grd1 :ToNeu_Release_Clutch = TRUE
  grd2 :ToNeu_CloseClutch = FALSE
  grd3 :Error_ToNeu_CloseClutch = FALSE
  grd4 :Clutch_Close = TRUE
THEN
  act1 :ToNeu_CloseClutch := TRUE
  act2 :isNeu := TRUE
END

Error_ToNeu_CloseClutch  $\triangle$  // Last Event of Senarion3
  extended
  STATUS
  ordinary
REFINES
  Error_ToNeu_CloseClutch
WHEN
  grd1 :ToNeu_Release_Clutch = TRUE
  grd2 :ToNeu_CloseClutch = FALSE
  grd3 :Error_ToNeu_CloseClutch = FALSE
THEN
  act1 :Error_ToNeu_CloseClutch := TRUE
END

NoNeu_ZeroTorque  $\triangle$  // First Event of Senarion2
  STATUS
  ordinary
REFINES
  NoNeu_ZeroTorque
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :NoNeu_ZeroTorque = FALSE
  grd3 :NoNeu_RequestOpenClutch_Releasing = FALSE
  grd4 :time  $\leq$  RequestNoNeuT + Zero_EX
  grd5 :Engine_ZeroTorque = TRUE
THEN
  act1 :NoNeu_ZeroTorque := TRUE
  act2 :NoNeu_ZeroTorqueT := time
END

NoNeu_RequestOpenClutch_Releasing  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestNoNeu = TRUE
  grd2 :NoNeu_ZeroTorque = FALSE
  grd3 :NoNeu_RequestOpenClutch_Releasing = FALSE
  grd4 :time  $\geq$  RequestNoNeuT + OpenClutch_Zero_DE
THEN
  act1 :NoNeu_RequestOpenClutch_Releasing := TRUE
  act2 :NoNeu_RequestOpenClutch_ReleasingT := time
END

NoNeu_OpenClutch_Releasing  $\triangle$ 
  STATUS
  ordinary
REFINES
  NoNeu_OpenClutch_Releasing
WHEN
```

## Gear Controller Case-study (Time Added Manually)

```
    grd1 :NoNeu_OpenClutch_Releasing = TRUE
    grd2 :NoNeu_OpenClutch_Releasing = FALSE
    grd3 :Error_NoNeu_OpenClutch_Releasing = FALSE
    grd4 :Clutch_Open = TRUE
THEN
    act1 :NoNeu_OpenClutch_Releasing := TRUE
    act2 :NoNeu_OpenClutch_ReleasingT := time
END
```

**Error\_NoNeu\_OpenClutch\_Releasing**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_OpenClutch\_Releasing

**WHEN**

```
    grd1 :NoNeu_RequestOpenClutch_Releasing = TRUE
    grd2 :NoNeu_OpenClutch_Releasing = FALSE
    grd3 :Error_NoNeu_OpenClutch_Releasing = FALSE
```

**THEN**

```
    act1 :Error_NoNeu_OpenClutch_Releasing := TRUE
```

**END**

**NoNeu\_Release\_NoClutch**  $\triangle$

**extended**

**STATUS**

**ordinary**

**REFINES**

NoNeu\_Release\_NoClutch

**WHEN**

```
    grd1 :NoNeu_ZeroTorque = TRUE
    grd2 :NoNeu_Release_NoClutch = FALSE
    grd3 :Error_NoNeu_Release_NoClutch = FALSE
    grd4 :Gear_Release = TRUE
```

**THEN**

```
    act1 :NoNeu_Release_NoClutch := TRUE
    act2 :NoNeu_Release_NoClutchT := time
```

**END**

**Error\_NoNeu\_Release\_NoClutch**  $\triangle$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_Release\_NoClutch

**WHEN**

```
    grd1 :NoNeu_ZeroTorque = TRUE
    grd2 :NoNeu_Release_NoClutch = FALSE
    grd3 :Error_NoNeu_Release_NoClutch = FALSE
```

**THEN**

```
    act1 :Error_NoNeu_Release_NoClutch := TRUE
```

**END**

**NoNeu\_Release\_Clutch**  $\triangle$

**extended**

**STATUS**

**ordinary**

**REFINES**

NoNeu\_Release\_Clutch

**WHEN**

```
    grd1 :NoNeu_OpenClutch_Releasing = TRUE
    grd2 :NoNeu_Release_Clutch = FALSE
    grd3 :Error_NoNeu_Release_Clutch = FALSE
    grd4 :Gear_Release = TRUE
```

**THEN**

```
    act1 :NoNeu_Release_Clutch := TRUE
    act2 :NoNeu_Release_ClutchT := time
```

**END**

**Error\_NoNeu\_Release\_Clutch**  $\triangle$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_Release\_Clutch

**WHEN**

```
    grd1 :NoNeu_OpenClutch_Releasing = TRUE
    grd2 :NoNeu_Release_Clutch = FALSE
    grd3 :Error_NoNeu_Release_Clutch = FALSE
```

**THEN**

```
    act1 :Error_NoNeu_Release_Clutch := TRUE
```

**END**

## Gear Controller Case-study (Time Added Manually)

END

**NoNeu\_SyncSpeed**  $\triangle$

**STATUS**

ordinary

REFINES

NoNeu\_SyncSpeed

WHEN

grd1 :NoNeu\_Release\_NoClutch = TRUE  
grd2 :NoNeu\_SyncSpeed = FALSE  
grd3 :NoNeu\_RequestOpenClutch\_Setting = FALSE  
grd4 :Engine\_SyncSpeed= TRUE  
grd5 :time  $\leq$  NoNeu\_Release\_NoClutchT + Sync\_EX

THEN

act1 :NoNeu\_SyncSpeed := TRUE  
act2 :NoNeu\_SyncSpeedT := time

END

**NoNeu\_RequestOpenClutch\_Setting**  $\triangle$

**STATUS**

ordinary

WHEN

grd1 :NoNeu\_Release\_NoClutch = TRUE  
grd2 :NoNeu\_SyncSpeed = FALSE  
grd3 :NoNeu\_RequestOpenClutch\_Setting = FALSE  
grd4 :time  $\geq$  NoNeu\_Release\_NoClutchT + OpenClutch\_Sync\_DE

THEN

act1 :NoNeu\_RequestOpenClutch\_Setting := TRUE  
act2 :NoNeu\_RequestOpenClutch\_SettingT := time

END

**NoNeu\_OpenClutch\_Setting**  $\triangle$

**STATUS**

ordinary

REFINES

NoNeu\_OpenClutch\_Setting

WHEN

grd1 :NoNeu\_RequestOpenClutch\_Setting = TRUE  
grd2 :Error\_NoNeu\_OpenClutch\_Setting = FALSE  
grd3 :NoNeu\_OpenClutch\_Setting = FALSE  
grd4 :Clutch\_Open = TRUE

THEN

act1 :NoNeu\_OpenClutch\_Setting := TRUE  
act2 :NoNeu\_OpenClutch\_SettingT := time

END

**Error\_NoNeu\_OpenClutch\_Setting**  $\triangle$

**STATUS**

ordinary

REFINES

Error\_NoNeu\_OpenClutch\_Setting

WHEN

grd1 :NoNeu\_RequestOpenClutch\_Setting = TRUE  
grd2 :Error\_NoNeu\_OpenClutch\_Setting = FALSE  
grd3 :NoNeu\_OpenClutch\_Setting = FALSE

THEN

act1 :Error\_NoNeu\_OpenClutch\_Setting := TRUE

END

**NoNeu\_SetGear\_NoClutch**  $\triangle$

extended

**STATUS**

ordinary

REFINES

NoNeu\_SetGear\_NoClutch

WHEN

grd1 :NoNeu\_SyncSpeed = TRUE  
grd2 :Error\_NoNeu\_SetGear\_NoClutch = FALSE  
grd3 :NoNeu\_SetGear\_NoClutch = FALSE  
grd4 :Gear\_Set = TRUE

THEN

act1 :NoNeu\_SetGear\_NoClutch := TRUE

END

**Error\_NoNeu\_SetGear\_NoClutch**  $\triangle$

extended

**STATUS**

ordinary

REFINES

## Gear Controller Case-study (Time Added Manually)

```
Error_NoNeu_SetGear_NoClutch
WHEN
  grd1 :NoNeu_SyncSpeed = TRUE
  grd2 :Error_NoNeu_SetGear_NoClutch = FALSE
  grd3 :NoNeu_SetGear_NoClutch = FALSE
THEN
  act1 :Error_NoNeu_SetGear_NoClutch := TRUE
END

NoNeu_SetGear_ReleasingClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  NoNeu_SetGear_ReleasingClutch
WHEN
  grd1 :NoNeu_Release_Clutch = TRUE
  grd2 :Error_NoNeu_SetGear_ReleasingClutch = FALSE
  grd3 :NoNeu_SetGear_ReleasingClutch = FALSE
  grd4 :Gear_Set = TRUE
THEN
  act1 :NoNeu_SetGear_ReleasingClutch := TRUE
  act2 :NoNeu_SetGear_ReleasingClutchT := time
END

Error_NoNeu_SetGear_ReleasingClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  Error_NoNeu_SetGear_ReleasingClutch
WHEN
  grd1 :NoNeu_Release_Clutch = TRUE
  grd2 :Error_NoNeu_SetGear_ReleasingClutch = FALSE
  grd3 :NoNeu_SetGear_ReleasingClutch = FALSE
THEN
  act1 :Error_NoNeu_SetGear_ReleasingClutch := TRUE
END

NoNeu_SetGear_SettingClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  NoNeu_SetGear_SettingClutch
WHEN
  grd1 :NoNeu_OpenClutch_Setting = TRUE
  grd2 :Error_NoNeu_SetGear_SettingClutch = FALSE
  grd3 :NoNeu_SetGear_SettingClutch = FALSE
  grd4 :Gear_Set = TRUE
THEN
  act1 :NoNeu_SetGear_SettingClutch := TRUE
  act2 :NoNeu_SetGear_SettingClutchT := time
END

Error_NoNeu_SetGear_SettingClutch  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  Error_NoNeu_SetGear_SettingClutch
WHEN
  grd1 :NoNeu_OpenClutch_Setting = TRUE
  grd2 :Error_NoNeu_SetGear_SettingClutch = FALSE
  grd3 :NoNeu_SetGear_SettingClutch = FALSE
THEN
  act1 :Error_NoNeu_SetGear_SettingClutch := TRUE
END

NoNeu_CloseClutch_Setting  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  NoNeu_CloseClutch_Setting
WHEN
  grd1 :NoNeu_SetGear_SettingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Setting = FALSE
  grd3 :NoNeu_CloseClutch_Setting = FALSE
  grd4 :Clutch_Close = TRUE
```



## Gear Controller Case-study (Time Added Manually)

```
THEN
  act1 :NoNeu_CloseClutch_Setting := TRUE
END

Error_NoNeu_CloseClutch_Setting  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  Error_NoNeu_CloseClutch_Setting
WHEN
  grd1 :NoNeu_SetGear_SettingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Setting = FALSE
  grd3 :NoNeu_CloseClutch_Setting = FALSE
THEN
  act1 :Error_NoNeu_CloseClutch_Setting := TRUE
END

NoNeu_CloseClutch_Releasing  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  NoNeu_CloseClutch_Releasing
WHEN
  grd1 :NoNeu_SetGear_ReleasingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Releasing = FALSE
  grd3 :NoNeu_CloseClutch_Releasing = FALSE
  grd4 :Clutch_Close = TRUE
THEN
  act1 :NoNeu_CloseClutch_Releasing := TRUE
END

Error_NoNeu_CloseClutch_Releasing  $\triangle$ 
  extended
  STATUS
  ordinary
REFINES
  Error_NoNeu_CloseClutch_Releasing
WHEN
  grd1 :NoNeu_SetGear_ReleasingClutch = TRUE
  grd2 :Error_NoNeu_CloseClutch_Releasing = FALSE
  grd3 :NoNeu_CloseClutch_Releasing = FALSE
THEN
  act1 :Error_NoNeu_CloseClutch_Releasing := TRUE
END

Engine_SyncSpeed  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestFromNeu = TRUE  $\vee$  NoNeu_Release_NoClutch = TRUE
  grd2 :Engine_SyncSpeed = FALSE
  grd3 :Engine_WaitForSyncClutch = FALSE
THEN
  act1 :Engine_SyncSpeed := TRUE
END

Engine_WaitForSyncClutch  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestFromNeu = TRUE  $\vee$  NoNeu_Release_NoClutch = TRUE
  grd2 :Engine_SyncSpeed = FALSE
  grd3 :Engine_WaitForSyncClutch = FALSE
THEN
  act1 :Engine_WaitForSyncClutch := TRUE
END

Engine_ZeroTorque  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1 :RequestToNeu = TRUE  $\vee$  RequestNoNeu = TRUE
  grd2 :Engine_ZeroTorque = FALSE
  grd3 :Engine_WaitForZeroClutch = FALSE
THEN
  act1 :Engine_ZeroTorque := TRUE
END
```

## Gear Controller Case-study (Time Added Manually)

### Engine\_WaitForZeroClutch $\triangle$

STATUS

ordinary

WHEN

grd1 :RequestToNeu = TRUE  $\vee$  RequestNoNeu = TRUE

grd2 :Engine\_ZeroTorque = FALSE

grd3 :Engine\_WaitForZeroClutch = FALSE

THEN

act1 :Engine\_WaitForZeroClutch := TRUE

END

### Clutch\_Open $\triangle$

STATUS

ordinary

WHEN

grd1 :FromNeu\_RequestOpenClutch = TRUE  $\vee$  ToNeu\_RequestOpenClutch = TRUE  $\vee$

NoNeu\_RequestOpenClutch\_Releasing = TRUE  $\vee$  NoNeu\_RequestOpenClutch\_Setting = TRUE

grd2 :Clutch\_Open = FALSE

grd3 :Error\_Clutch\_Open = FALSE

THEN

act1 :Clutch\_Open := TRUE

END

### Error\_Clutch\_Open $\triangle$

STATUS

ordinary

WHEN

grd1 :FromNeu\_RequestOpenClutch = TRUE  $\vee$  ToNeu\_RequestOpenClutch = TRUE  $\vee$

NoNeu\_RequestOpenClutch\_Releasing = TRUE  $\vee$  NoNeu\_RequestOpenClutch\_Setting = TRUE

grd2 :Clutch\_Open = FALSE

grd3 :Error\_Clutch\_Open = FALSE

THEN

act1 :Error\_Clutch\_Open := TRUE

END

### Clutch\_Close $\triangle$

STATUS

ordinary

WHEN

grd1 :FromNeu\_SetGear\_Clutch = TRUE  $\vee$  ToNeu\_Release\_Clutch = TRUE  $\vee$

NoNeu\_SetGear\_ReleasingClutch = TRUE  $\vee$  NoNeu\_SetGear\_SettingClutch = TRUE

grd2 :Clutch\_Close = FALSE

grd3 :Error\_Clutch\_Close = FALSE

THEN

act1 :Clutch\_Close := TRUE

END

### Error\_Clutch\_Close $\triangle$

STATUS

ordinary

WHEN

grd1 :FromNeu\_SetGear\_Clutch = TRUE  $\vee$  ToNeu\_Release\_Clutch = TRUE  $\vee$

NoNeu\_SetGear\_ReleasingClutch = TRUE  $\vee$  NoNeu\_SetGear\_SettingClutch = TRUE

grd2 :Clutch\_Close = FALSE

grd3 :Error\_Clutch\_Close = FALSE

THEN

act1 :Error\_Clutch\_Close := TRUE

END

### Gear\_Release $\triangle$

STATUS

ordinary

WHEN

grd1 :ToNeu\_ZeroTorque = TRUE  $\vee$  ToNeu\_OpenClutch = TRUE  $\vee$

NoNeu\_ZeroTorque = TRUE  $\vee$  NoNeu\_OpenClutch\_Releasing = TRUE

grd2 :Gear\_Release = FALSE

grd3 :Error\_Gear\_Release = FALSE

THEN

act1 :Gear\_Release := TRUE

END

### Error\_Gear\_Release $\triangle$

STATUS

ordinary

WHEN

grd1 :ToNeu\_ZeroTorque = TRUE  $\vee$  ToNeu\_OpenClutch = TRUE  $\vee$

## Gear Controller Case-study (Time Added Manually)

```

    NoNeu_ZeroTorque = TRUE ∨ NoNeu_OpenClutch_Releasing = TRUE
grd2 :Gear_Release = FALSE
grd3 :Error_Gear_Release = FALSE
THEN
    act1 :Error_Gear_Release := TRUE
END

Gear_Set  $\triangle$ 
STATUS
    ordinary
WHEN
    FromNeu_SyncSpeed = TRUE ∨ FromNeu_OpenClutch = TRUE ∨
grd1 :NoNeu_Release_Clutch = TRUE ∨ NoNeu_SyncSpeed = TRUE ∨
    NoNeu_OpenClutch_Setting = TRUE
grd2 :Gear_Set = FALSE
grd3 :Error_Gear_Set = FALSE
THEN
    act1 :Gear_Set := TRUE
END

Error_Gear_Set  $\triangle$ 
STATUS
    ordinary
WHEN
    FromNeu_SyncSpeed = TRUE ∨ FromNeu_OpenClutch = TRUE ∨
grd1 :NoNeu_Release_Clutch = TRUE ∨ NoNeu_SyncSpeed = TRUE ∨
    NoNeu_OpenClutch_Setting = TRUE
grd2 :Gear_Set = FALSE
grd3 :Error_Gear_Set = FALSE
THEN
    act1 :Error_Gear_Set := TRUE
END

FINAL  $\triangle$ 
    extended
STATUS
    ordinary
REFINES
    FINAL
WHEN
    FromNeu_SetGear_NoClutch = TRUE ∨ NoNeu_SetGear_NoClutch = TRUE ∨
grd1 :ToNeu_Release_NoClutch = TRUE ∨ FromNeu_CloseClutch = TRUE ∨
    NoNeu_CloseClutch_Setting = TRUE ∨ NoNeu_CloseClutch_Releasing = TRUE ∨
    ToNeu_CloseClutch = TRUE
THEN
    act1 :RequestFromNeu := FALSE
    act2 :RequestNoNeu := FALSE
    act3 :RequestToNeu := FALSE
    act4 :FromNeu_SyncSpeed := FALSE
    act5 :FromNeu_OpenClutch := FALSE
    act6 :FromNeu_SetGear_NoClutch := FALSE
    act7 :FromNeu_SetGear_Clutch := FALSE
    act8 :FromNeu_CloseClutch := FALSE
    act9 :ToNeu_Release_NoClutch := FALSE
    act10 :ToNeu_CloseClutch := FALSE
    act11 :ToNeu_ZeroTorque := FALSE // Senario3 Flage
    act12 :ToNeu_OpenClutch := FALSE // Senario3 Flage
    act13 :ToNeu_Release_Clutch := FALSE // Senario3 Flage
    act14 :NoNeu_ZeroTorque := FALSE // Senario2 Flage
    act15 :NoNeu_OpenClutch_Releasing := FALSE
    act16 :NoNeu_Release_NoClutch := FALSE // Senario2 Flage
    act17 :NoNeu_Release_Clutch := FALSE // Senario2 Flage
    act18 :NoNeu_SyncSpeed := FALSE // Senario2 Flage
    act19 :NoNeu_OpenClutch_Setting := FALSE // Senario2 Flage
    act20 :NoNeu_SetGear_NoClutch := FALSE // Senario2 Flage
    act21 :NoNeu_SetGear_ReleasingClutch := FALSE // Senario2 Flage
    act22 :NoNeu_SetGear_SettingClutch := FALSE // Senario2 Flage
    act23 :NoNeu_CloseClutch_Setting := FALSE // Senario2 Flage
    act24 :NoNeu_CloseClutch_Releasing := FALSE // Senario2 Flage
    act25 :Engine_SyncSpeed := FALSE
    act26 :Engine_WaitForSyncClutch := FALSE
    act27 :Engine_ZeroTorque := FALSE
    act28 :Engine_WaitForZeroClutch := FALSE
    act29 :Clutch_Open := FALSE // Clutch Flags
    act30 :Clutch_Close := FALSE // Clutch Flags
    act31 :Gear_Release := FALSE // Gear Flags
    act32 :Gear_Set := FALSE // Gear Flags
    act33 :FromNeu_RequestOpenClutch := FALSE // Senario1 Flage

```

## Gear Controller Case-study (Time Added Manually)

```

act34 :ToNeu_RequestOpenClutch := FALSE // Scenario3 Flag
act35 :NoNeu_RequestOpenClutch_Releasing := FALSE // Scenario2 Flag
act36 :NoNeu_RequestOpenClutch_Setting := FALSE // Scenario2 Flag
END

Tick_Tock  $\triangleq$ 
  STATUS
  ordinary
REFINES
  Tick_Tock
ANY
  tick
WHERE
  grd1 :tick > 0
  grd2 :RequestFromNeu = TRUE  $\wedge$  FromNeu_RequestOpenClutch= FALSE  $\wedge$  // Scenario1
        FromNeu_SyncSpeed = FALSE  $\Rightarrow$  time+tick  $\leq$  Sync_DL+RequestFromNeuT
  grd3 :FromNeu_RequestOpenClutch = TRUE  $\wedge$  FromNeu_OpenClutch= FALSE  $\wedge$ 
        Error_FromNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+FromNeu_RequestOpenClutchT
  grd4 :FromNeu_OpenClutch = TRUE  $\wedge$  FromNeu_SetGear_Clutch= FALSE  $\wedge$ 
        Error_FromNeu_SetGear_Clutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_OpenClutchT
  grd5 :FromNeu_SyncSpeed = TRUE  $\wedge$  FromNeu_SetGear_NoClutch= FALSE  $\wedge$ 
        Error_FromNeu_SetGear_NoClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_SyncSpeedT
  grd6 :FromNeu_SetGear_Clutch = TRUE  $\wedge$  FromNeu_CloseClutch= FALSE  $\wedge$  // Scenario1
        Error_FromNeu_CloseClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+FromNeu_SetGear_ClutchT
  grd7 :RequestToNeu = TRUE  $\wedge$  ToNeu_RequestOpenClutch= FALSE  $\wedge$  // Scenario3
        ToNeu_ZeroTorque= FALSE  $\Rightarrow$  time+tick  $\leq$  Zero_DL+RequestToNeuT
  grd8 :ToNeu_RequestOpenClutch = TRUE  $\wedge$  ToNeu_OpenClutch= FALSE  $\wedge$ 
        Error_ToNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+ToNeu_RequestOpenClutchT
  grd9 :ToNeu_ZeroTorque = TRUE  $\wedge$  ToNeu_Release_NoClutch= FALSE  $\wedge$ 
        Error_ToNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_ZeroTorqueT
  grd10 :ToNeu_OpenClutch = TRUE  $\wedge$  ToNeu_Release_Clutch= FALSE  $\wedge$ 
        Error_ToNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_OpenClutchT
  grd11 :ToNeu_Release_Clutch = TRUE  $\wedge$  ToNeu_CloseClutch= FALSE  $\wedge$  // Scenario3
        Error_ToNeu_CloseClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+ToNeu_Release_ClutchT
        RequestNoNeu = TRUE  $\wedge$  NoNeu_ZeroTorque = FALSE  $\wedge$  // Scenario2
  grd12 :NoNeu_RequestOpenClutch_Releasing = FALSE
         $\Rightarrow$  time+tick  $\leq$  Zero_DL+RequestNoNeuT
        NoNeu_RequestOpenClutch_Releasing = TRUE  $\wedge$ 
  grd13 :NoNeu_OpenClutch_Releasing = FALSE  $\wedge$ 
        Error_NoNeu_OpenClutch_Releasing = FALSE
         $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL +NoNeu_RequestOpenClutch_ReleasingT
  grd14 :NoNeu_ZeroTorque = TRUE  $\wedge$  NoNeu_Release_NoClutch= FALSE  $\wedge$ 
        Error_NoNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_ZeroTorqueT
        NoNeu_Release_NoClutch = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$ 
  grd15 :NoNeu_RequestOpenClutch_Setting = FALSE
         $\Rightarrow$  time+tick  $\leq$  Sync_DL+NoNeu_Release_NoClutchT
        NoNeu_RequestOpenClutch_Setting = TRUE  $\wedge$  NoNeu_OpenClutch_Setting = FALSE  $\wedge$ 
  grd16 :Error_NoNeu_OpenClutch_Setting = FALSE
         $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+NoNeu_RequestOpenClutch_SettingT
        NoNeu_SyncSpeed = TRUE  $\wedge$  NoNeu_SetGear_NoClutch= FALSE  $\wedge$  // Scenario2_1
  grd17 :Error_NoNeu_SetGear_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_SyncSpeedT
        NoNeu_OpenClutch_Setting = TRUE  $\wedge$  NoNeu_SetGear_SettingClutch= FALSE  $\wedge$ 
  grd18 :Error_NoNeu_SetGear_SettingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_OpenClutch_SettingT
        NoNeu_SetGear_SettingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Setting= FALSE  $\wedge$  // Scenario2_2
  grd19 :Error_NoNeu_CloseClutch_Setting= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNeu_SetGear_SettingClutchT
        NoNeu_OpenClutch_Releasing = TRUE  $\wedge$  NoNeu_Release_Clutch= FALSE  $\wedge$ 
  grd20 :Error_NoNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_OpenClutch_ReleasingT
        NoNeu_Release_Clutch = TRUE  $\wedge$  NoNeu_SetGear_ReleasingClutch= FALSE  $\wedge$ 
  grd21 :Error_NoNeu_SetGear_ReleasingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_Release_ClutchT
        NoNeu_SetGear_ReleasingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Releasing= FALSE  $\wedge$  // Scenario2_3
  grd22 :Error_NoNeu_CloseClutch_Releasing= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNeu_SetGear_ReleasingClutchT
THEN
  act1 :time := time + tick
END
END

```

## Machine m9

### MACHINE

```
// Deadline(RequestFromNeu, FromNeu_SyncSpeed V FromNeu_RequestOpenClutch, Sync_DL)
// Expiry(RequestFromNeu, FromNeu_SyncSpeed,Sync_EX)
// Delay(RequestFromNeu, FromNeu_RequestOpenClutch, OpenClutch_Sync_DE)
// Deadline(FromNeu_RequestOpenClutch, FromNeu_RequestOpenClutch V FromNeu_OpenClutch V Error_FromNeu_OpenClutch, OpenClutch_DL)
// Deadline(FromNeu_SyncSpeed, FromNeu_SetGear_NoClutch V Error_FromNeu_SetGear_NoClutch, SetGear_r_DL)
// Deadline(FromNeu_OpenClutch, FromNeu_SetGear_Clutch V Error_FromNeu_SetGear_Clutch, SetGear_DL)
// Deadline(FromNeu_SetGear_Clutch, FromNeu_CloseClutch V Error_FromNeu_CloseClutch, CloseClutch_DL)
// Deadline(RequestNoNeu, NoNeu_ZeroTorque V NoNeu_RequestOpenClutch_Releasing, Zero_DL)
// Expiry(RequestNoNeu, NoNeu_ZeroTorque, Zero_EX)
// Delay(RequestNoNeu, NoNeu_RequestOpenClutch_Releasing, OpenClutch_Zero_DE)
// Deadline(NoNeu_RequestOpenClutch_Releasing, NoNeu_OpenClutch_Releasing V Error_NoNeu_OpenClutch_Releasing, OpenClutch_DL)
// Deadline(NoNeu_ZeroTorque, NoNeu_Release_NoClutch V Error_NoNeu_Release_NoClutch, Release_DL)
// Deadline(NoNeu_OpenClutch_Releasing, NoNeu_Release_Clutch V Error_NoNeu_Release_Clutch, Release_DL)
// Deadline(NoNeu_Release_NoClutch, NoNeu_SyncSpeed V NoNeu_RequestOpenClutch_Setting, Sync_DL)
// Expiry(NoNeu_Release_NoClutch, NoNeu_SyncSpeed,Sync_EX)
// Delay(NoNeu_Release_NoClutch, NoNeu_RequestOpenClutch_Setting, OpenClutch_Sync_DE)
// Deadline(NoNeu_RequestOpenClutch_Setting, NoNeu_OpenClutch_Setting V Error_NoNeu_OpenClutch_Setting, OpenClutch_DL)
// Deadline(NoNeu_SyncSpeed, NoNeu_SetGear_NoClutch V Error_NoNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(NoNeu_OpenClutch_Setting, NoNeu_SetGear_SettingClutch V Error_NoNeu_SetGear_SettingClutch, SetGear_DL)
// Deadline(NoNeu_SetGear_SettingClutch, NoNeu_CloseClutch_Setting V Error_NoNeu_CloseClutch_Setting, CloseClutch_DL)
// Deadline(NoNeu_Release_Clutch, NoNeu_SetGear_ReleasingClutch V Error_NoNeu_SetGear_ReleasingClutch, SetGear_DL)
// Deadline(NoNeu_SetGear_ReleasingClutch, NoNeu_CloseClutch_Releasing V Error_NoNeu_CloseClutch_Releasing, CloseClutch_DL)
// Deadline(RequestToNeu, ToNeu_ZeroTorque V ToNeu_RequestOpenClutch, Zero_DL)
// Expiry(RequestToNeu, ToNeu_ZeroTorque, Zero_EX)
// Delay(RequestToNeu, ToNeu_RequestOpenClutch, OpenClutch_Zero_DE)
// Deadline(ToNeu_RequestOpenClutch, ToNeu_OpenClutch V Error_ToNeu_OpenClutch, OpenClutch_DL)
// Deadline(ToNeu_ZeroTorque, ToNeu_Release_NoClutch V Error_ToNeu_Release_NoClutch, Release_DL)
// Deadline(ToNeu_OpenClutch, ToNeu_Release_Clutch V Error_ToNeu_Release_Clutch, Release_DL)
// Deadline(ToNeu_Release_Clutch, ToNeu_CloseClutch V Error_ToNeu_CloseClutch, CloseClutch_DL)
// Deadline(RequestFromNeu, Engine_Request_SyncSpeed, Channel_DL)
// Deadline(NoNeu_Release_NoClutch, Engine_Request_SyncSpeed, Channel_DL)
// Deadline(RequestToNeu, Engine_Request_ZeroTorque, Channel_DL)
// Deadline(RequestNoNeu, Engine_Request_ZeroTorque, Channel_DL)
// Deadline(Engine_ZeroTorque, ToNeu_ZeroTorque, Channel_DL)
// Deadline(Engine_SyncSpeed, FromNeu_SyncSpeed, Channel_DL)
// Deadline(FromNeu_RequestOpenClutch, Clutch_Request_Open, Channel_DL )
// Deadline(ToNeu_RequestOpenClutch, Clutch_Request_Open, Channel_DL )
// Deadline(NoNeu_RequestOpenClutch_Releasing, Clutch_Request_Open, Channel_DL )
// Deadline(NoNeu_RequestOpenClutch_Setting, Clutch_Request_Open, Channel_DL )
// Deadline(FromNeu_SetGear_Clutch, Clutch_Request_Close, Channel_DL )
// Deadline(NoNeu_SetGear_ReleasingClutch, Clutch_Request_Close, Channel_DL )
// Deadline(NoNeu_SetGear_SettingClutch, Clutch_Request_Close, Channel_DL )
// Deadline(ToNeu_Release_Clutch, Clutch_Request_Close, Channel_DL )
// Deadline(Clutch_Open, FromNeu_OpenClutch V ToNeu_OpenClutch V NoNeu_OpenClutch_Releasing V NoNeu_OpenClutch_Setting, Channel_DL)
```

m  
9

## Gear Controller Case-study (Time Added Manually)

```
// Deadline(Clutch_Close, FromNeu_CloseClutch V ToNeu_CloseClutch V NoNeu_CloseClutch_Releasing V
NoNeu_CloseClutch_Setting, Channel_DL )
// Deadline(ToNeu_ZeroTorque, Gear_Request_Release, Channel_DL )
// Deadline(ToNeu_OpenClutch, Gear_Request_Release, Channel_DL )
// Deadline(NoNeu_ZeroTorque, Gear_Request_Release, Channel_DL )
// Deadline(NoNeu_OpenClutch_Releasing, Gear_Request_Release, Channel_DL )
// Deadline(NoNeu_SyncSpeed, Gear_Request_Set, Channel_DL )
// Deadline(NoNeu_OpenClutch_Setting, Gear_Request_Set, Channel_DL )
// Deadline(NoNeu_Release_Clutch, Gear_Request_Set, Channel_DL )
// Deadline(FromNeu_SyncSpeed, Gear_Request_Set, Channel_DL )
// Deadline(ToNeu_OpenClutch, Gear_Request_Set, Channel_DL )
// Deadline(Gear_Release, ToNeu_Release_Clutch V ToNeu_Release_NoClutch V NoNeu_Release_NoClutch
V NoNeu_Release_Clutch, Channel_DL )
// Deadline(Gear_Set, FromNeu_SetGear_Clutch V FromNeu_SetGear_NoClutch V NoNeu_SetGear_NoClutch
V NoNeu_SetGear_ReleasingClutch
V NoNeu_SetGear_SettingClutch, Channel_DL )
// Deadline(Engine_Request_SyncSpeed, Engine_SyncSpeed V Engine_WaitForSyncClutch, Engine_Sync_DL)
// Deadline(Engine_Request_ZeroTorque, Engine_ZeroTorque V Engine_WaitForZeroClutch, Engine_Zero_DL
)
// Deadline(Clutch_Request_Open, Clutch_Open V Error_Clutch_Open, Clutch_Open_DL)
// Deadline(Clutch_Request_Close, Clutch_Close V Error_Clutch_Close, Clutch_Close_DL)
// Deadline(Gear_Request_Release, Gear_Release V Error_Gear_Release, Gear_Release_DL)
// Deadline(Gear_Request_Set, Gear_Set V Error_Gear_Set, Gear_Set_DL)
//
```

### REFINES

m8

### SEES

c6

### VARIABLES

```
time // Time
RequestFromNeuT // Time
RequestNoNeuT // Time
RequestToNeuT // Time
isNeu // Gear Status
RequestFromNeu // Flags
RequestNoNeu // Flags
RequestToNeu // Flags
FromNeu_SyncSpeed // Senario1
FromNeu_OpenClutch // Flage
FromNeu_SetGear_NoClutch // Flage
FromNeu_SetGear_Clutch // Flage
FromNeu_CloseClutch // Flage
Error_FromNeu_OpenClutch // Flage
Error_FromNeu_SetGear_NoClutch // Flage
Error_FromNeu_SetGear_Clutch // Flage
Error_FromNeu_CloseClutch // Senario1
FromNeu_OpenClutchT // TIME
FromNeu_SyncSpeedT // TIME
FromNeu_SetGear_ClutchT // TIME
ToNeu_ZeroTorque // Senario3 Flage
ToNeu_OpenClutch // Senario3 Flage
Error_ToNeu_OpenClutch // Senario3 Flage
ToNeu_Release_NoClutch // Senario3 Flage
Error_ToNeu_Release_NoClutch // Senario3 Flage
ToNeu_Release_Clutch // Senario3 Flage
Error_ToNeu_Release_Clutch // Senario3 Flage
ToNeu_CloseClutch // Senario3 Flage
Error_ToNeu_CloseClutch // Senario3 Flage
ToNeu_ZeroTorqueT // TIME
ToNeu_OpenClutchT // TIME
ToNeu_Release_ClutchT // TIME
NoNeu_ZeroTorque // Senario2 Flage
NoNeu_Release_NoClutch // Senario2 Flage
NoNeu_OpenClutch_Releasing // Senario2 Flage
NoNeu_Release_Clutch // Senario2 Flage
NoNeu_SyncSpeed // Senario2 Flage
NoNeu_OpenClutch_Setting // Senario2 Flage
```

## Gear Controller Case-study (Time Added Manually)

```

NoNeu_SetGear_NoClutch      // Senario2 Flage
NoNeu_SetGear_ReleasingClutch // Senario2 Flage
NoNeu_SetGear_SettingClutch  // Senario2 Flage
NoNeu_CloseClutch_Releasing // Senario2 Flage
NoNeu_CloseClutch_Setting    // Senario2 Flage
Error_NoNeu_OpenClutch_Releasing // Senario2 Flage
Error_NoNeu_Release_Clutch    // Senario2 Flage
Error_NoNeu_Release_NoClutch // Senario2 Flage
Error_NoNeu_OpenClutch_Setting // Senario2 Flage
Error_NoNeu_SetGear_NoClutch  // Senario2 Flage
Error_NoNeu_SetGear_ReleasingClutch // Senario2 Flage
Error_NoNeu_SetGear_SettingClutch // Senario2 Flage
Error_NoNeu_CloseClutch_Releasing // Senario2 Flage
Error_NoNeu_CloseClutch_Setting // Senario2 Flage
NoNeu_ZeroTorqueT           // Senario2 Time
NoNeu_Release_NoClutchT     // Senario2 Time
NoNeu_OpenClutch_ReleasingT // Senario2 Time
NoNeu_Release_ClutchT       // Senario2 Time
NoNeu_SetGear_ReleasingClutchT // Senario2 Time
NoNeu_SetGear_SettingClutchT // Senario2 Time
NoNeu_SyncSpeedT            // Senario2 Time
NoNeu_OpenClutch_SettingT    // Senario2 Time
Engine_SyncSpeed             // Engine Flgas
Engine_WaitForSyncClutch     // Engine Flgas
Engine_ZeroTorque            // Engine Flgas
Engine_WaitForZeroClutch     // Engine Flgas
Clutch_Open                  // Clutch Flgas
Error_Clutch_Open            // Clutch Flgas
Clutch_Close                 // Clutch Flgas
Error_Clutch_Close           // Clutch Flgas
Gear_Release                  // Gear Flgas
Error_Gear_Release           // Gear Flgas
Gear_Set                      // Gear Flgas
Error_Gear_Set               // Gear Flgas
FromNeu_RequestOpenClutch    // Senario1 Flage
ToNeu_RequestOpenClutch      // Senario3 Flage
NoNeu_RequestOpenClutch_Releasing // Senario2 Flage
NoNeu_RequestOpenClutch_Setting // Senario2 Flage
FromNeu_RequestOpenClutchT   // Senario1 Time
ToNeu_RequestOpenClutchT     // Senario3 Time
NoNeu_RequestOpenClutch_ReleasingT // Senario2 Time
NoNeu_RequestOpenClutch_SettingT // Senario2 Time
Engine_Request_SyncSpeed      // Engine Flgas
Engine_Request_ZeroTorque     // Engine Flgas
Clutch_Request_Open           // Clutch Flgas
Clutch_Request_Close          // Clutch Flgas
Gear_Request_Release           // Gear Flgas
Gear_Request_Set              // Gear Flgas
Engine_Request_SyncSpeedT     // Engine Time
Engine_Request_ZeroTorqueT    // Engine Time
Clutch_Request_OpenT          // Clutch Time
Clutch_Request_CloseT         // Clutch Time
Gear_Request_ReleaseT         // Gear Time
Gear_Request_SetT             // Gear Time
Engine_SyncSpeedT             // Engine Flgas
Engine_ZeroTorqueT           // Engine Flgas
Clutch_OpenT                  // Clutch Flgas
Clutch_CloseT                 // Clutch Flgas
Gear_ReleaseT                 // Gear Flgas
Gear_SetT                     // Gear Flgas

```

### INVARIANTS

```

{Engine_Request_SyncSpeed,Engine_Request_ZeroTorque,
inv1 :   Clutch_Request_Open,Clutch_Request_Close,
         Gear_Request_Release,Gear_Request_Set} ∈ ℙ(BOOL)
{Engine_Request_SyncSpeedT,Engine_Request_ZeroTorqueT,
inv2 :   Clutch_Request_OpenT,Clutch_Request_CloseT,
         Gear_Request_ReleaseT,Gear_Request_SetT,Engine_SyncSpeedT ,
         Engine_ZeroTorqueT ,Clutch_OpenT ,Clutch_CloseT ,
         Gear_ReleaseT,Gear_SetT} ⊆ ℕ

```



## Gear Controller Case-study (Time Added Manually)

inv3 : Engine\_Request\_SyncSpeed = TRUE  $\Rightarrow$  RequestFromNeu = TRUE  $\vee$  NoNeu\_Release\_NoClutch = TRUE  
inv4 : Engine\_Request\_ZeroTorque = TRUE  $\Rightarrow$  RequestToNeu = TRUE  $\vee$  RequestNoNeu = TRUE  
inv5 : Clutch\_Request\_Open= TRUE  $\Rightarrow$  FromNeu\_RequestOpenClutch = TRUE  $\vee$  ToNeu\_RequestOpenClutch = TRUE  
     $\vee$   
        NoNeu\_RequestOpenClutch\_Releasing = TRUE  $\vee$  NoNeu\_RequestOpenClutch\_Setting = TRUE  
inv6 : Clutch\_Request\_Close = TRUE  $\Rightarrow$  FromNeu\_SetGear\_Clutch = TRUE  $\vee$  ToNeu\_Release\_Clutch = TRUE  $\vee$   
        NoNeu\_SetGear\_ReleasingClutch = TRUE  $\vee$  NoNeu\_SetGear\_SettingClutch= TRUE  
inv7 : Gear\_Request\_Release= TRUE  $\Rightarrow$  ToNeu\_ZeroTorque = TRUE  $\vee$  ToNeu\_OpenClutch = TRUE  $\vee$   
        NoNeu\_ZeroTorque = TRUE  $\vee$  NoNeu\_OpenClutch\_Releasing= TRUE  
        Gear\_Request\_Set = TRUE  $\Rightarrow$  FromNeu\_SyncSpeed = TRUE  $\vee$  FromNeu\_OpenClutch = TRUE  $\vee$   
inv8 : NoNeu\_Release\_Clutch = TRUE  $\vee$  NoNeu\_SyncSpeed = TRUE  $\vee$   
        NoNeu\_OpenClutch\_Setting = TRUE

### EVENTS

INITIALISATION  $\triangle$

STATUS

ordinary

BEGIN

act1 : time := 0  
act2 : isNeu := TRUE  
act3 : RequestNoNeu := FALSE  
act4 : RequestToNeu := FALSE  
act5 : RequestFromNeu := FALSE  
act6 : RequestFromNeuT := 0  
act7 : RequestNoNeuT := 0  
act8 : RequestToNeuT := 0  
act9 : FromNeu\_SyncSpeed := FALSE  
act10 : FromNeu\_OpenClutch := FALSE  
act11 : FromNeu\_SetGear\_NoClutch := FALSE  
act12 : FromNeu\_SetGear\_Clutch := FALSE  
act13 : FromNeu\_CloseClutch := FALSE  
act14 : Error\_FromNeu\_OpenClutch := FALSE  
act15 : Error\_FromNeu\_SetGear\_NoClutch := FALSE  
act16 : Error\_FromNeu\_SetGear\_Clutch := FALSE  
act17 : Error\_FromNeu\_CloseClutch := FALSE  
act18 : FromNeu\_OpenClutchT := 0  
act19 : FromNeu\_SyncSpeedT := 0  
act20 : FromNeu\_SetGear\_ClutchT := 0  
act21 : ToNeu\_ZeroTorque:= FALSE  
act22 : ToNeu\_OpenClutch := FALSE  
act23 : Error\_ToNeu\_OpenClutch := FALSE  
act24 : ToNeu\_Release\_NoClutch:= FALSE  
act25 : Error\_ToNeu\_Release\_NoClutch:= FALSE  
act26 : ToNeu\_Release\_Clutch:= FALSE  
act27 : Error\_ToNeu\_Release\_Clutch := FALSE  
act28 : ToNeu\_CloseClutch:= FALSE  
act29 : Error\_ToNeu\_CloseClutch:= FALSE  
act30 : ToNeu\_ZeroTorqueT := 0  
act31 : ToNeu\_OpenClutchT := 0  
act32 : ToNeu\_Release\_ClutchT:= 0  
act33 : NoNeu\_ZeroTorque:= FALSE  
act34 : NoNeu\_OpenClutch\_Releasing:= FALSE  
act35 : NoNeu\_Release\_NoClutch:= FALSE  
act36 : NoNeu\_Release\_Clutch:= FALSE  
act37 : NoNeu\_SyncSpeed := FALSE  
act38 : NoNeu\_OpenClutch\_Setting := FALSE  
act39 : NoNeu\_SetGear\_NoClutch:= FALSE  
act40 : NoNeu\_SetGear\_ReleasingClutch:= FALSE  
act41 : NoNeu\_SetGear\_SettingClutch:= FALSE  
act42 : NoNeu\_CloseClutch\_Releasing:= FALSE  
act43 : NoNeu\_CloseClutch\_Setting:= FALSE  
act44 : Error\_NoNeu\_OpenClutch\_Releasing:= FALSE  
act45 : Error\_NoNeu\_Release\_NoClutch:= FALSE  
act46 : Error\_NoNeu\_Release\_Clutch:= FALSE  
act47 : Error\_NoNeu\_OpenClutch\_Setting := FALSE  
act48 : Error\_NoNeu\_SetGear\_NoClutch:= FALSE  
act49 : Error\_NoNeu\_SetGear\_ReleasingClutch:= FALSE  
act50 : Error\_NoNeu\_SetGear\_SettingClutch:= FALSE



## Gear Controller Case-study (Time Added Manually)

```
act51 : Error_NoNeu_CloseClutch_Releasing :=FALSE
act52 : Error_NoNeu_CloseClutch_Setting :=FALSE
act53 : NoNeu_ZeroTorqueT:= 0
act54 : NoNeu_Release_NoClutchT :=0
act55 : NoNeu_OpenClutch_ReleasingT:= 0
act56 : NoNeu_Release_ClutchT :=0
act57 : NoNeu_SyncSpeedT :=0
act58 : NoNeu_OpenClutch_SettingT:= 0
act59 : NoNeu_SetGear_ReleasingClutchT :=0
act60 : NoNeu_SetGear_SettingClutchT :=0
act61 : Engine_SyncSpeed :=FALSE
act62 : Engine_WaitForSyncClutch :=FALSE
act63 : Engine_ZeroTorque :=FALSE
act64 : Engine_WaitForZeroClutch :=FALSE
act65 : Clutch_Open :=FALSE
act66 : Error_Clutch_Open :=FALSE
act67 : Clutch_Close :=FALSE
act68 : Error_Clutch_Close :=FALSE
act69 : Gear_Release :=FALSE
act70 : Error_Gear_Release :=FALSE
act71 : Gear_Set :=FALSE
act72 : Error_Gear_Set :=FALSE
act73 : FromNeu_RequestOpenClutch :=FALSE
act74 : ToNeu_RequestOpenClutch :=FALSE
act75 : NoNeu_RequestOpenClutch_Releasing :=FALSE
act76 : NoNeu_RequestOpenClutch_Setting :=FALSE
act77 : FromNeu_RequestOpenClutchT :=0
act78 : ToNeu_RequestOpenClutchT :=0
act79 : NoNeu_RequestOpenClutch_ReleasingT :=0
act80 : NoNeu_RequestOpenClutch_SettingT :=0
act81 : Engine_Request_SyncSpeed :=FALSE // Engine Flgas
act82 : Engine_Request_ZeroTorque :=FALSE // Engine Flgas
act83 : Clutch_Request_Open :=FALSE // Clutch Flags
act84 : Clutch_Request_Close :=FALSE // Clutch Flags
act85 : Gear_Request_Release :=FALSE // Gear Flags
act86 : Gear_Request_Set :=FALSE // Gear Flags
act87 : Engine_Request_SyncSpeedT :=0 // Engine Time
act88 : Engine_Request_ZeroTorqueT :=0 // Engine Time
act89 : Clutch_Request_OpenT :=0 // Clutch Time
act90 : Clutch_Request_CloseT :=0 // Clutch Time
act91 : Gear_Request_ReleaseT :=0 // Gear Time
act92 : Gear_Request_SetT :=0 // Gear Time
act93 : Engine_SyncSpeedT :=0 // Engine Flgas
act94 : Engine_ZeroTorqueT :=0 // Engine Flgas
act95 : Clutch_OpenT :=0 // Clutch Flags
act96 : Clutch_CloseT :=0 // Clutch Flags
act97 : Gear_ReleaseT :=0 // Gear Flags
act98 : Gear_SetT :=0 // Gear Flags
```

END

**RequestFromNeu**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

RequestFromNeu

**WHEN**

```
grd1 : RequestFromNeu = FALSE
grd2 : RequestNoNeu = FALSE
grd3 : RequestToNeu = FALSE
grd4 : isNeu = TRUE
```

**THEN**

```
act1 : RequestFromNeu := TRUE
act2 : RequestFromNeuT := time
```

END

**RequestNoNeu**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

RequestNoNeu

## Gear Controller Case-study (Time Added Manually)

**WHEN**

grd1 : RequestFromNeu = FALSE  
grd2 : RequestNoNeu = FALSE  
grd3 : RequestToNeu = FALSE  
grd4 : isNeu = FALSE

**THEN**

act1 : RequestNoNeu := TRUE  
act2 : RequestNoNeuT := time

**END**

**RequestToNeu**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

RequestToNeu

**WHEN**

grd1 : RequestFromNeu = FALSE  
grd2 : RequestNoNeu = FALSE  
grd3 : RequestToNeu = FALSE  
grd4 : isNeu = FALSE

**THEN**

act1 : RequestToNeu := TRUE  
act2 : RequestToNeuT := time

**END**

**FromNeu\_SyncSpeed**  $\triangleq$

**extended**

**STATUS**

**ordinary**

**REFINES**

FromNeu\_SyncSpeed

**WHEN**

grd1 : RequestFromNeu = TRUE  
grd2 : FromNeu\_SyncSpeed = FALSE  
grd3 : FromNeu\_RequestOpenClutch = FALSE  
grd4 : Engine\_SyncSpeed = TRUE  
grd5 : time  $\leq$  RequestFromNeuT + Sync\_EX

**THEN**

act1 : FromNeu\_SyncSpeed := TRUE  
act2 : FromNeu\_SyncSpeedT := time

**END**

**FromNeu\_RequestOpenClutch**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

FromNeu\_RequestOpenClutch

**WHEN**

grd1 : RequestFromNeu = TRUE  
grd2 : FromNeu\_SyncSpeed = FALSE  
grd3 : FromNeu\_RequestOpenClutch = FALSE  
grd4 : time  $\geq$  RequestFromNeuT + OpenClutch\_Zero\_DE

**THEN**

act1 : FromNeu\_RequestOpenClutch := TRUE  
act2 : FromNeu\_RequestOpenClutchT := time

**END**

**FromNeu\_OpenClutch**  $\triangleq$

**extended**

**STATUS**

**ordinary**

**REFINES**

FromNeu\_OpenClutch

**WHEN**

grd1 : FromNeu\_RequestOpenClutch = TRUE  
grd2 : Error\_FromNeu\_OpenClutch = FALSE  
grd3 : FromNeu\_OpenClutch = FALSE  
grd4 : Clutch\_Open = TRUE

**THEN**

act1 : FromNeu\_OpenClutch := TRUE

## Gear Controller Case-study (Time Added Manually)

```
act2 : FromNeu_OpenClutchT := time
END

Error_FromNeu_OpenClutch ≐
  STATUS
  ordinary
REFINES
  Error_FromNeu_OpenClutch
WHEN
  grd1 : FromNeu_RequestOpenClutch = TRUE
  grd2 : Error_FromNeu_OpenClutch = FALSE
  grd3 : FromNeu_OpenClutch = FALSE
THEN
  act1 : Error_FromNeu_OpenClutch := TRUE
END

FromNeu_SetGear_NoClutch ≐
  extended
  STATUS
  ordinary
REFINES
  FromNeu_SetGear_NoClutch
WHEN
  grd1 : FromNeu_SyncSpeed = TRUE
  grd2 : Error_FromNeu_SetGear_NoClutch = FALSE
  grd3 : FromNeu_SetGear_NoClutch = FALSE
  grd4 : Gear_Set = TRUE
THEN
  act1 : FromNeu_SetGear_NoClutch := TRUE
  act2 : isNeu := FALSE
END

Error_FromNeu_SetGear_NoClutch ≐
  STATUS
  ordinary
REFINES
  Error_FromNeu_SetGear_NoClutch
WHEN
  grd1 : FromNeu_SyncSpeed = TRUE
  grd2 : Error_FromNeu_SetGear_NoClutch = FALSE
  grd3 : FromNeu_SetGear_NoClutch = FALSE
  grd4 : Gear_Set = TRUE
THEN
  act1 : Error_FromNeu_SetGear_NoClutch := TRUE
END

FromNeu_SetGear_Clutch ≐
  extended
  STATUS
  ordinary
REFINES
  FromNeu_SetGear_Clutch
WHEN
  grd1 : FromNeu_OpenClutch = TRUE
  grd2 : Error_FromNeu_SetGear_Clutch = FALSE
  grd3 : FromNeu_SetGear_Clutch = FALSE
  grd4 : Gear_Set = TRUE
THEN
  act1 : FromNeu_SetGear_Clutch := TRUE
  act2 : FromNeu_SetGear_ClutchT := time
END

Error_FromNeu_SetGear_Clutch ≐
  STATUS
  ordinary
REFINES
  Error_FromNeu_SetGear_Clutch
WHEN
  grd1 : FromNeu_OpenClutch = TRUE
  grd2 : Error_FromNeu_SetGear_Clutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```

    grd3 : FromNeu_SetGear_Clutch = FALSE
THEN
    act1 : Error_FromNeu_SetGear_Clutch := TRUE
END

FromNeu_CloseClutch  $\triangleq$ 
    extended
        STATUS
    ordinary
REFINES
    FromNeu_CloseClutch
WHEN
    grd1 : FromNeu_SetGear_Clutch = TRUE
    grd2 : Error_FromNeu_CloseClutch = FALSE
    grd3 : FromNeu_CloseClutch = FALSE
    grd4 : Clutch_Close = TRUE
THEN
    act1 : FromNeu_CloseClutch := TRUE
    act2 : isNeu :=FALSE
END

Error_FromNeu_CloseClutch  $\triangleq$ 
    STATUS
    ordinary
REFINES
    Error_FromNeu_CloseClutch
WHEN
    grd1 : FromNeu_SetGear_Clutch = TRUE
    grd2 : Error_FromNeu_CloseClutch = FALSE
    grd3 : FromNeu_CloseClutch = FALSE
THEN
    act1 : Error_FromNeu_CloseClutch := TRUE
END

ToNeu_ZeroTorque  $\triangleq$  // First Event of Senarion3
    extended
        STATUS
    ordinary
REFINES
    ToNeu_ZeroTorque
WHEN
    grd1 : RequestToNeu = TRUE
    grd2 : ToNeu_ZeroTorque = FALSE
    grd3 : ToNeu_RequestOpenClutch = FALSE
    grd4 : Engine_ZeroTorque = TRUE
    grd5 : time  $\leq$  RequestToNeuT + Zero_EX
THEN
    act1 : ToNeu_ZeroTorque := TRUE
    act2 : ToNeu_ZeroTorqueT :=time
END

ToNeu_RequestOpenClutch  $\triangleq$ 
    STATUS
    ordinary
REFINES
    ToNeu_RequestOpenClutch
WHEN
    grd1 : RequestToNeu = TRUE
    grd2 : ToNeu_ZeroTorque = FALSE
    grd3 : ToNeu_RequestOpenClutch = FALSE
    grd4 : time  $\geq$  RequestToNeuT + OpenClutch_Zero_DE
THEN
    act1 : ToNeu_RequestOpenClutch := TRUE
    act2 : ToNeu_RequestOpenClutchT :=time
END

ToNeu_OpenClutch  $\triangleq$ 
    extended
        STATUS
    ordinary
```

## Gear Controller Case-study (Time Added Manually)

### REFINES

ToNeu\_OpenClutch

### WHEN

*grd1* : *ToNeu\_RequestOpenClutch* = TRUE  
*grd2* : *ToNeu\_OpenClutch* = FALSE  
*grd3* : *Error\_ToNeu\_OpenClutch* = FALSE  
*grd4* : *Clutch\_Open* = TRUE

### THEN

*act1* : *ToNeu\_OpenClutch* := TRUE  
*act2* : *ToNeu\_OpenClutchT* :=time

### END

**Error\_ToNeu\_OpenClutch**  $\triangleq$

**STATUS**

**ordinary**

### REFINES

Error\_ToNeu\_OpenClutch

### WHEN

*grd1* : *ToNeu\_RequestOpenClutch* = TRUE  
*grd2* : *ToNeu\_OpenClutch* = FALSE  
*grd3* : *Error\_ToNeu\_OpenClutch* = FALSE

### THEN

*act1* : *Error\_ToNeu\_OpenClutch* := TRUE

### END

**ToNeu\_Release\_NoClutch**  $\triangleq$

**extended**

**STATUS**

**ordinary**

### REFINES

ToNeu\_Release\_NoClutch

### WHEN

*grd1* : *ToNeu\_ZeroTorque* = TRUE  
*grd2* : *ToNeu\_Release\_NoClutch* = FALSE  
*grd3* : *Error\_ToNeu\_Release\_NoClutch* = FALSE  
*grd4* : *Gear\_Release* = TRUE

### THEN

*act1* : *ToNeu\_Release\_NoClutch* := TRUE  
*act2* : *isNeu* := TRUE

### END

**Error\_ToNeu\_Release\_NoClutch**  $\triangleq$

**STATUS**

**ordinary**

### REFINES

Error\_ToNeu\_Release\_NoClutch

### WHEN

*grd1* : *ToNeu\_ZeroTorque* = TRUE  
*grd2* : *ToNeu\_Release\_NoClutch* = FALSE  
*grd3* : *Error\_ToNeu\_Release\_NoClutch* = FALSE

### THEN

*act1* : *Error\_ToNeu\_Release\_NoClutch* := TRUE

### END

**ToNeu\_Release\_Clutch**  $\triangleq$

**extended**

**STATUS**

**ordinary**

### REFINES

ToNeu\_Release\_Clutch

### WHEN

*grd1* : *ToNeu\_OpenClutch* = TRUE  
*grd2* : *ToNeu\_Release\_Clutch* = FALSE  
*grd3* : *Error\_ToNeu\_Release\_Clutch* = FALSE  
*grd4* : *Gear\_Release* = TRUE

### THEN

*act1* : *ToNeu\_Release\_Clutch* := TRUE  
*act2* : *ToNeu\_Release\_ClutchT* :=time

### END

## Gear Controller Case-study (Time Added Manually)

```
Error_ToNeu_Release_Clutch  $\triangleq$   
  STATUS  
  ordinary  
REFINES  
  Error_ToNeu_Release_Clutch  
WHEN  
  grd1 : ToNeu_OpenClutch = TRUE  
  grd2 : ToNeu_Release_Clutch = FALSE  
  grd3 : Error_ToNeu_Release_Clutch = FALSE  
THEN  
  act1 : Error_ToNeu_Release_Clutch := TRUE  
END  
  
ToNeu_CloseClutch  $\triangleq$   
  extended  
  STATUS  
  ordinary  
REFINES  
  ToNeu_CloseClutch  
WHEN  
  grd1 : ToNeu_Release_Clutch = TRUE  
  grd2 : ToNeu_CloseClutch = FALSE  
  grd3 : Error_ToNeu_CloseClutch = FALSE  
  grd4 : Clutch_Close = TRUE  
THEN  
  act1 : ToNeu_CloseClutch := TRUE  
  act2 : isNeu := TRUE  
END  
  
Error_ToNeu_CloseClutch  $\triangleq$  // Last Event of Senarion3  
  STATUS  
  ordinary  
REFINES  
  Error_ToNeu_CloseClutch  
WHEN  
  grd1 : ToNeu_Release_Clutch = TRUE  
  grd2 : ToNeu_CloseClutch = FALSE  
  grd3 : Error_ToNeu_CloseClutch = FALSE  
THEN  
  act1 : Error_ToNeu_CloseClutch := TRUE  
END  
  
NoNeu_ZeroTorque  $\triangleq$  // First Event of Senarion2  
  extended  
  STATUS  
  ordinary  
REFINES  
  NoNeu_ZeroTorque  
WHEN  
  grd1 : RequestNoNeu = TRUE  
  grd2 : NoNeu_ZeroTorque = FALSE  
  grd3 : NoNeu_RequestOpenClutch_Releasing = FALSE  
  grd4 : time  $\leq$  RequestNoNeuT + Zero_EX  
  grd5 : Engine_ZeroTorque = TRUE  
THEN  
  act1 : NoNeu_ZeroTorque := TRUE  
  act2 : NoNeu_ZeroTorqueT := time  
END  
  
NoNeu_RequestOpenClutch_Releasing  $\triangleq$   
  STATUS  
  ordinary  
REFINES  
  NoNeu_RequestOpenClutch_Releasing  
WHEN  
  grd1 : RequestNoNeu = TRUE  
  grd2 : NoNeu_ZeroTorque = FALSE  
  grd3 : NoNeu_RequestOpenClutch_Releasing = FALSE  
  grd4 : time  $\geq$  RequestNoNeuT + OpenClutch_Zero_DE  
THEN
```

## Gear Controller Case-study (Time Added Manually)

```
act1 : NoNeu_RequestOpenClutch_Releasing := TRUE
act2 : NoNeu_RequestOpenClutch_ReleasingT := time
END
```

**NoNeu\_OpenClutch\_Releasing**  $\triangle$

**extended**  
**STATUS**  
**ordinary**

**REFINES**

NoNeu\_OpenClutch\_Releasing

**WHEN**

```
grd1 : NoNeu_OpenClutch_Releasing = TRUE
grd2 : NoNeu_OpenClutch_Releasing = FALSE
grd3 : Error_NoNeu_OpenClutch_Releasing = FALSE
grd4 : Clutch_Open = TRUE
```

**THEN**

```
act1 : NoNeu_OpenClutch_Releasing := TRUE
act2 : NoNeu_OpenClutch_ReleasingT := time
```

**END**

**Error\_NoNeu\_OpenClutch\_Releasing**  $\triangle$

**STATUS**  
**ordinary**

**REFINES**

Error\_NoNeu\_OpenClutch\_Releasing

**WHEN**

```
grd1 : NoNeu_RequestOpenClutch_Releasing = TRUE
grd2 : NoNeu_OpenClutch_Releasing = FALSE
grd3 : Error_NoNeu_OpenClutch_Releasing = FALSE
```

**THEN**

```
act1 : Error_NoNeu_OpenClutch_Releasing := TRUE
```

**END**

**NoNeu\_Release\_NoClutch**  $\triangle$

**extended**  
**STATUS**  
**ordinary**

**REFINES**

NoNeu\_Release\_NoClutch

**WHEN**

```
grd1 : NoNeu_ZeroTorque = TRUE
grd2 : NoNeu_Release_NoClutch = FALSE
grd3 : Error_NoNeu_Release_NoClutch = FALSE
grd4 : Gear_Release = TRUE
```

**THEN**

```
act1 : NoNeu_Release_NoClutch := TRUE
act2 : NoNeu_Release_NoClutchT := time
```

**END**

**Error\_NoNeu\_Release\_NoClutch**  $\triangle$

**STATUS**  
**ordinary**

**REFINES**

Error\_NoNeu\_Release\_NoClutch

**WHEN**

```
grd1 : NoNeu_ZeroTorque = TRUE
grd2 : NoNeu_Release_NoClutch = FALSE
grd3 : Error_NoNeu_Release_NoClutch = FALSE
```

**THEN**

```
act1 : Error_NoNeu_Release_NoClutch := TRUE
```

**END**

**NoNeu\_Release\_Clutch**  $\triangle$

**extended**  
**STATUS**  
**ordinary**

**REFINES**

NoNeu\_Release\_Clutch

**WHEN**

```
grd1 : NoNeu_OpenClutch_Releasing = TRUE
```

## Gear Controller Case-study (Time Added Manually)

```
    grd2 : NoNeu_Release_Clutch = FALSE
    grd3 : Error_NoNeu_Release_Clutch = FALSE
    grd4 : Gear_Release = TRUE
THEN
    act1 : NoNeu_Release_Clutch := TRUE
    act2 : NoNeu_Release_ClutchT := time
END

Error_NoNeu_Release_Clutch  $\triangleq$ 
    STATUS
    ordinary
REFINES
    Error_NoNeu_Release_Clutch
WHEN
    grd1 : NoNeu_OpenClutch_Releasing = TRUE
    grd2 : NoNeu_Release_Clutch = FALSE
    grd3 : Error_NoNeu_Release_Clutch = FALSE
THEN
    act1 : Error_NoNeu_Release_Clutch := TRUE
END

NoNeu_SyncSpeed  $\triangleq$ 
    extended
    STATUS
    ordinary
REFINES
    NoNeu_SyncSpeed
WHEN
    grd1 : NoNeu_Release_NoClutch = TRUE
    grd2 : NoNeu_SyncSpeed = FALSE
    grd3 : NoNeu_RequestOpenClutch_Setting = FALSE
    grd4 : Engine_SyncSpeed = TRUE
    grd5 : time  $\leq$  NoNeu_Release_NoClutchT + Sync_EX
THEN
    act1 : NoNeu_SyncSpeed := TRUE
    act2 : NoNeu_SyncSpeedT := time
END

NoNeu_RequestOpenClutch_Setting  $\triangleq$ 
    STATUS
    ordinary
REFINES
    NoNeu_RequestOpenClutch_Setting
WHEN
    grd1 : NoNeu_Release_NoClutch = TRUE
    grd2 : NoNeu_SyncSpeed = FALSE
    grd3 : NoNeu_RequestOpenClutch_Setting = FALSE
    grd4 : time  $\geq$  NoNeu_Release_NoClutchT + OpenClutch_Sync_DE
THEN
    act1 : NoNeu_RequestOpenClutch_Setting := TRUE
    act2 : NoNeu_RequestOpenClutch_SettingT := time
END

NoNeu_OpenClutch_Setting  $\triangleq$ 
    extended
    STATUS
    ordinary
REFINES
    NoNeu_OpenClutch_Setting
WHEN
    grd1 : NoNeu_RequestOpenClutch_Setting = TRUE
    grd2 : Error_NoNeu_OpenClutch_Setting = FALSE
    grd3 : NoNeu_OpenClutch_Setting = FALSE
    grd4 : Clutch_Open = TRUE
THEN
    act1 : NoNeu_OpenClutch_Setting := TRUE
    act2 : NoNeu_OpenClutch_SettingT := time
END

Error_NoNeu_OpenClutch_Setting  $\triangleq$ 
```



## Gear Controller Case-study (Time Added Manually)

```

    STATUS
    ordinary
REFINES
    Error_NoNeu_OpenClutch_Setting
WHEN
    grd1 : NoNeu_RequestOpenClutch_Setting = TRUE
    grd2 : Error_NoNeu_OpenClutch_Setting = FALSE
    grd3 : NoNeu_OpenClutch_Setting = FALSE
THEN
    act1 : Error_NoNeu_OpenClutch_Setting := TRUE
END

    NoNeu_SetGear_NoClutch ≙
    extended
    STATUS
    ordinary
REFINES
    NoNeu_SetGear_NoClutch
WHEN
    grd1 : NoNeu_SyncSpeed = TRUE
    grd2 : Error_NoNeu_SetGear_NoClutch = FALSE
    grd3 : NoNeu_SetGear_NoClutch = FALSE
    grd4 : Gear_Set = TRUE
THEN
    act1 : NoNeu_SetGear_NoClutch := TRUE
END

    Error_NoNeu_SetGear_NoClutch ≙
    STATUS
    ordinary
REFINES
    Error_NoNeu_SetGear_NoClutch
WHEN
    grd1 : NoNeu_SyncSpeed = TRUE
    grd2 : Error_NoNeu_SetGear_NoClutch = FALSE
    grd3 : NoNeu_SetGear_NoClutch = FALSE
THEN
    act1 : Error_NoNeu_SetGear_NoClutch := TRUE
END

    NoNeu_SetGear_ReleasingClutch ≙
    extended
    STATUS
    ordinary
REFINES
    NoNeu_SetGear_ReleasingClutch
WHEN
    grd1 : NoNeu_Release_Clutch = TRUE
    grd2 : Error_NoNeu_SetGear_ReleasingClutch = FALSE
    grd3 : NoNeu_SetGear_ReleasingClutch = FALSE
    grd4 : Gear_Set = TRUE
THEN
    act1 : NoNeu_SetGear_ReleasingClutch := TRUE
    act2 : NoNeu_SetGear_ReleasingClutchT := time
END

    Error_NoNeu_SetGear_ReleasingClutch ≙
    STATUS
    ordinary
REFINES
    Error_NoNeu_SetGear_ReleasingClutch
WHEN
    grd1 : NoNeu_Release_Clutch = TRUE
    grd2 : Error_NoNeu_SetGear_ReleasingClutch = FALSE
    grd3 : NoNeu_SetGear_ReleasingClutch = FALSE
THEN
    act1 : Error_NoNeu_SetGear_ReleasingClutch := TRUE
END

    NoNeu_SetGear_SettingClutch ≙
```

## Gear Controller Case-study (Time Added Manually)

```
    extended
      STATUS
    ordinary
  REFINES
    NoNeu_SetGear_SettingClutch
  WHEN
    grd1 : NoNeu_OpenClutch_Setting = TRUE
    grd2 : Error_NoNeu_SetGear_SettingClutch = FALSE
    grd3 : NoNeu_SetGear_SettingClutch = FALSE
    grd4 : Gear_Set = TRUE
  THEN
    act1 : NoNeu_SetGear_SettingClutch := TRUE
    act2 : NoNeu_SetGear_SettingClutchT := time
  END
```

```
    Error_NoNeu_SetGear_SettingClutch ≐
      STATUS
```

```
    ordinary
  REFINES
    Error_NoNeu_SetGear_SettingClutch
  WHEN
    grd1 : NoNeu_OpenClutch_Setting = TRUE
    grd2 : Error_NoNeu_SetGear_SettingClutch = FALSE
    grd3 : NoNeu_SetGear_SettingClutch = FALSE
  THEN
    act1 : Error_NoNeu_SetGear_SettingClutch := TRUE
  END
```

```
    NoNeu_CloseClutch_Setting ≐
```

```
    extended
      STATUS
    ordinary
  REFINES
    NoNeu_CloseClutch_Setting
  WHEN
    grd1 : NoNeu_SetGear_SettingClutch = TRUE
    grd2 : Error_NoNeu_CloseClutch_Setting = FALSE
    grd3 : NoNeu_CloseClutch_Setting = FALSE
    grd4 : Clutch_Close = TRUE
  THEN
    act1 : NoNeu_CloseClutch_Setting := TRUE
  END
```

```
    Error_NoNeu_CloseClutch_Setting ≐
      STATUS
```

```
    ordinary
  REFINES
    Error_NoNeu_CloseClutch_Setting
  WHEN
    grd1 : NoNeu_SetGear_SettingClutch = TRUE
    grd2 : Error_NoNeu_CloseClutch_Setting = FALSE
    grd3 : NoNeu_CloseClutch_Setting = FALSE
  THEN
    act1 : Error_NoNeu_CloseClutch_Setting := TRUE
  END
```

```
    NoNeu_CloseClutch_Releasing ≐
```

```
    extended
      STATUS
    ordinary
  REFINES
    NoNeu_CloseClutch_Releasing
  WHEN
    grd1 : NoNeu_SetGear_ReleasingClutch = TRUE
    grd2 : Error_NoNeu_CloseClutch_Releasing = FALSE
    grd3 : NoNeu_CloseClutch_Releasing = FALSE
    grd4 : Clutch_Close = TRUE
  THEN
    act1 : NoNeu_CloseClutch_Releasing := TRUE
  END
```

## Gear Controller Case-study (Time Added Manually)

**Error\_NoNeu\_CloseClutch\_Releasing**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_CloseClutch\_Releasing

**WHEN**

grd1 : NoNeu\_SetGear\_ReleasingClutch = TRUE  
grd2 : Error\_NoNeu\_CloseClutch\_Releasing = FALSE  
grd3 : NoNeu\_CloseClutch\_Releasing = FALSE

**THEN**

act1 : Error\_NoNeu\_CloseClutch\_Releasing := TRUE

**END**

**Engine\_Request\_SyncSpeed**  $\triangleq$

**STATUS**

**ordinary**

**WHEN**

grd1 : RequestFromNeu = TRUE  $\vee$  NoNeu\_Release\_NoClutch = TRUE  
grd2 : Engine\_Request\_SyncSpeed = FALSE

**THEN**

act1 : Engine\_Request\_SyncSpeed := TRUE  
act2 : Engine\_Request\_SyncSpeedT := time

**END**

**Engine\_SyncSpeed**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

Engine\_SyncSpeed

**WHEN**

grd1 : Engine\_Request\_SyncSpeed = TRUE  
grd2 : Engine\_SyncSpeed = FALSE  
grd3 : Engine\_WaitForSyncClutch = FALSE

**THEN**

act1 : Engine\_SyncSpeed := TRUE  
act2 : Engine\_SyncSpeedT := time

**END**

**Engine\_WaitForSyncClutch**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

Engine\_WaitForSyncClutch

**WHEN**

grd1 : Engine\_Request\_SyncSpeed = TRUE  
grd2 : Engine\_SyncSpeed = FALSE  
grd3 : Engine\_WaitForSyncClutch = FALSE

**THEN**

act1 : Engine\_WaitForSyncClutch := TRUE

**END**

**Engine\_Request\_ZeroTorque**  $\triangleq$

**STATUS**

**ordinary**

**WHEN**

grd1 : RequestToNeu = TRUE  $\vee$  RequestNoNeu = TRUE  
grd2 : Engine\_Request\_ZeroTorque = FALSE

**THEN**

act1 : Engine\_Request\_ZeroTorque := TRUE  
act2 : Engine\_Request\_ZeroTorqueT := time

**END**

**Engine\_ZeroTorque**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

Engine\_ZeroTorque

**WHEN**

## Gear Controller Case-study (Time Added Manually)

```
    grd1 : Engine_Request_ZeroTorque = TRUE
    grd2 : Engine_ZeroTorque = FALSE
    grd3 : Engine_WaitForZeroClutch = FALSE
THEN
    act1 : Engine_ZeroTorque := TRUE
    act2 : Engine_ZeroTorqueT := time
END

Engine_WaitForZeroClutch  $\triangleq$ 
    STATUS
    ordinary
REFINES
    Engine_WaitForZeroClutch
WHEN
    grd1 : Engine_Request_ZeroTorque = TRUE
    grd2 : Engine_ZeroTorque = FALSE
    grd3 : Engine_WaitForZeroClutch = FALSE
THEN
    act1 : Engine_WaitForZeroClutch := TRUE
END

Clutch_Request_Open  $\triangleq$ 
    STATUS
    ordinary
WHEN
    grd1 : FromNeu_RequestOpenClutch = TRUE  $\vee$  ToNeu_RequestOpenClutch = TRUE  $\vee$ 
           NoNeu_RequestOpenClutch_Releasing = TRUE  $\vee$  NoNeu_RequestOpenClutch_Setting = TRUE
    grd2 : Clutch_Request_Open = FALSE
THEN
    act1 : Clutch_Request_Open := TRUE
    act2 : Clutch_Request_OpenT := time
END

Clutch_Open  $\triangleq$ 
    STATUS
    ordinary
REFINES
    Clutch_Open
WHEN
    grd1 : Clutch_Request_Open = TRUE
    grd2 : Clutch_Open = FALSE
    grd3 : Error_Clutch_Open = FALSE
THEN
    act1 : Clutch_Open := TRUE
    act2 : Clutch_OpenT := time
END

Error_Clutch_Open  $\triangleq$ 
    STATUS
    ordinary
REFINES
    Error_Clutch_Open
WHEN
    grd1 : Clutch_Request_Open = TRUE
    grd2 : Clutch_Open = FALSE
    grd3 : Error_Clutch_Open = FALSE
THEN
    act1 : Error_Clutch_Open := TRUE
END

Clutch_Request_Close  $\triangleq$ 
    STATUS
    ordinary
WHEN
    grd1 : FromNeu_SetGear_Clutch = TRUE  $\vee$  ToNeu_Release_Clutch = TRUE  $\vee$ 
           NoNeu_SetGear_ReleasingClutch = TRUE  $\vee$  NoNeu_SetGear_SettingClutch = TRUE
    grd2 : Clutch_Request_Close = FALSE
THEN
    act1 : Clutch_Request_Close := TRUE
```

## Gear Controller Case-study (Time Added Manually)

act2 : Clutch\_Request\_CloseT := time  
END

**Clutch\_Close**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Clutch\_Close

**WHEN**

grd1 : Clutch\_Request\_Close = TRUE

grd2 : Clutch\_Close = FALSE

grd3 : Error\_Clutch\_Close = FALSE

**THEN**

act1 : Clutch\_Close := TRUE

act2 : Clutch\_CloseT := time

**END**

**Error\_Clutch\_Close**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Error\_Clutch\_Close

**WHEN**

grd1 : Clutch\_Request\_Close = TRUE

grd2 : Clutch\_Close = FALSE

grd3 : Error\_Clutch\_Close = FALSE

**THEN**

act1 : Error\_Clutch\_Close := TRUE

**END**

**Gear\_Request\_Release**  $\triangleq$   
**STATUS**

**ordinary**

**WHEN**

grd1 : ToNeu\_ZeroTorque = TRUE  $\vee$  ToNeu\_OpenClutch = TRUE  $\vee$   
NoNeu\_ZeroTorque = TRUE  $\vee$  NoNeu\_OpenClutch\_Releasing = TRUE

grd2 : Gear\_Request\_Release = FALSE

**THEN**

act1 : Gear\_Request\_Release := TRUE

act2 : Gear\_Request\_ReleaseT := time

**END**

**Gear\_Release**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Gear\_Release

**WHEN**

grd1 : Gear\_Request\_Release = TRUE

grd2 : Gear\_Release = FALSE

grd3 : Error\_Gear\_Release = FALSE

**THEN**

act1 : Gear\_Release := TRUE

act2 : Gear\_ReleaseT := time

**END**

**Error\_Gear\_Release**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Error\_Gear\_Release

**WHEN**

grd1 : Gear\_Request\_Release = TRUE

grd2 : Gear\_Release = FALSE

grd3 : Error\_Gear\_Release = FALSE

**THEN**

act1 : Error\_Gear\_Release := TRUE

**END**

## Gear Controller Case-study (Time Added Manually)

```
Gear_Request_Set  $\triangleq$   
  STATUS  
  ordinary  
WHEN  
    FromNeu_SyncSpeed = TRUE  $\vee$  FromNeu_OpenClutch = TRUE  $\vee$   
  grd1 :      NoNeu_Release_Clutch = TRUE  $\vee$  NoNeu_SyncSpeed = TRUE  $\vee$   
              NoNeu_OpenClutch_Setting = TRUE  
  grd2 : Gear_Request_Set = FALSE  
THEN  
  act1 : Gear_Request_Set := TRUE  
  act2 : Gear_Request_SetT := time  
END  
  
Gear_Set  $\triangleq$   
  STATUS  
  ordinary  
REFINES  
  Gear_Set  
WHEN  
  grd1 : Gear_Request_Set = TRUE  
  grd2 : Gear_Set = FALSE  
  grd3 : Error_Gear_Set = FALSE  
THEN  
  act1 : Gear_Set := TRUE  
  act2 : Gear_SetT := time  
END  
  
Error_Gear_Set  $\triangleq$   
  STATUS  
  ordinary  
REFINES  
  Error_Gear_Set  
WHEN  
  grd1 : Gear_Request_Set = TRUE  
  grd2 : Gear_Set = FALSE  
  grd3 : Error_Gear_Set = FALSE  
THEN  
  act1 : Error_Gear_Set := TRUE  
END  
  
FINAL  $\triangleq$   
  STATUS  
  ordinary  
REFINES  
  FINAL  
WHEN  
    FromNeu_SetGear_NoClutch = TRUE  $\vee$  NoNeu_SetGear_NoClutch = TRUE  $\vee$   
  grd1 :      ToNeu_Release_NoClutch = TRUE  $\vee$  FromNeu_CloseClutch = TRUE  $\vee$   
              NoNeu_CloseClutch_Setting = TRUE  $\vee$  NoNeu_CloseClutch_Releasing = TRUE  $\vee$   
              ToNeu_CloseClutch = TRUE  
THEN  
  act1 : RequestFromNeu := FALSE  
  act2 : RequestNoNeu := FALSE  
  act3 : RequestToNeu := FALSE  
  act4 : FromNeu_SyncSpeed := FALSE  
  act5 : FromNeu_OpenClutch := FALSE  
  act6 : FromNeu_SetGear_NoClutch := FALSE  
  act7 : FromNeu_SetGear_Clutch := FALSE  
  act8 : FromNeu_CloseClutch := FALSE  
  act9 : ToNeu_Release_NoClutch := FALSE  
  act10 : ToNeu_CloseClutch := FALSE  
  act11 : ToNeu_ZeroTorque := FALSE  
  act12 : ToNeu_OpenClutch := FALSE  
  act13 : ToNeu_Release_Clutch := FALSE  
  act14 : NoNeu_ZeroTorque := FALSE  
  act15 : NoNeu_OpenClutch_Releasing := FALSE  
  act16 : NoNeu_Release_NoClutch := FALSE  
  act17 : NoNeu_Release_Clutch := FALSE
```

## Gear Controller Case-study (Time Added Manually)

```

act18 : NoNeu_SyncSpeed :=FALSE
act19 : NoNeu_OpenClutch_Setting :=FALSE
act20 : NoNeu_SetGear_NoClutch:= FALSE
act21 : NoNeu_SetGear_ReleasingClutch:= FALSE
act22 : NoNeu_SetGear_SettingClutch:= FALSE
act23 : NoNeu_CloseClutch_Setting:= FALSE
act24 : NoNeu_CloseClutch_Releasing:= FALSE
act25 : Engine_SyncSpeed :=FALSE
act26 : Engine_WaitForSyncClutch :=FALSE
act27 : Engine_ZeroTorque :=FALSE
act28 : Engine_WaitForZeroClutch :=FALSE
act29 : Clutch_Open :=FALSE
act30 : Clutch_Close :=FALSE
act31 : Gear_Release :=FALSE
act32 : Gear_Set :=FALSE
act33 : FromNeu_RequestOpenClutch :=FALSE
act34 : ToNeu_RequestOpenClutch :=FALSE
act35 : NoNeu_RequestOpenClutch_Releasing :=FALSE
act36 : NoNeu_RequestOpenClutch_Setting :=FALSE
act37 : Engine_Request_SyncSpeed :=FALSE // Engine Flgas
act38 : Engine_Request_ZeroTorque :=FALSE // Engine Flgas
act39 : Clutch_Request_Open :=FALSE // Clutch Flags
act40 : Clutch_Request_Close :=FALSE // Clutch Flags
act41 : Gear_Request_Release :=FALSE // Gear Flags
act42 : Gear_Request_Set :=FALSE // Gear Flags

```

END

**Tick\_Tock**  $\triangleq$   
**extended**  
**STATUS**  
**ordinary**

**REFINES**

Tick\_Tock

**ANY**

tick

**WHERE**

```

grd1 : tick > 0
grd2 : RequestFromNeu = TRUE  $\wedge$  FromNeu_RequestOpenClutch= FALSE  $\wedge$  // Scenario1
      FromNeu_SyncSpeed = FALSE  $\Rightarrow$  time+tick  $\leq$  Sync_DL+RequestFromNeuT
grd3 : FromNeu_RequestOpenClutch = TRUE  $\wedge$  FromNeu_OpenClutch= FALSE  $\wedge$ 
      Error_FromNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+FromNeu_RequestOpenClutchT
grd4 : FromNeu_OpenClutch = TRUE  $\wedge$  FromNeu_SetGear_Clutch= FALSE  $\wedge$ 
      Error_FromNeu_SetGear_Clutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_OpenClutchT
grd5 : FromNeu_SyncSpeed = TRUE  $\wedge$  FromNeu_SetGear_NoClutch= FALSE  $\wedge$ 
      Error_FromNeu_SetGear_NoClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_SyncSpeedT
grd6 : FromNeu_SetGear_Clutch = TRUE  $\wedge$  FromNeu_CloseClutch= FALSE  $\wedge$  // Scenario
      Error_FromNeu_CloseClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+FromNeu_Set n1
      Gear_ClutchT
grd7 : RequestToNeu = TRUE  $\wedge$  ToNeu_RequestOpenClutch= FALSE  $\wedge$  // Scenario3
      ToNeu_ZeroTorque= FALSE  $\Rightarrow$  time+tick  $\leq$  Zero_DL+RequestToNeuT
grd8 : ToNeu_RequestOpenClutch = TRUE  $\wedge$  ToNeu_OpenClutch= FALSE  $\wedge$ 
      Error_ToNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+ToNeu_RequestOpenClutchT
grd9 : ToNeu_ZeroTorque = TRUE  $\wedge$  ToNeu_Release_NoClutch= FALSE  $\wedge$ 
      Error_ToNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_ZeroTorqueT
grd10 : ToNeu_OpenClutch = TRUE  $\wedge$  ToNeu_Release_Clutch= FALSE  $\wedge$ 
      Error_ToNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_OpenClutchT
grd11 : ToNeu_Release_Clutch = TRUE  $\wedge$  ToNeu_CloseClutch= FALSE  $\wedge$  // Scenario
      Error_ToNeu_CloseClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+ToNeu_Release 3
      _ClutchT
grd12 : RequestNoNeu = TRUE  $\wedge$  NoNeu_ZeroTorque = FALSE  $\wedge$  // Scenario2
      NoNeu_RequestOpenClutch_Releasing = FALSE
       $\Rightarrow$  time+tick  $\leq$  Zero_DL+RequestNoNeuT
grd13 : NoNeu_RequestOpenClutch_Releasing = TRUE  $\wedge$ 
      NoNeu_OpenClutch_Releasing = FALSE  $\wedge$ 
      Error_NoNeu_OpenClutch_Releasing = FALSE

```

## Gear Controller Case-study (Time Added Manually)

```

    ⇒ time+tick ≤ OpenClutch_DL + NoNeu_RequestOpenClutch_ReleasingT
grd14 : NoNeu_ZeroTorque = TRUE ∧ NoNeu_Release_NoClutch= FALSE ∧
    Error_NoNeu_Release_NoClutch= FALSE ⇒ time+tick ≤ Release_DL+NoNeu_ZeroTorqueT
    NoNeu_Release_NoClutch = TRUE ∧ NoNeu_SyncSpeed= FALSE ∧
grd15 : NoNeu_RequestOpenClutch_Setting = FALSE
    ⇒ time+tick ≤ Sync_DL+NoNeu_Release_NoClutchT
    NoNeu_RequestOpenClutch_Setting = TRUE ∧ NoNeu_OpenClutch_Setting = FALSE ∧
grd16 : Error_NoNeu_OpenClutch_Setting = FALSE
    ⇒ time+tick ≤ OpenClutch_DL+NoNeu_RequestOpenClutch_SettingT
grd17 : NoNeu_SyncSpeed = TRUE ∧ NoNeu_SetGear_NoClutch= FALSE ∧ // Senario2
    Error_NoNeu_SetGear_NoClutch= FALSE ⇒ time+tick ≤ SetGear_DL+NoNeu_Sy _1
ncSpeedT
grd18 : NoNeu_OpenClutch_Setting = TRUE ∧ NoNeu_SetGear_SettingClutch= FALSE ∧
    Error_NoNeu_SetGear_SettingClutch= FALSE ⇒ time+tick ≤ SetGear_DL+NoNeu_OpenClutch_Setti
ngT
grd19 : NoNeu_SetGear_SettingClutch = TRUE ∧ NoNeu_CloseClutch_Setting= FALSE ∧ // Senario
: Error_NoNeu_CloseClutch_Setting= FALSE ⇒ time+tick ≤ CloseClutch_DL+NoNeu_ 2_2
SetGear_SettingClutchT
grd20 : NoNeu_OpenClutch_Releasing = TRUE ∧ NoNeu_Release_Clutch= FALSE ∧
    Error_NoNeu_Release_Clutch= FALSE ⇒ time+tick ≤ Release_DL+NoNeu_OpenClutch_ReleasingT
grd21 : NoNeu_Release_Clutch = TRUE ∧ NoNeu_SetGear_ReleasingClutch= FALSE ∧
    Error_NoNeu_SetGear_ReleasingClutch= FALSE ⇒ time+tick ≤ SetGear_DL+NoNeu_Release_Clutch
T
grd22 : NoNeu_SetGear_ReleasingClutch = TRUE ∧ NoNeu_CloseClutch_Releasing= FALSE ∧ // Senari
: Error_NoNeu_CloseClutch_Releasing= FALSE ⇒ time+tick ≤ CloseClutch_DL+NoNe 02_3
u_SetGear_ReleasingClutchT
grd23 : RequestFromNeu = TRUE ∧ Engine_Request_SyncSpeed = FALSE // Engine Channel
    ⇒ time+tick ≤ RequestFromNeuT + Channel_DL
grd24 : NoNeu_Release_NoClutch = TRUE ∧ Engine_Request_SyncSpeed = FALSE // Engine Channel
    ⇒ time+tick ≤ NoNeu_Release_NoClutchT + Channel_DL
grd25 : RequestToNeu = TRUE ∧ Engine_Request_ZeroTorque = FALSE // EngineChannel
    ⇒ time+tick ≤ RequestToNeuT + Channel_DL
grd26 : RequestNoNeu = TRUE ∧ Engine_Request_ZeroTorque = FALSE // EngineChannel
    ⇒ time+tick ≤ RequestNoNeuT + Channel_DL
grd27 : Engine_ZeroTorque = TRUE ∧ ToNeu_ZeroTorque = FALSE ∧ NoNeu_ZeroTorque = // EngineChann
FALSE el
    ⇒ time+tick ≤ Engine_ZeroTorqueT + Channel_DL
grd28 : Engine_SyncSpeed = TRUE ∧ FromNeu_SyncSpeed = FALSE ∧ NoNeu_SyncSpeed = // EngineChann
FALSE el
    ⇒ time+tick ≤ Engine_SyncSpeedT + Channel_DL
grd29 : FromNeu_RequestOpenClutch = TRUE ∧ Clutch_Request_Open = FALSE // ClutchChannel
    ⇒ time+tick ≤ FromNeu_RequestOpenClutchT + Channel_DL
grd30 : ToNeu_RequestOpenClutch = TRUE ∧ Clutch_Request_Open = FALSE // ClutchChannel
    ⇒ time+tick ≤ ToNeu_RequestOpenClutchT + Channel_DL
grd31 : NoNeu_RequestOpenClutch_Releasing = TRUE ∧ Clutch_Request_Open = FALSE // ClutchChannel
    ⇒ time+tick ≤ NoNeu_RequestOpenClutch_ReleasingT + Channel_DL
grd32 : NoNeu_RequestOpenClutch_Setting = TRUE ∧ Clutch_Request_Open = FALSE // ClutchChannel
    ⇒ time+tick ≤ NoNeu_RequestOpenClutch_SettingT + Channel_DL
grd33 : FromNeu_SetGear_Clutch = TRUE ∧ Clutch_Request_Close = FALSE // ClutchChannel
    ⇒ time+tick ≤ FromNeu_SetGear_ClutchT + Channel_DL
grd34 : NoNeu_SetGear_ReleasingClutch = TRUE ∧ Clutch_Request_Close = FALSE // ClutchChannel
    ⇒ time+tick ≤ NoNeu_SetGear_ReleasingClutchT + Channel_DL
grd35 : NoNeu_SetGear_SettingClutch = TRUE ∧ Clutch_Request_Close = FALSE // ClutchChannel
    ⇒ time+tick ≤ FromNeu_SetGear_ClutchT + Channel_DL
grd36 : ToNeu_Release_Clutch = TRUE ∧ Clutch_Request_Close = FALSE // ClutchChannel
    ⇒ time+tick ≤ ToNeu_Release_ClutchT + Channel_DL
grd37 : Clutch_Open = TRUE ∧ FromNeu_OpenClutch = FALSE ∧ ToNeu_OpenClutch = FA // ClutchChann
LSE el
    ∧ NoNeu_OpenClutch_Releasing = FALSE ∧ NoNeu_OpenClutch_Setting = F
    FALSE

```



## Gear Controller Case-study (Time Added Manually)

```

    ⇒ time+tick ≤ Clutch_OpenT + Channel_DL
    Clutch_Close = TRUE ∧ FromNeu_CloseClutch = FALSE ∧ ToNeu_CloseClutch = FA // ClutchChann
    LSE el
grd38 :    ∧ NoNeu_CloseClutch_Releasing = FALSE ∧ NoNeu_CloseClutch_Setting = F
    ALSE
    ⇒ time+tick ≤ Clutch_CloseT + Channel_DL
grd39 :    ToNeu_ZeroTorque = TRUE ∧ Gear_Request_Release = FALSE // GearChannel
    ⇒ time+tick ≤ ToNeu_ZeroTorqueT + Channel_DL
grd40 :    ToNeu_OpenClutch = TRUE ∧ Gear_Request_Release = FALSE // GearChannel
    ⇒ time+tick ≤ ToNeu_OpenClutchT + Channel_DL
grd41 :    NoNeu_ZeroTorque = TRUE ∧ Gear_Request_Release = FALSE // GearChannel
    ⇒ time+tick ≤ NoNeu_ZeroTorqueT + Channel_DL
grd42 :    NoNeu_OpenClutch_Releasing = TRUE ∧ Gear_Request_Release = FALSE // GearChannel
    ⇒ time+tick ≤ NoNeu_OpenClutch_ReleasingT + Channel_DL
grd43 :    NoNeu_SyncSpeed = TRUE ∧ Gear_Request_Set = FALSE // GearChannel
    ⇒ time+tick ≤ NoNeu_SyncSpeedT + Channel_DL
grd44 :    NoNeu_OpenClutch_Setting = TRUE ∧ Gear_Request_Set = FALSE // GearChannel
    ⇒ time+tick ≤ NoNeu_OpenClutch_SettingT + Channel_DL
grd45 :    NoNeu_Release_Clutch = TRUE ∧ Gear_Request_Set = FALSE // GearChannel
    ⇒ time+tick ≤ NoNeu_Release_ClutchT + Channel_DL
grd46 :    FromNeu_SyncSpeed = TRUE ∧ Gear_Set = FALSE // GearChannel
    ⇒ time+tick ≤ FromNeu_SyncSpeedT + Channel_DL
grd47 :    ToNeu_OpenClutch = TRUE ∧ Gear_Set = FALSE // GearChannel
    ⇒ time+tick ≤ ToNeu_OpenClutchT + Channel_DL
    Gear_Release = TRUE ∧ ToNeu_Release_Clutch = FALSE ∧ ToNeu_Release_NoClutch // GearChann
grd48 : = FALSE el
    ∧ NoNeu_Release_NoClutch = FALSE ∧ NoNeu_Release_Clutch = FALSE
    ⇒ time+tick ≤ Gear_ReleaseT + Channel_DL
    Gear_Set = TRUE ∧ FromNeu_SetGear_Clutch = FALSE ∧ FromNeu_SetGear_NoClutch // GearChan
    = FALSE nel
grd49 :    ∧ NoNeu_SetGear_NoClutch = FALSE ∧ NoNeu_SetGear_ReleasingClutch = FA
    LSE
    ∧ NoNeu_SetGear_SettingClutch = FALSE
    ⇒ time+tick ≤ Gear_SetT + Channel_DL
grd50 :    Engine_Request_SyncSpeed = TRUE ∧ Engine_SyncSpeed = FALSE ∧ Engine_WaitForSyncCl // Engi
    utch = FALSE ne
    ⇒ time+tick ≤ Engine_Request_SyncSpeedT + Engine_Sync_DL
grd51 :    Engine_Request_ZeroTorque = TRUE ∧ Engine_ZeroTorque = FALSE ∧ Engine_WaitForZero // Engi
    Clutch = FALSE ne
    ⇒ time+tick ≤ Engine_Request_ZeroTorqueT + Engine_Zero_DL
grd52 :    Clutch_Request_Open = TRUE ∧ Clutch_Open = FALSE ∧ Error_Clutch_Open = FALSE // Clutch
    ⇒ time+tick ≤ Clutch_Request_OpenT + Clutch_Open_DL
grd53 :    Clutch_Request_Close = TRUE ∧ Clutch_Close = FALSE ∧ Error_Clutch_Close = FALSE // Clutch
    ⇒ time+tick ≤ Clutch_Request_CloseT + Clutch_Close_DL
grd54 :    Gear_Request_Release = TRUE ∧ Gear_Release = FALSE ∧ Error_Gear_Release = FALSE // Gear
    ⇒ time+tick ≤ Gear_Request_ReleaseT + Gear_Release_DL
grd55 :    Gear_Request_Set = TRUE ∧ Gear_Set = FALSE ∧ Error_Gear_Set = FALSE // Gear
    ⇒ time+tick ≤ Gear_Request_SetT + Gear_Set_DL

```

**THEN**

*act1* : time :=time + tick

**END**

**END**

## Machine m10

### MACHINE

m1  
0

```
// Deadline(RequestFromNeu, FromNeu_SyncSpeed V FromNeu_RequestOpenClutch, Sync_DL)
// Expiry(RequestFromNeu, FromNeu_SyncSpeed, Sync_EX)
// Delay(RequestFromNeu, FromNeu_RequestOpenClutch, OpenClutch_Sync_DE)
// Deadline(FromNeu_RequestOpenClutch, FromNeu_RequestOpenClutch V FromNeu_OpenClutch V Error_
FromNeu_OpenClutch, OpenClutch_DL)
// Deadline(FromNeu_SyncSpeed, FromNeu_SetGear_NoClutch V Error_FromNeu_SetGear_NoClutch, SetGe
ar_DL)
// Deadline(FromNeu_OpenClutch, FromNeu_SetGear_Clutch V Error_FromNeu_SetGear_Clutch, SetGear_
DL)
// Deadline(FromNeu_SetGear_Clutch, FromNeu_CloseClutch V Error_FromNeu_CloseClutch, CloseClutch_
DL)
// Deadline(RequestNoNeu, NoNeu_ZeroTorque V NoNeu_RequestOpenClutch_Releasing, Zero_DL)
// Expiry(RequestNoNeu, NoNeu_ZeroTorque, Zero_EX)
// Delay(RequestNoNeu, NoNeu_RequestOpenClutch_Releasing, OpenClutch_Zero_DE)
// Deadline(NoNeu_RequestOpenClutch_Releasing, NoNeu_OpenClutch_Releasing V Error_NoNeu_OpenClut
ch_Releasing, OpenClutch_DL)
// Deadline(NoNeu_ZeroTorque, NoNeu_Release_NoClutch V Error_NoNeu_Release_NoClutch, Release_DL)
// Deadline(NoNeu_OpenClutch_Releasing, NoNeu_Release_Clutch V Error_NoNeu_Release_Clutch, Release
_DL)
// Deadline(NoNeu_Release_NoClutch, NoNeu_SyncSpeed V NoNeu_RequestOpenClutch_Setting, Sync_DL)
// Expiry(NoNeu_Release_NoClutch, NoNeu_SyncSpeed, Sync_EX)
// Delay(NoNeu_Release_NoClutch, NoNeu_RequestOpenClutch_Setting, OpenClutch_Sync_DE)
// Deadline(NoNeu_RequestOpenClutch_Setting, NoNeu_OpenClutch_Setting V Error_NoNeu_OpenClutch_Se
tting, OpenClutch_DL)
// Deadline(NoNeu_SyncSpeed, NoNeu_SetGear_NoClutch V Error_NoNeu_SetGear_NoClutch, SetGear_DL)
// Deadline(NoNeu_OpenClutch_Setting, NoNeu_SetGear_SettingClutch V Error_NoNeu_SetGear_SettingClut
ch, SetGear_DL)
// Deadline(NoNeu_SetGear_SettingClutch, NoNeu_CloseClutch_Setting V Error_NoNeu_CloseClutch_Setting
, CloseClutch_DL)
// Deadline(NoNeu_Release_Clutch, NoNeu_SetGear_ReleasingClutch V Error_NoNeu_SetGear_ReleasingCl
utch, SetGear_DL)
// Deadline(NoNeu_SetGear_ReleasingClutch, NoNeu_CloseClutch_Releasing V Error_NoNeu_CloseClutch_
Releasing, CloseClutch_DL)
// Deadline(RequestToNeu, ToNeu_ZeroTorque V ToNeu_RequestOpenClutch, Zero_DL)
// Expiry(RequestToNeu, ToNeu_ZeroTorque, Zero_EX)
// Delay(RequestToNeu, ToNeu_RequestOpenClutch, OpenClutch_Zero_DE)
// Deadline(ToNeu_RequestOpenClutch, ToNeu_OpenClutch V Error_ToNeu_OpenClutch, OpenClutch_DL)
// Deadline(ToNeu_ZeroTorque, ToNeu_Release_NoClutch V Error_ToNeu_Release_NoClutch, Release_DL)
// Deadline(ToNeu_OpenClutch, ToNeu_Release_Clutch V Error_ToNeu_Release_Clutch, Release_DL)
// Deadline(ToNeu_Release_Clutch, ToNeu_CloseClutch V Error_ToNeu_CloseClutch, CloseClutch_DL)
//
// Deadline(Channel_RequestFromNeu, Channel_Request_SyncSpeed, Channel_DL)
// Deadline(Channel_NoNeu_Release_NoClutch, Channel_Request_SyncSpeed, Channel_DL)
// Deadline(Channel_RequestToNeu, Channel_Request_ZeroTorque, Channel_DL)
// Deadline(Channel_RequestNoNeu, Channel_Request_ZeroTorque, Channel_DL)
// Deadline(Channel_ZeroTorque, Channel_ToNeu_ZeroTorque, Channel_DL)
// Deadline(Channel_SyncSpeed, Channel_FromNeu_SyncSpeed, Channel_DL)
// Deadline(Channel_FromNeu_RequestOpenClutch, Channel_Clutch_Request_Open, Channel_DL )
// Deadline(Channel_ToNeu_RequestOpenClutch, Channel_Request_Open, Channel_DL )
// Deadline(Channel_NoNeu_RequestOpenClutch_Releasing, Channel_Request_Open, Channel_DL )
// Deadline(Channel_NoNeu_RequestOpenClutch_Setting, Channel_Request_Open, Channel_DL )
// Deadline(Channel_FromNeu_SetGear_Clutch, Channel_Request_Close, Channel_DL )
// Deadline(Channel_NoNeu_SetGear_ReleasingClutch, Channel_Request_Close, Channel_DL )
// Deadline(Channel_NoNeu_SetGear_SettingClutch, Channel_Request_Close, Channel_DL )
// Deadline(Channel_ToNeu_Release_Clutch, Channel_Request_Close, Channel_DL )
// Deadline(Channel_Open, Channel_FromNeu_OpenClutch V Channel_ToNeu_OpenClutch V
Channel_NoNeu_OpenClutch_Releasing V Channel_NoNeu_OpenClutch_Setting, Channel_DL)
```

## Gear Controller Case-study (Time Added Manually)

```
// Deadline(Channel_Close, Channel_FromNeu_CloseClutch  $\vee$  Channel_ToNeu_CloseClutch  $\vee$ 
// Channel_NoNeu_CloseClutch_Releasing  $\vee$  Channel_NoNeu_CloseClutch_Setting, Channel_DL )
// Deadline(Channel_ToNeu_ZeroTorque, Channel_Request_Release, Channel_DL )
// Deadline(Channel_ToNeu_OpenClutch, Channel_Request_Release, Channel_DL )
// Deadline(Channel_NoNeu_ZeroTorque, Channel_Request_Release, Channel_DL )
// Deadline(Channel_NoNeu_OpenClutch_Releasing, Channel_Request_Release, Channel_DL )
// Deadline(Channel_NoNeu_SyncSpeed, Channel_Request_Set, Channel_DL )
// Deadline(Channel_NoNeu_OpenClutch_Setting, Channel_Request_Set, Channel_DL )
// Deadline(Channel_NoNeu_Release_Clutch, Channel_Request_Set, Channel_DL )
// Deadline(Channel_FromNeu_SyncSpeed, Channel_Set, Channel_DL )
// Deadline(Channel_ToNeu_OpenClutch, Channel_Set, Channel_DL )
// Deadline(Channel_Release, Channel_ToNeu_Release_Clutch  $\vee$  Channel_ToNeu_Release_NoClutch  $\vee$ 
// Channel_NoNeu_Release_NoClutch  $\vee$  Channel_NoNeu_Release_Clutch, Channel_DL )
// Deadline(Channel_Set, Channel_FromNeu_SetGear_Clutch  $\vee$  Channel_FromNeu_SetGear_NoClutch  $\vee$ 
// Channel_NoNeu_SetGear_NoClutch  $\vee$  Channel_NoNeu_SetGear_ReleasingClutch
//  $\vee$  Channel_NoNeu_SetGear_SettingClutch, Channel_DL )
//
// Deadline(Engine_Request_SyncSpeed, Engine_SyncSpeed  $\vee$  Engine_WaitForSyncClutch, Engine_Sync_DL)
// Deadline(Engine_Request_ZeroTorque, Engine_ZeroTorque  $\vee$  Engine_WaitForZeroClutch, Engine_Zero_D
L)
// Deadline(Clutch_Request_Open, Clutch_Open  $\vee$  Error_Clutch_Open, Clutch_Open_DL)
// Deadline(Clutch_Request_Close, Clutch_Close  $\vee$  Error_Clutch_Close, Clutch_Close_DL)
// Deadline(Gear_Request_Release, Gear_Release  $\vee$  Error_Gear_Release, Gear_Release_DL)
// Deadline(Gear_Request_Set, Gear_Set  $\vee$  Error_Gear_Set, Gear_Set_DL)
//
```

### REFINES

m9

### SEES

c6

### VARIABLES

```
time // Time
isNeu // Gear Status
RequestFromNeu // Flags
FromNeu_SyncSpeed // Senario1
FromNeu_RequestOpenClutch // Senario1 Flag
FromNeu_OpenClutch // Flage
FromNeu_SetGear_NoClutch // Flage
FromNeu_SetGear_Clutch // Flage
FromNeu_CloseClutch // Flage
Error_FromNeu_OpenClutch // Flage
Error_FromNeu_SetGear_NoClutch // Flage
Error_FromNeu_SetGear_Clutch // Flage
Error_FromNeu_CloseClutch // Senario1
RequestFromNeuT // Time
FromNeu_OpenClutchT // TIME
FromNeu_SyncSpeedT // TIME
FromNeu_SetGear_ClutchT // TIME
RequestToNeu // Flags
ToNeu_ZeroTorque // Senario3 Flage
ToNeu_RequestOpenClutch // Senario3 Flag
ToNeu_OpenClutch // Senario3 Flage
Error_ToNeu_OpenClutch // Senario3 Flage
ToNeu_Release_NoClutch // Senario3 Flage
Error_ToNeu_Release_NoClutch // Senario3 Flage
ToNeu_Release_Clutch // Senario3 Flage
Error_ToNeu_Release_Clutch // Senario3 Flage
ToNeu_CloseClutch // Senario3 Flage
Error_ToNeu_CloseClutch // Senario3 Flage
RequestToNeuT // Time
ToNeu_ZeroTorqueT // TIME
ToNeu_OpenClutchT // TIME
ToNeu_Release_ClutchT // TIME
RequestNoNeu // Flags
NoNeu_ZeroTorque // Senario2 Flage
NoNeu_Release_NoClutch // Senario2 Flage
NoNeu_RequestOpenClutch_Releasing // Senario2 Flag
```

## Gear Controller Case-study (Time Added Manually)

```
NoNeu_OpenClutch_Releasing // Senario2 Flage
NoNeu_Release_Clutch // Senario2 Flage
NoNeu_SyncSpeed // Senario2 Flage
NoNeu_RequestOpenClutch_Setting // Senario2 Flage
NoNeu_OpenClutch_Setting // Senario2 Flage
NoNeu_SetGear_NoClutch // Senario2 Flage
NoNeu_SetGear_ReleasingClutch // Senario2 Flage
NoNeu_SetGear_SettingClutch // Senario2 Flage
NoNeu_CloseClutch_Releasing // Senario2 Flage
NoNeu_CloseClutch_Setting // Senario2 Flage
Error_NoNeu_OpenClutch_Releasing // Senario2 Flage
Error_NoNeu_Release_Clutch // Senario2 Flage
Error_NoNeu_Release_NoClutch // Senario2 Flage
Error_NoNeu_OpenClutch_Setting // Senario2 Flage
Error_NoNeu_SetGear_NoClutch // Senario2 Flage
Error_NoNeu_SetGear_ReleasingClutch // Senario2 Flage
Error_NoNeu_SetGear_SettingClutch // Senario2 Flage
Error_NoNeu_CloseClutch_Releasing // Senario2 Flage
Error_NoNeu_CloseClutch_Setting // Senario2 Flage
RequestNoNeuT // Time
NoNeu_ZeroTorqueT // Senario2 Time
NoNeu_Release_NoClutchT // Senario2 Time
NoNeu_OpenClutch_ReleasingT // Senario2 Time
NoNeu_Release_ClutchT // Senario2 Time
NoNeu_SetGear_ReleasingClutchT // Senario2 Time
NoNeu_SetGear_SettingClutchT // Senario2 Time
NoNeu_SyncSpeedT // Senario2 Time
NoNeu_OpenClutch_SettingT // Senario2 Time
FromNeu_RequestOpenClutchT // Senario1 Time
ToNeu_RequestOpenClutchT // Senario3 Time
NoNeu_RequestOpenClutch_ReleasingT // Senario2 Time
NoNeu_RequestOpenClutch_SettingT // Senario2 Time
Engine_SyncSpeed // Engine Flgas
Engine_WaitForSyncClutch // Engine Flgas
Engine_ZeroTorque // Engine Flgas
Engine_WaitForZeroClutch // Engine Flgas
Engine_Request_SyncSpeed // Engine Flgas
Engine_Request_ZeroTorque // Engine Flgas
Engine_Request_SyncSpeedT // Engine Time
Engine_Request_ZeroTorqueT // Engine Time
Engine_SyncSpeedT // Engine Flgas
Engine_ZeroTorqueT // Engine Flgas
Engine_time // Engine_time
Clutch_Request_Open // Clutch Flgas
Clutch_Request_Close // Clutch Flgas
Clutch_Open // Clutch Flgas
Error_Clutch_Open // Clutch Flgas
Clutch_Close // Clutch Flgas
Error_Clutch_Close // Clutch Flgas
Clutch_Request_OpenT // Clutch Time
Clutch_Request_CloseT // Clutch Time
Clutch_OpenT // Clutch Flgas
Clutch_CloseT // Clutch Flgas
Clutch_time // Clutch_time
Gear_Request_Release // Gear Flgas
Gear_Request_Set // Gear Flgas
Gear_Release // Gear Flgas
Error_Gear_Release // Gear Flgas
Gear_Set // Gear Flgas
Error_Gear_Set // Gear Flgas
Gear_Request_ReleaseT // Gear Time
Gear_Request_SetT // Gear Time
Gear_ReleaseT // Gear Flgas
Gear_SetT // Gear Flgas
Gear_time // Gear_time
Channel_RequestFromNeu // ChannelFlgas
Channel_FromNeu_SyncSpeed // ChannelSenario1
Channel_FromNeu_RequestOpenClutch // Channel Senario1 Flage
Channel_FromNeu_OpenClutch // ChannelFlage
Channel_FromNeu_SetGear_Clutch // ChannelFlage
Channel_FromNeu_SetGear_NoClutch // ChannelFlage
```

## Gear Controller Case-study (Time Added Manually)

```
Channel_FromNeu_CloseClutch      // ChannelFlage
Channel_RequestFromNeuT          // Channel_Time
Channel_FromNeu_OpenClutchT      // ChannelTIME
Channel_FromNeu_SyncSpeedT       // ChannelTIME
Channel_FromNeu_SetGear_ClutchT  // ChannelTIME
Channel_FromNeu_RequestOpenClutchT // Channel Senario1 Time
Channel_RequestToNeu            // ChannelFlags
Channel_ToNeu_ZeroTorque        // ChannelSenario3 Flage
Channel_ToNeu_RequestOpenClutch // ChannelSenario3 Flage
Channel_ToNeu_OpenClutch       // ChannelSenario3 Flage
Channel_ToNeu_Release_Clutch   // Channel Senario3 Flage
Channel_ToNeu_Release_NoClutch // Channel Senario3 Flage
Channel_ToNeu_CloseClutch      // Channel Senario3 Flage
Channel_RequestToNeuT          // Channel_Time
Channel_ToNeu_ZeroTorqueT      // ChannelTIME
Channel_ToNeu_OpenClutchT      // ChannelTIME
Channel_ToNeu_Release_ClutchT  // ChannelTIME
Channel_ToNeu_RequestOpenClutchT // Channel Senario3 Time
Channel_RequestNoNeu          // ChannelFlags
Channel_NoNeu_ZeroTorque      // ChannelSenario2 Flage
Channel_NoNeu_Release_NoClutch // ChannelSenario2 Flage
Channel_NoNeu_RequestOpenClutch_Releasing // Channel Senario2 Flage
Channel_NoNeu_OpenClutch_Releasing // ChannelSenario2 Flage
Channel_NoNeu_Release_Clutch  // ChannelSenario2 Flage
Channel_NoNeu_SyncSpeed       // ChannelSenario2 Flage
Channel_NoNeu_RequestOpenClutch_Setting // Channel Senario2 Flage
Channel_NoNeu_OpenClutch_Setting // ChannelSenario2 Flage
Channel_NoNeu_SetGear_ReleasingClutch // ChannelSenario2 Flage
Channel_NoNeu_SetGear_SettingClutch // ChannelSenario2 Flage
Channel_NoNeu_SetGear_NoClutch // ChannelSenario2 Flage
Channel_NoNeu_CloseClutch_Releasing // ChannelSenario2 Flage
Channel_NoNeu_CloseClutch_Setting // ChannelSenario2 Flage
Channel_RequestNoNeuT        // ChannelTime
Channel_NoNeu_ZeroTorqueT    // ChannelSenario2 Time
Channel_NoNeu_Release_NoClutchT // ChannelSenario2 Time
Channel_NoNeu_OpenClutch_ReleasingT // ChannelSenario2 Time
Channel_NoNeu_Release_ClutchT // ChannelSenario2 Time
Channel_NoNeu_SetGear_ReleasingClutchT // Channel Senario2 Time
Channel_NoNeu_SetGear_SettingClutchT // ChannelSenario2 Time
Channel_NoNeu_SyncSpeedT     // ChannelSenario2 Time
Channel_NoNeu_OpenClutch_SettingT // ChannelSenario2 Time
Channel_NoNeu_RequestOpenClutch_ReleasingT // Channel Senario2 Time
Channel_NoNeu_RequestOpenClutch_SettingT // Channel Senario2 Time
Channel_Request_SyncSpeed    // Channel Engine Flgas
Channel_Request_ZeroTorque   // Channel Engine Flgas
Channel_SyncSpeed           // Channel Engine Flgas
Channel_ZeroTorque          // Channel Engine Flgas
Channel_SyncSpeedT         // Channel Engine Flgas
Channel_ZeroTorqueT        // Channel Engine Flgas
Channel_Request_SyncSpeedT // Channel Engine Flgas
Channel_Request_ZeroTorqueT // Channel Engine Flgas
Channel_Request_Open       // Channel Clutch Flgas
Channel_Request_Close     // Channel Clutch Flgas
Channel_Open              // Channel Clutch Flgas
Channel_Close            // Channel Clutch Flgas
Channel_OpenT            // Channel Clutch Flgas
Channel_CloseT          // Channel Clutch Flgas
Channel_Request_OpenT    // Channel Clutch Flgas
Channel_Request_CloseT  // Channel Clutch Flgas
Channel_Request_Release  // Channel Gear Flgas
Channel_Request_Set      // Channel Gear Flgas
Channel_Release         // Channel Gear Flgas
Channel_Set             // Channel Gear Flgas
Channel_ReleaseT       // Channel Gear Flgas
Channel_SetT          // Channel Gear Flgas
Channel_Request_ReleaseT // Channel Gear Flgas
Channel_Request_SetT    // Channel Gear Flgas
Channel_time           // CHnanel time
```

### INVARIANTS

```
inv1 : {Channel_RequestFromNeu, Channel_FromNeu_SyncSpeed ,
```

## Gear Controller Case-study (Time Added Manually)

Channel\_FromNeu\_RequestOpenClutch ,Channel\_FromNeu\_OpenClutch ,  
Channel\_FromNeu\_SetGear\_Clutch ,Channel\_FromNeu\_SetGear\_NoClutch ,  
Channel\_FromNeu\_CloseClutch , Channel\_RequestToNeu ,  
Channel\_ToNeu\_ZeroTorque ,Channel\_ToNeu\_RequestOpenClutch,  
Channel\_ToNeu\_OpenClutch ,Channel\_ToNeu\_Release\_Clutch,  
Channel\_ToNeu\_Release\_NoClutch, Channel\_ToNeu\_CloseClutch,  
Channel\_RequestNoNeu,Channel\_NoNeu\_ZeroTorque,  
Channel\_NoNeu\_Release\_NoClutch ,Channel\_NoNeu\_RequestOpenClutch\_Releasing,  
Channel\_NoNeu\_OpenClutch\_Releasing,Channel\_NoNeu\_Release\_Clutch,  
Channel\_NoNeu\_SyncSpeed,Channel\_NoNeu\_RequestOpenClutch\_Setting ,  
Channel\_NoNeu\_OpenClutch\_Setting,Channel\_NoNeu\_SetGear\_ReleasingClutch,  
Channel\_NoNeu\_SetGear\_SettingClutch,Channel\_NoNeu\_SetGear\_NoClutch,  
Channel\_NoNeu\_CloseClutch\_Releasing,Channel\_NoNeu\_CloseClutch\_Setting,  
Channel\_Request\_SyncSpeed,Channel\_Request\_ZeroTorque,  
Channel\_SyncSpeed,Channel\_ZeroTorque,Channel\_Request\_Open,  
Channel\_Request\_Close,Channel\_Open, Channel\_Close,  
Channel\_Request\_Release,Channel\_Request\_Set,Channel\_Release,  
Channel\_Set}  $\in \mathbb{P}(\text{BOOL})$

{Channel\_RequestFromNeuT ,  
Channel\_FromNeu\_OpenClutchT ,Channel\_FromNeu\_SyncSpeedT ,  
Channel\_FromNeu\_SetGear\_ClutchT ,Channel\_FromNeu\_RequestOpenClutchT,  
Channel\_RequestToNeuT, Channel\_ToNeu\_ZeroTorqueT ,  
Channel\_ToNeu\_OpenClutchT, Channel\_ToNeu\_Release\_ClutchT ,  
Channel\_ToNeu\_RequestOpenClutchT, Channel\_RequestNoNeuT,  
Channel\_NoNeu\_Release\_NoClutchT,Channel\_NoNeu\_OpenClutch\_ReleasingT,  
Channel\_NoNeu\_Release\_ClutchT,Channel\_NoNeu\_SetGear\_ReleasingClutchT,  
inv2 : Channel\_NoNeu\_SetGear\_SettingClutchT,Channel\_NoNeu\_SyncSpeedT,  
Channel\_NoNeu\_OpenClutch\_SettingT,Channel\_NoNeu\_RequestOpenClutch\_ReleasingT ,  
Channel\_NoNeu\_RequestOpenClutch\_SettingT,Channel\_NoNeu\_ZeroTorqueT,  
Channel\_SyncSpeedT, Channel\_ZeroTorqueT,  
Channel\_Request\_SyncSpeedT, Channel\_Request\_ZeroTorqueT,  
Channel\_OpenT,Channel\_CloseT, Channel\_Request\_OpenT,  
Channel\_Request\_CloseT, Channel\_ReleaseT,Channel\_SetT,  
Channel\_Request\_ReleaseT, Channel\_Request\_SetT,  
Channel\_time, Engine\_time, Gear\_time, Clutch\_time}  $\subseteq \mathbb{N}$

inv3 : Channel\_RequestFromNeu = RequestFromNeu  
inv4 : Channel\_FromNeu\_SyncSpeed = FromNeu\_SyncSpeed  
inv5 : Channel\_FromNeu\_RequestOpenClutch = FromNeu\_RequestOpenClutch  
inv6 : Channel\_FromNeu\_OpenClutch = FromNeu\_OpenClutch  
inv7 : Channel\_FromNeu\_SetGear\_Clutch = FromNeu\_SetGear\_Clutch  
inv8 : Channel\_FromNeu\_SetGear\_NoClutch = FromNeu\_SetGear\_NoClutch  
inv9 : Channel\_FromNeu\_CloseClutch = FromNeu\_CloseClutch  
inv10 : Channel\_RequestFromNeuT = RequestFromNeuT  
inv11 : Channel\_FromNeu\_OpenClutchT = FromNeu\_OpenClutchT  
inv12 : Channel\_FromNeu\_SyncSpeedT = FromNeu\_SyncSpeedT  
inv13 : Channel\_FromNeu\_SetGear\_ClutchT = FromNeu\_SetGear\_ClutchT  
inv14 : Channel\_FromNeu\_RequestOpenClutchT = FromNeu\_RequestOpenClutchT  
inv15 : Channel\_RequestToNeu = RequestToNeu  
inv16 : Channel\_ToNeu\_ZeroTorque = ToNeu\_ZeroTorque  
inv17 : Channel\_ToNeu\_RequestOpenClutch = ToNeu\_RequestOpenClutch  
inv18 : Channel\_ToNeu\_OpenClutch = ToNeu\_OpenClutch  
inv19 : Channel\_ToNeu\_Release\_Clutch = ToNeu\_Release\_Clutch  
inv20 : Channel\_ToNeu\_Release\_NoClutch = ToNeu\_Release\_NoClutch  
inv21 : Channel\_ToNeu\_CloseClutch = ToNeu\_CloseClutch  
inv22 : Channel\_RequestToNeuT = RequestToNeuT  
inv23 : Channel\_ToNeu\_ZeroTorqueT = ToNeu\_ZeroTorqueT  
inv24 : Channel\_ToNeu\_OpenClutchT = ToNeu\_OpenClutchT  
inv25 : Channel\_ToNeu\_Release\_ClutchT = ToNeu\_Release\_ClutchT  
inv26 : Channel\_ToNeu\_RequestOpenClutchT = ToNeu\_RequestOpenClutchT  
inv27 : Channel\_RequestNoNeu = RequestNoNeu  
inv28 : Channel\_NoNeu\_ZeroTorque = NoNeu\_ZeroTorque  
inv29 : Channel\_NoNeu\_Release\_NoClutch = NoNeu\_Release\_NoClutch  
inv30 : Channel\_NoNeu\_RequestOpenClutch\_Releasing = NoNeu\_RequestOpenClutch\_Releasing  
inv31 : Channel\_NoNeu\_OpenClutch\_Releasing = NoNeu\_OpenClutch\_Releasing  
inv32 : Channel\_NoNeu\_Release\_Clutch = NoNeu\_Release\_Clutch



## Gear Controller Case-study (Time Added Manually)

```
inv33 : Channel_NoNeu_SyncSpeed = NoNeu_SyncSpeed
inv34 : Channel_NoNeu_RequestOpenClutch_Setting = NoNeu_RequestOpenClutch_Setting
inv35 : Channel_NoNeu_OpenClutch_Setting = NoNeu_OpenClutch_Setting
inv36 : Channel_NoNeu_SetGear_ReleasingClutch = NoNeu_SetGear_ReleasingClutch
inv37 : Channel_NoNeu_SetGear_SettingClutch = NoNeu_SetGear_SettingClutch
inv38 : Channel_NoNeu_SetGear_NoClutch = NoNeu_SetGear_NoClutch
inv39 : Channel_NoNeu_CloseClutch_Releasing = NoNeu_CloseClutch_Releasing
inv40 : Channel_NoNeu_CloseClutch_Setting = NoNeu_CloseClutch_Setting
inv41 : Channel_RequestNoNeuT = RequestNoNeuT
inv42 : Channel_NoNeu_ZeroTorqueT = NoNeu_ZeroTorqueT
inv43 : Channel_NoNeu_Release_NoClutchT = NoNeu_Release_NoClutchT
inv44 : Channel_NoNeu_OpenClutch_ReleasingT = NoNeu_OpenClutch_ReleasingT
inv45 : Channel_NoNeu_Release_ClutchT = NoNeu_Release_ClutchT
inv46 : Channel_NoNeu_SetGear_ReleasingClutchT = NoNeu_SetGear_ReleasingClutchT
inv47 : Channel_NoNeu_SetGear_SettingClutchT = NoNeu_SetGear_SettingClutchT
inv48 : Channel_NoNeu_SyncSpeedT = NoNeu_SyncSpeedT
inv49 : Channel_NoNeu_OpenClutch_SettingT = NoNeu_OpenClutch_SettingT
inv50 : Channel_NoNeu_RequestOpenClutch_ReleasingT = NoNeu_RequestOpenClutch_ReleasingT
inv51 : Channel_NoNeu_RequestOpenClutch_SettingT = NoNeu_RequestOpenClutch_SettingT
inv52 : Channel_Request_SyncSpeed = Engine_Request_SyncSpeed
inv53 : Channel_Request_ZeroTorque = Engine_Request_ZeroTorque
inv54 : Channel_SyncSpeed = Engine_SyncSpeed
inv55 : Channel_ZeroTorque = Engine_ZeroTorque
inv56 : Channel_SyncSpeedT = Engine_SyncSpeedT
inv57 : Channel_ZeroTorqueT = Engine_ZeroTorqueT
inv58 : Channel_Request_SyncSpeedT = Engine_Request_SyncSpeedT
inv59 : Channel_Request_ZeroTorqueT = Engine_Request_ZeroTorqueT
inv60 : Channel_Request_Open = Clutch_Request_Open
inv61 : Channel_Request_Close = Clutch_Request_Close
inv62 : Channel_Open = Clutch_Open
inv63 : Channel_Close = Clutch_Close
inv64 : Channel_OpenT = Clutch_OpenT
inv65 : Channel_CloseT = Clutch_CloseT
inv66 : Channel_Request_OpenT = Clutch_Request_OpenT
inv67 : Channel_Request_CloseT = Clutch_Request_CloseT
inv68 : Channel_Request_Release = Gear_Request_Release
inv69 : Channel_Request_Set = Gear_Request_Set
inv70 : Channel_Release = Gear_Release
inv71 : Channel_Set = Gear_Set
inv72 : Channel_ReleaseT = Gear_ReleaseT
inv73 : Channel_SetT = Gear_SetT
inv74 : Channel_Request_ReleaseT = Gear_Request_ReleaseT
inv75 : Channel_Request_SetT = Gear_Request_SetT
inv76 : Channel_time = time
inv77 : Engine_time = time
inv78 : Clutch_time = time
inv79 : Gear_time = time
```

### EVENTS

#### INITIALISATION $\triangle$

extended

STATUS

ordinary

#### BEGIN

```
act1 : time := 0
act2 : isNeu := TRUE
act3 : RequestNoNeu := FALSE
act4 : RequestToNeu := FALSE
act5 : RequestFromNeu := FALSE
act6 : RequestFromNeuT := 0
act7 : RequestNoNeuT := 0
act8 : RequestToNeuT := 0
act9 : FromNeu_SyncSpeed := FALSE
act10 : FromNeu_OpenClutch := FALSE
act11 : FromNeu_SetGear_NoClutch := FALSE
act12 : FromNeu_SetGear_Clutch := FALSE
act13 : FromNeu_CloseClutch := FALSE
act14 : Error_FromNeu_OpenClutch := FALSE
act15 : Error_FromNeu_SetGear_NoClutch := FALSE
act16 : Error_FromNeu_SetGear_Clutch := FALSE
act17 : Error_FromNeu_CloseClutch := FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
act18 : FromNeu_OpenClutchT :=0
act19 : FromNeu_SyncSpeedT :=0
act20 : FromNeu_SetGear_ClutchT :=0
act21 : ToNeu_ZeroTorque:= FALSE
act22 : ToNeu_OpenClutch :=FALSE
act23 : Error_ToNeu_OpenClutch :=FALSE
act24 : ToNeu_Release_NoClutch:= FALSE
act25 : Error_ToNeu_Release_NoClutch:= FALSE
act26 : ToNeu_Release_Clutch:= FALSE
act27 : Error_ToNeu_Release_Clutch :=FALSE
act28 : ToNeu_CloseClutch:= FALSE
act29 : Error_ToNeu_CloseClutch:= FALSE
act30 : ToNeu_ZeroTorqueT :=0
act31 : ToNeu_OpenClutchT :=0
act32 : ToNeu_Release_ClutchT:=0
act33 : NoNeu_ZeroTorque:= FALSE
act34 : NoNeu_OpenClutch_Releasing:= FALSE
act35 : NoNeu_Release_NoClutch:= FALSE
act36 : NoNeu_Release_Clutch:= FALSE
act37 : NoNeu_SyncSpeed :=FALSE
act38 : NoNeu_OpenClutch_Setting :=FALSE
act39 : NoNeu_SetGear_NoClutch:= FALSE
act40 : NoNeu_SetGear_ReleasingClutch:= FALSE
act41 : NoNeu_SetGear_SettingClutch:= FALSE
act42 : NoNeu_CloseClutch_Releasing:= FALSE
act43 : NoNeu_CloseClutch_Setting:= FALSE
act44 : Error_NoNeu_OpenClutch_Releasing:= FALSE
act45 : Error_NoNeu_Release_NoClutch:= FALSE
act46 : Error_NoNeu_Release_Clutch:= FALSE
act47 : Error_NoNeu_OpenClutch_Setting :=FALSE
act48 : Error_NoNeu_SetGear_NoClutch:= FALSE
act49 : Error_NoNeu_SetGear_ReleasingClutch:= FALSE
act50 : Error_NoNeu_SetGear_SettingClutch:= FALSE
act51 : Error_NoNeu_CloseClutch_Releasing :=FALSE
act52 : Error_NoNeu_CloseClutch_Setting :=FALSE
act53 : NoNeu_ZeroTorqueT:= 0
act54 : NoNeu_Release_NoClutchT :=0
act55 : NoNeu_OpenClutch_ReleasingT:=0
act56 : NoNeu_Release_ClutchT :=0
act57 : NoNeu_SyncSpeedT :=0
act58 : NoNeu_OpenClutch_SettingT:= 0
act59 : NoNeu_SetGear_ReleasingClutchT :=0
act60 : NoNeu_SetGear_SettingClutchT :=0
act61 : Engine_SyncSpeed :=FALSE
act62 : Engine_WaitForSyncClutch :=FALSE
act63 : Engine_ZeroTorque :=FALSE
act64 : Engine_WaitForZeroClutch :=FALSE
act65 : Clutch_Open :=FALSE
act66 : Error_Clutch_Open :=FALSE
act67 : Clutch_Close :=FALSE
act68 : Error_Clutch_Close :=FALSE
act69 : Gear_Release :=FALSE
act70 : Error_Gear_Release :=FALSE
act71 : Gear_Set :=FALSE
act72 : Error_Gear_Set :=FALSE
act73 : FromNeu_RequestOpenClutch :=FALSE
act74 : ToNeu_RequestOpenClutch :=FALSE
act75 : NoNeu_RequestOpenClutch_Releasing :=FALSE
act76 : NoNeu_RequestOpenClutch_Setting :=FALSE
act77 : FromNeu_RequestOpenClutchT :=0
act78 : ToNeu_RequestOpenClutchT :=0
act79 : NoNeu_RequestOpenClutch_ReleasingT :=0
act80 : NoNeu_RequestOpenClutch_SettingT :=0
act81 : Engine_Request_SyncSpeed :=FALSE // Engine Flgas
act82 : Engine_Request_ZeroTorque :=FALSE // Engine Flgas
act83 : Clutch_Request_Open :=FALSE // Clutch Flags
act84 : Clutch_Request_Close :=FALSE // Clutch Flags
act85 : Gear_Request_Release :=FALSE // Gear Flags
act86 : Gear_Request_Set :=FALSE // Gear Flags
```



## Gear Controller Case-study (Time Added Manually)

```
act87 : Engine_Request_SyncSpeedT :=0      // Engine Time
act88 : Engine_Request_ZeroTorqueT :=0     // Engine Time
act89 : Clutch_Request_OpenT :=0         // Clutch Time
act90 : Clutch_Request_CloseT :=0        // Clutch Time
act91 : Gear_Request_ReleaseT :=0        // Gear Time
act92 : Gear_Request_SetT :=0            // Gear Time
act93 : Engine_SyncSpeedT :=0            // Engine Flags
act94 : Engine_ZeroTorqueT :=0           // Engine Flags
act95 : Clutch_OpenT :=0                 // Clutch Flags
act96 : Clutch_CloseT :=0                // Clutch Flags
act97 : Gear_ReleaseT :=0                 // Gear Flags
act98 : Gear_SetT :=0                     // Gear Flags
act99 : Channel_RequestFromNeu :=FALSE    // ChannelFlags
act100 : Channel_FromNeu_SyncSpeed :=FALSE // ChannelSenario1
act101 : Channel_FromNeu_RequestOpenClutch :=FALSE // Channel Senario1 Flag
act102 : Channel_FromNeu_OpenClutch :=FALSE // ChannelFlage
act103 : Channel_FromNeu_SetGear_Clutch :=FALSE // ChannelFlage
act104 : Channel_FromNeu_SetGear_NoClutch :=FALSE // ChannelFlage
act105 : Channel_FromNeu_CloseClutch :=FALSE // ChannelFlage
act106 : Channel_RequestToNeu :=FALSE     // ChannelFlags
act107 : Channel_ToNeu_ZeroTorque :=FALSE // ChannelSenario3 Flage
act108 : Channel_ToNeu_RequestOpenClutch :=FALSE // ChannelSenario3 Flage
act109 : Channel_ToNeu_OpenClutch :=FALSE // ChannelSenario3 Flage
act110 : Channel_ToNeu_Release_Clutch :=FALSE // Channel Senario3 Flage
act111 : Channel_ToNeu_Release_NoClutch :=FALSE // Channel Senario3 Flage
act112 : Channel_ToNeu_CloseClutch :=FALSE // Channel Senario3 Flage
act113 : Channel_RequestNoNeu :=FALSE     // ChannelFlags
act114 : Channel_NoNeu_ZeroTorque :=FALSE // ChannelSenario2 Flage
act115 : Channel_NoNeu_Release_NoClutch :=FALSE // ChannelSenario2 Flage
act116 : Channel_NoNeu_RequestOpenClutch_Releasing :=FALSE // Channel Senario2 Flage
act117 : Channel_NoNeu_OpenClutch_Releasing :=FALSE // ChannelSenario2 Flage
act118 : Channel_NoNeu_Release_Clutch :=FALSE // ChannelSenario2 Flage
act119 : Channel_NoNeu_SyncSpeed :=FALSE // ChannelSenario2 Flage
act120 : Channel_NoNeu_RequestOpenClutch_Setting :=FALSE // Channel Senario2 Flage
act121 : Channel_NoNeu_OpenClutch_Setting :=FALSE // ChannelSenario2 Flage
act122 : Channel_NoNeu_SetGear_ReleasingClutch :=FALSE // ChannelSenario2 Flage
act123 : Channel_NoNeu_SetGear_SettingClutch :=FALSE // ChannelSenario2 Flage
act124 : Channel_NoNeu_SetGear_NoClutch :=FALSE // ChannelSenario2 Flage
act125 : Channel_NoNeu_CloseClutch_Releasing :=FALSE // ChannelSenario2 Flage
act126 : Channel_NoNeu_CloseClutch_Setting :=FALSE // ChannelSenario2 Flage
act127 : Channel_Request_SyncSpeed :=FALSE // Channel Engine Flags
act128 : Channel_Request_ZeroTorque :=FALSE // Channel Engine Flgas
act129 : Channel_SyncSpeed :=FALSE        // Channel Engine Flags
act130 : Channel_ZeroTorque :=FALSE       // Channel Engine Flgas
act131 : Channel_Request_Open :=FALSE     // Channel Clutch Flags
act132 : Channel_Request_Close :=FALSE    // Channel Clutch Flags
act133 : Channel_Open :=FALSE             // Channel Clutch Flags
act134 : Channel_Close :=FALSE            // Channel Clutch Flags
act135 : Channel_Request_Release :=FALSE // Channel Gear Flags
act136 : Channel_Request_Set :=FALSE      // Channel Gear Flags
act137 : Channel_Release :=FALSE          // Channel Gear Flags
act138 : Channel_Set :=FALSE              // Channel Gear Flags
act139 : Channel_OpenT :=0                // Channel Clutch Flags
act140 : Channel_CloseT :=0               // Channel Clutch Flags
act141 : Channel_Request_OpenT :=0        // Channel Clutch Flags
act142 : Channel_Request_CloseT :=0       // Channel Clutch Flags
act143 : Channel_SyncSpeedT :=0           // Channel Engine Flags
act144 : Channel_ZeroTorqueT :=0          // Channel Engine Flgas
act145 : Channel_Request_SyncSpeedT :=0   // Channel Engine Flags
act146 : Channel_Request_ZeroTorqueT :=0 // Channel Engine Flgas
act147 : Channel_RequestNoNeuT :=0        // ChannelTime
act148 : Channel_NoNeu_ZeroTorqueT :=0    // ChannelSenario2 Time
act149 : Channel_NoNeu_Release_NoClutchT :=0 // ChannelSenario2 Time
act150 : Channel_NoNeu_OpenClutch_ReleasingT :=0 // Channelenario2 Time
act151 : Channel_NoNeu_Release_ClutchT :=0 // ChannelSenario2 Time
act152 : Channel_NoNeu_SetGear_ReleasingClutchT :=0 // Channel Senario2 Time
act153 : Channel_NoNeu_SetGear_SettingClutchT :=0 // ChannelSenario2 Time
act154 : Channel_NoNeu_SyncSpeedT :=0     // ChannelSenario2 Time
act155 : Channel_NoNeu_OpenClutch_SettingT :=0 // ChannelSenario2 Time
act156 : Channel_NoNeu_RequestOpenClutch_ReleasingT :=0 // Channel Senario2 Time
act157 : Channel_NoNeu_RequestOpenClutch_SettingT :=0 // Channel Senario2 Time
```

## Gear Controller Case-study (Time Added Manually)

```
act158 : Channel_RequestToNeuT :=0      // Channel_Time
act159 : Channel_ToNeu_ZeroTorqueT :=0  // ChannelTIME
act160 : Channel_ToNeu_OpenClutchT :=0  // ChannelTIME
act161 : Channel_ToNeu_Release_ClutchT :=0 // ChannelTIME
act162 : Channel_ToNeu_RequestOpenClutchT :=0 // Channel Scenario3 Time
act163 : Channel_RequestFromNeuT :=0    // Channel_Time
act164 : Channel_FromNeu_OpenClutchT :=0 // ChannelTIME
act165 : Channel_FromNeu_SyncSpeedT :=0  // ChannelTIME
act166 : Channel_FromNeu_SetGear_ClutchT :=0 // ChannelTIME
act167 : Channel_FromNeu_RequestOpenClutchT :=0 // Channel Scenario1 Time
act168 : Channel_ReleaseT :=0           // Channel Gear Flags
act169 : Channel_SetT :=0               // Channel Gear Flags
act170 : Channel_Request_ReleaseT :=0    // Channel Gear Flags
act171 : Channel_Request_SetT :=0       // Channel Gear Flags
act172 : Channel_time :=0               // CHnanel time
act173 : Gear_time :=0                 // Gear_time
act174 : Engine_time :=0               // Engine_time
act175 : Clutch_time :=0               // Clutch_time
```

END

### RequestFromNeu $\triangleq$

extended

STATUS

ordinary

REFINES

RequestFromNeu

WHEN

```
grd1 : RequestFromNeu = FALSE
grd2 : RequestNoNeu = FALSE
grd3 : RequestToNeu = FALSE
grd4 : isNeu = TRUE
```

THEN

```
act1 : RequestFromNeu := TRUE
act2 : RequestFromNeuT := time
act3 : Channel_RequestFromNeu := TRUE
act4 : Channel_RequestFromNeuT := Channel_time
```

END

### RequestNoNeu $\triangleq$

extended

STATUS

ordinary

REFINES

RequestNoNeu

WHEN

```
grd1 : RequestFromNeu = FALSE
grd2 : RequestNoNeu = FALSE
grd3 : RequestToNeu = FALSE
grd4 : isNeu = FALSE
```

THEN

```
act1 : RequestNoNeu := TRUE
act2 : RequestNoNeuT := time
act3 : Channel_RequestNoNeu := TRUE
act4 : Channel_RequestNoNeuT := Channel_time
```

END

### RequestToNeu $\triangleq$

extended

STATUS

ordinary

REFINES

RequestToNeu

WHEN

```
grd1 : RequestFromNeu = FALSE
grd2 : RequestNoNeu = FALSE
grd3 : RequestToNeu = FALSE
grd4 : isNeu = FALSE
```

THEN

```
act1 : RequestToNeu := TRUE
act2 : RequestToNeuT := time
```

## Gear Controller Case-study (Time Added Manually)

```
act3 : Channel_RequestToNeu := TRUE
act4 : Channel_RequestToNeuT := Channel_time
END

FromNeu_SyncSpeed  $\triangleleft$ 
  STATUS
  ordinary
REFINES
  FromNeu_SyncSpeed
WHEN
  grd1 : RequestFromNeu = TRUE
  grd2 : FromNeu_SyncSpeed = FALSE
  grd3 : FromNeu_RequestOpenClutch = FALSE
  grd4 : Channel_SyncSpeed = TRUE
  grd5 : time  $\leq$  RequestFromNeuT + Sync_EX
THEN
  act1 : FromNeu_SyncSpeed := TRUE
  act2 : FromNeu_SyncSpeedT := time
  act3 : Channel_FromNeu_SyncSpeed := TRUE
  act4 : Channel_FromNeu_SyncSpeedT := Channel_time
END

FromNeu_RequestOpenClutch  $\triangleleft$ 
  extended
  STATUS
  ordinary
REFINES
  FromNeu_RequestOpenClutch
WHEN
  grd1 : RequestFromNeu = TRUE
  grd2 : FromNeu_SyncSpeed = FALSE
  grd3 : FromNeu_RequestOpenClutch = FALSE
  grd4 : time  $\geq$  RequestFromNeuT + OpenClutch_Zero_DE
THEN
  act1 : FromNeu_RequestOpenClutch := TRUE
  act2 : FromNeu_RequestOpenClutchT := time
  act3 : Channel_FromNeu_RequestOpenClutch := TRUE
  act4 : Channel_FromNeu_RequestOpenClutchT := Channel_time
END

FromNeu_OpenClutch  $\triangleleft$ 
  STATUS
  ordinary
REFINES
  FromNeu_OpenClutch
WHEN
  grd1 : FromNeu_RequestOpenClutch = TRUE
  grd2 : Error_FromNeu_OpenClutch = FALSE
  grd3 : FromNeu_OpenClutch = FALSE
  grd4 : Channel_Open = TRUE
THEN
  act1 : FromNeu_OpenClutch := TRUE
  act2 : FromNeu_OpenClutchT := time
  act3 : Channel_FromNeu_OpenClutch := TRUE
  act4 : Channel_FromNeu_OpenClutchT := Channel_time
END

Error_FromNeu_OpenClutch  $\triangleleft$ 
  extended
  STATUS
  ordinary
REFINES
  Error_FromNeu_OpenClutch
WHEN
  grd1 : FromNeu_RequestOpenClutch = TRUE
  grd2 : Error_FromNeu_OpenClutch = FALSE
  grd3 : FromNeu_OpenClutch = FALSE
THEN
  act1 : Error_FromNeu_OpenClutch := TRUE
END
```

## Gear Controller Case-study (Time Added Manually)

**FromNeu\_SetGear\_NoClutch**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

FromNeu\_SetGear\_NoClutch

**WHEN**

grd1 : FromNeu\_SyncSpeed = TRUE  
grd2 : Error\_FromNeu\_SetGear\_NoClutch = FALSE  
grd3 : FromNeu\_SetGear\_NoClutch = FALSE  
grd4 : Channel\_Set = TRUE

**THEN**

act1 : FromNeu\_SetGear\_NoClutch := TRUE  
act2 : isNeu := FALSE  
act3 : Channel\_FromNeu\_SetGear\_NoClutch := TRUE

**END**

**Error\_FromNeu\_SetGear\_NoClutch**  $\triangle$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_FromNeu\_SetGear\_NoClutch

**WHEN**

grd1 : *FromNeu\_SyncSpeed = TRUE*  
grd2 : *Error\_FromNeu\_SetGear\_NoClutch = FALSE*  
grd3 : *FromNeu\_SetGear\_NoClutch = FALSE*  
grd4 : *Gear\_Set = TRUE*

**THEN**

act1 : *Error\_FromNeu\_SetGear\_NoClutch := TRUE*

**END**

**FromNeu\_SetGear\_Clutch**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

FromNeu\_SetGear\_Clutch

**WHEN**

grd1 : FromNeu\_OpenClutch = TRUE  
grd2 : Error\_FromNeu\_SetGear\_Clutch = FALSE  
grd3 : FromNeu\_SetGear\_Clutch = FALSE  
grd4 : Channel\_Set = TRUE

**THEN**

act1 : FromNeu\_SetGear\_Clutch := TRUE  
act2 : FromNeu\_SetGear\_ClutchT := time  
act3 : Channel\_FromNeu\_SetGear\_Clutch := TRUE  
act4 : Channel\_FromNeu\_SetGear\_ClutchT := Channel\_time

**END**

**Error\_FromNeu\_SetGear\_Clutch**  $\triangle$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_FromNeu\_SetGear\_Clutch

**WHEN**

grd1 : *FromNeu\_OpenClutch = TRUE*  
grd2 : *Error\_FromNeu\_SetGear\_Clutch = FALSE*  
grd3 : *FromNeu\_SetGear\_Clutch = FALSE*

**THEN**

act1 : *Error\_FromNeu\_SetGear\_Clutch := TRUE*

**END**

**FromNeu\_CloseClutch**  $\triangle$

**STATUS**

**ordinary**

**REFINES**

FromNeu\_CloseClutch

**WHEN**

grd1 : FromNeu\_SetGear\_Clutch = TRUE

## Gear Controller Case-study (Time Added Manually)

```
    grd2 : Error_FromNeu_CloseClutch = FALSE
    grd3 : FromNeu_CloseClutch = FALSE
    grd4 : Channel_Close = TRUE
THEN
    act1 : FromNeu_CloseClutch := TRUE
    act2 : isNeu := FALSE
    act3 : Channel_FromNeu_CloseClutch := TRUE
END

Error_FromNeu_CloseClutch  $\triangleq$ 
    extended
    STATUS
    ordinary
REFINES
    Error_FromNeu_CloseClutch
WHEN
    grd1 : FromNeu_SetGear_Clutch = TRUE
    grd2 : Error_FromNeu_CloseClutch = FALSE
    grd3 : FromNeu_CloseClutch = FALSE
THEN
    act1 : Error_FromNeu_CloseClutch := TRUE
END

ToNeu_ZeroTorque  $\triangleq$  // First Event of Senarion3
    STATUS
    ordinary
REFINES
    ToNeu_ZeroTorque
WHEN
    grd1 : RequestToNeu = TRUE
    grd2 : ToNeu_ZeroTorque = FALSE
    grd3 : ToNeu_RequestOpenClutch = FALSE
    grd4 : Channel_ZeroTorque = TRUE
    grd5 : time  $\leq$  RequestToNeuT + Zero_EX
THEN
    act1 : ToNeu_ZeroTorque := TRUE
    act2 : ToNeu_ZeroTorqueT := time
    act3 : Channel_ToNeu_ZeroTorque := TRUE
    act4 : Channel_ToNeu_ZeroTorqueT := Channel_time
END

ToNeu_RequestOpenClutch  $\triangleq$ 
    extended
    STATUS
    ordinary
REFINES
    ToNeu_RequestOpenClutch
WHEN
    grd1 : RequestToNeu = TRUE
    grd2 : ToNeu_ZeroTorque = FALSE
    grd3 : ToNeu_RequestOpenClutch = FALSE
    grd4 : time  $\geq$  RequestToNeuT + OpenClutch_Zero_DE
THEN
    act1 : ToNeu_RequestOpenClutch := TRUE
    act2 : ToNeu_RequestOpenClutchT := time
    act3 : Channel_ToNeu_RequestOpenClutch := TRUE
    act4 : Channel_ToNeu_RequestOpenClutchT := Channel_time
END

ToNeu_OpenClutch  $\triangleq$ 
    STATUS
    ordinary
REFINES
    ToNeu_OpenClutch
WHEN
    grd1 : ToNeu_RequestOpenClutch = TRUE
    grd2 : ToNeu_OpenClutch = FALSE
    grd3 : Error_ToNeu_OpenClutch = FALSE
    grd4 : Channel_Open = TRUE
THEN
```

## Gear Controller Case-study (Time Added Manually)

```
act1 : ToNeu_OpenClutch := TRUE
act2 : ToNeu_OpenClutchT := time
act3 : Channel_ToNeu_OpenClutch := TRUE
act4 : Channel_ToNeu_OpenClutchT := Channel_time
END

Error_ToNeu_OpenClutch ≙
  extended
  STATUS
  ordinary
REFINES
  Error_ToNeu_OpenClutch
WHEN
  grd1 : ToNeu_RequestOpenClutch = TRUE
  grd2 : ToNeu_OpenClutch = FALSE
  grd3 : Error_ToNeu_OpenClutch = FALSE
THEN
  act1 : Error_ToNeu_OpenClutch := TRUE
END

ToNeu_Release_NoClutch ≙
  STATUS
  ordinary
REFINES
  ToNeu_Release_NoClutch
WHEN
  grd1 : ToNeu_ZeroTorque = TRUE
  grd2 : ToNeu_Release_NoClutch = FALSE
  grd3 : Error_ToNeu_Release_NoClutch = FALSE
  grd4 : Channel_Release = TRUE
THEN
  act1 : ToNeu_Release_NoClutch := TRUE
  act2 : isNeu := TRUE
  act3 : Channel_ToNeu_Release_NoClutch := TRUE
END

Error_ToNeu_Release_NoClutch ≙
  extended
  STATUS
  ordinary
REFINES
  Error_ToNeu_Release_NoClutch
WHEN
  grd1 : ToNeu_ZeroTorque = TRUE
  grd2 : ToNeu_Release_NoClutch = FALSE
  grd3 : Error_ToNeu_Release_NoClutch = FALSE
THEN
  act1 : Error_ToNeu_Release_NoClutch := TRUE
END

ToNeu_Release_Clutch ≙
  STATUS
  ordinary
REFINES
  ToNeu_Release_Clutch
WHEN
  grd1 : ToNeu_OpenClutch = TRUE
  grd2 : ToNeu_Release_Clutch = FALSE
  grd3 : Error_ToNeu_Release_Clutch = FALSE
  grd4 : Channel_Release = TRUE
THEN
  act1 : ToNeu_Release_Clutch := TRUE
  act2 : ToNeu_Release_ClutchT := time
  act3 : Channel_ToNeu_Release_Clutch := TRUE
  act4 : Channel_ToNeu_Release_ClutchT := Channel_time
END

Error_ToNeu_Release_Clutch ≙
  extended
  STATUS
```

## Gear Controller Case-study (Time Added Manually)

```
ordinary
REFINES
  Error_ToNeu_Release_Clutch
WHEN
  grd1 : ToNeu_OpenClutch = TRUE
  grd2 : ToNeu_Release_Clutch = FALSE
  grd3 : Error_ToNeu_Release_Clutch = FALSE
THEN
  act1 : Error_ToNeu_Release_Clutch := TRUE
END

ToNeu_CloseClutch ≐
  STATUS
  ordinary
REFINES
  ToNeu_CloseClutch
WHEN
  grd1 : ToNeu_Release_Clutch = TRUE
  grd2 : ToNeu_CloseClutch = FALSE
  grd3 : Error_ToNeu_CloseClutch = FALSE
  grd4 : Channel_Close = TRUE
THEN
  act1 : ToNeu_CloseClutch := TRUE
  act2 : isNeu := TRUE
  act3 : Channel_ToNeu_CloseClutch := TRUE
END

Error_ToNeu_CloseClutch ≐ // Last Event of Senarion3
  extended
  STATUS
  ordinary
REFINES
  Error_ToNeu_CloseClutch
WHEN
  grd1 : ToNeu_Release_Clutch = TRUE
  grd2 : ToNeu_CloseClutch = FALSE
  grd3 : Error_ToNeu_CloseClutch = FALSE
THEN
  act1 : Error_ToNeu_CloseClutch := TRUE
END

NoNeu_ZeroTorque ≐ // First Event of Senarion2
  STATUS
  ordinary
REFINES
  NoNeu_ZeroTorque
WHEN
  grd1 : RequestNoNeu = TRUE
  grd2 : NoNeu_ZeroTorque = FALSE
  grd3 : NoNeu_RequestOpenClutch_Releasing = FALSE
  grd4 : time ≤ RequestNoNeuT + Zero_EX
  grd5 : Channel_ZeroTorque = TRUE
THEN
  act1 : NoNeu_ZeroTorque := TRUE
  act2 : NoNeu_ZeroTorqueT := time
  act3 : Channel_NoNeu_ZeroTorque := TRUE
  act4 : Channel_NoNeu_ZeroTorqueT := Channel_time
END

NoNeu_RequestOpenClutch_Releasing ≐
  extended
  STATUS
  ordinary
REFINES
  NoNeu_RequestOpenClutch_Releasing
WHEN
  grd1 : RequestNoNeu = TRUE
  grd2 : NoNeu_ZeroTorque = FALSE
  grd3 : NoNeu_RequestOpenClutch_Releasing = FALSE
  grd4 : time ≥ RequestNoNeuT + OpenClutch_Zero_DE
```

## Gear Controller Case-study (Time Added Manually)

```
THEN
  act1 : NoNeu_RequestOpenClutch_Releasing :=TRUE
  act2 : NoNeu_RequestOpenClutch_ReleasingT :=time
  act3 : Channel_NoNeu_RequestOpenClutch_Releasing :=TRUE
  act4 : Channel_NoNeu_RequestOpenClutch_ReleasingT :=Channel_time
END
```

**NoNeu\_OpenClutch\_Releasing**  $\triangle$   
**STATUS**

**ordinary**

**REFINES**

NoNeu\_OpenClutch\_Releasing

**WHEN**

```
grd1 : NoNeu_OpenClutch_Releasing = TRUE
grd2 : NoNeu_OpenClutch_Releasing = FALSE
grd3 : Error_NoNeu_OpenClutch_Releasing = FALSE
grd4 : Channel_Open = TRUE
```

**THEN**

```
act1 : NoNeu_OpenClutch_Releasing := TRUE
act2 : NoNeu_OpenClutch_ReleasingT := time
act3 : Channel_NoNeu_OpenClutch_Releasing := TRUE
act4 : Channel_NoNeu_OpenClutch_ReleasingT := Channel_time
```

**END**

**Error\_NoNeu\_OpenClutch\_Releasing**  $\triangle$   
**extended**  
**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_OpenClutch\_Releasing

**WHEN**

```
grd1 : NoNeu_RequestOpenClutch_Releasing = TRUE
grd2 : NoNeu_OpenClutch_Releasing = FALSE
grd3 : Error_NoNeu_OpenClutch_Releasing = FALSE
```

**THEN**

```
act1 : Error_NoNeu_OpenClutch_Releasing := TRUE
```

**END**

**NoNeu\_Release\_NoClutch**  $\triangle$   
**STATUS**

**ordinary**

**REFINES**

NoNeu\_Release\_NoClutch

**WHEN**

```
grd1 : NoNeu_ZeroTorque = TRUE
grd2 : NoNeu_Release_NoClutch = FALSE
grd3 : Error_NoNeu_Release_NoClutch = FALSE
grd4 : Channel_Release = TRUE
```

**THEN**

```
act1 : NoNeu_Release_NoClutch := TRUE
act2 : NoNeu_Release_NoClutchT := time
act3 : Channel_NoNeu_Release_NoClutch := TRUE
act4 : Channel_NoNeu_Release_NoClutchT := Channel_time
```

**END**

**Error\_NoNeu\_Release\_NoClutch**  $\triangle$   
**extended**  
**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_Release\_NoClutch

**WHEN**

```
grd1 : NoNeu_ZeroTorque = TRUE
grd2 : NoNeu_Release_NoClutch = FALSE
grd3 : Error_NoNeu_Release_NoClutch = FALSE
```

**THEN**

```
act1 : Error_NoNeu_Release_NoClutch := TRUE
```

**END**

**NoNeu\_Release\_Clutch**  $\triangle$



## Gear Controller Case-study (Time Added Manually)

```

    STATUS
    ordinary
REFINES
NoNeu_Release_Clutch
WHEN
    grd1 : NoNeu_OpenClutch_Releasing = TRUE
    grd2 : NoNeu_Release_Clutch = FALSE
    grd3 : Error_NoNeu_Release_Clutch = FALSE
    grd4 : Channel_Release = TRUE
THEN
    act1 : NoNeu_Release_Clutch := TRUE
    act2 : NoNeu_Release_ClutchT := time
    act3 : Channel_NoNeu_Release_Clutch := TRUE
    act4 : Channel_NoNeu_Release_ClutchT := Channel_time
END

Error_NoNeu_Release_Clutch ≙
    extended
    STATUS
    ordinary
REFINES
Error_NoNeu_Release_Clutch
WHEN
    grd1 : NoNeu_OpenClutch_Releasing = TRUE
    grd2 : NoNeu_Release_Clutch = FALSE
    grd3 : Error_NoNeu_Release_Clutch = FALSE
THEN
    act1 : Error_NoNeu_Release_Clutch := TRUE
END

NoNeu_SyncSpeed ≙
    STATUS
    ordinary
REFINES
NoNeu_SyncSpeed
WHEN
    grd1 : NoNeu_Release_NoClutch = TRUE
    grd2 : NoNeu_SyncSpeed = FALSE
    grd3 : NoNeu_RequestOpenClutch_Setting = FALSE
    grd4 : Channel_SyncSpeed = TRUE
    grd5 : time ≤ NoNeu_Release_NoClutchT + Sync_EX
THEN
    act1 : NoNeu_SyncSpeed := TRUE
    act2 : NoNeu_SyncSpeedT := time
    act3 : Channel_NoNeu_SyncSpeed := TRUE
    act4 : Channel_NoNeu_SyncSpeedT := Channel_time
END

NoNeu_RequestOpenClutch_Setting ≙
    extended
    STATUS
    ordinary
REFINES
NoNeu_RequestOpenClutch_Setting
WHEN
    grd1 : NoNeu_Release_NoClutch = TRUE
    grd2 : NoNeu_SyncSpeed = FALSE
    grd3 : NoNeu_RequestOpenClutch_Setting = FALSE
    grd4 : time ≥ NoNeu_Release_NoClutchT + OpenClutch_Sync_DE
THEN
    act1 : NoNeu_RequestOpenClutch_Setting := TRUE
    act2 : NoNeu_RequestOpenClutch_SettingT := time
    act3 : Channel_NoNeu_RequestOpenClutch_Setting := TRUE
    act4 : Channel_NoNeu_RequestOpenClutch_SettingT := Channel_time
END

NoNeu_OpenClutch_Setting ≙
    STATUS
    ordinary
REFINES
```

## Gear Controller Case-study (Time Added Manually)

```
NoNeu_OpenClutch_Setting
WHEN
  grd1 : NoNeu_RequestOpenClutch_Setting = TRUE
  grd2 : Error_NoNeu_OpenClutch_Setting = FALSE
  grd3 : NoNeu_OpenClutch_Setting = FALSE
  grd4 : Channel_Open = TRUE
THEN
  act1 : NoNeu_OpenClutch_Setting := TRUE
  act2 : NoNeu_OpenClutch_SettingT := time
  act3 : Channel_NoNeu_OpenClutch_Setting := TRUE
  act4 : Channel_NoNeu_OpenClutch_SettingT := Channel_time
END
```

**Error\_NoNeu\_OpenClutch\_Setting**  $\triangleq$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_OpenClutch\_Setting

**WHEN**

```
  grd1 : NoNeu_RequestOpenClutch_Setting = TRUE
  grd2 : Error_NoNeu_OpenClutch_Setting = FALSE
  grd3 : NoNeu_OpenClutch_Setting = FALSE
```

**THEN**

```
  act1 : Error_NoNeu_OpenClutch_Setting := TRUE
```

**END**

**NoNeu\_SetGear\_NoClutch**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

NoNeu\_SetGear\_NoClutch

**WHEN**

```
  grd1 : NoNeu_SyncSpeed = TRUE
  grd2 : Error_NoNeu_SetGear_NoClutch = FALSE
  grd3 : NoNeu_SetGear_NoClutch = FALSE
  grd4 : Channel_Set = TRUE
```

**THEN**

```
  act1 : NoNeu_SetGear_NoClutch := TRUE
  act2 : Channel_NoNeu_SetGear_NoClutch := TRUE
```

**END**

**Error\_NoNeu\_SetGear\_NoClutch**  $\triangleq$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_SetGear\_NoClutch

**WHEN**

```
  grd1 : NoNeu_SyncSpeed = TRUE
  grd2 : Error_NoNeu_SetGear_NoClutch = FALSE
  grd3 : NoNeu_SetGear_NoClutch = FALSE
```

**THEN**

```
  act1 : Error_NoNeu_SetGear_NoClutch := TRUE
```

**END**

**NoNeu\_SetGear\_ReleasingClutch**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

NoNeu\_SetGear\_ReleasingClutch

**WHEN**

```
  grd1 : NoNeu_Release_Clutch = TRUE
  grd2 : Error_NoNeu_SetGear_ReleasingClutch = FALSE
  grd3 : NoNeu_SetGear_ReleasingClutch = FALSE
  grd4 : Channel_Set = TRUE
```

**THEN**

```
  act1 : NoNeu_SetGear_ReleasingClutch := TRUE
  act2 : NoNeu_SetGear_ReleasingClutchT := time
  act3 : Channel_NoNeu_SetGear_ReleasingClutch := TRUE
```

## Gear Controller Case-study (Time Added Manually)

**act4** : Channel\_NoNeu\_SetGear\_ReleasingClutchT := Channel\_time  
**END**

**Error\_NoNeu\_SetGear\_ReleasingClutch**  $\triangleq$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_SetGear\_ReleasingClutch

**WHEN**

*grd1* : NoNeu\_Release\_Clutch = TRUE

*grd2* : Error\_NoNeu\_SetGear\_ReleasingClutch = FALSE

*grd3* : NoNeu\_SetGear\_ReleasingClutch = FALSE

**THEN**

*act1* : Error\_NoNeu\_SetGear\_ReleasingClutch := TRUE

**END**

**NoNeu\_SetGear\_SettingClutch**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

NoNeu\_SetGear\_SettingClutch

**WHEN**

*grd1* : NoNeu\_OpenClutch\_Setting = TRUE

*grd2* : Error\_NoNeu\_SetGear\_SettingClutch = FALSE

*grd3* : NoNeu\_SetGear\_SettingClutch = FALSE

*grd4* : Channel\_Set = TRUE

**THEN**

*act1* : NoNeu\_SetGear\_SettingClutch := TRUE

*act2* : NoNeu\_SetGear\_SettingClutchT := time

*act3* : Channel\_NoNeu\_SetGear\_SettingClutch := TRUE

*act4* : Channel\_NoNeu\_SetGear\_SettingClutchT := Channel\_time

**END**

**Error\_NoNeu\_SetGear\_SettingClutch**  $\triangleq$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_SetGear\_SettingClutch

**WHEN**

*grd1* : NoNeu\_OpenClutch\_Setting = TRUE

*grd2* : Error\_NoNeu\_SetGear\_SettingClutch = FALSE

*grd3* : NoNeu\_SetGear\_SettingClutch = FALSE

**THEN**

*act1* : Error\_NoNeu\_SetGear\_SettingClutch := TRUE

**END**

**NoNeu\_CloseClutch\_Setting**  $\triangleq$

**STATUS**

**ordinary**

**REFINES**

NoNeu\_CloseClutch\_Setting

**WHEN**

*grd1* : NoNeu\_SetGear\_SettingClutch = TRUE

*grd2* : Error\_NoNeu\_CloseClutch\_Setting = FALSE

*grd3* : NoNeu\_CloseClutch\_Setting = FALSE

*grd4* : Channel\_Close = TRUE

**THEN**

*act1* : NoNeu\_CloseClutch\_Setting := TRUE

*act2* : Channel\_NoNeu\_CloseClutch\_Setting := TRUE

**END**

**Error\_NoNeu\_CloseClutch\_Setting**  $\triangleq$

**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_NoNeu\_CloseClutch\_Setting

**WHEN**

## Gear Controller Case-study (Time Added Manually)

```
    grd1 : NoNeu_SetGear_SettingClutch = TRUE
    grd2 : Error_NoNeu_CloseClutch_Setting = FALSE
    grd3 : NoNeu_CloseClutch_Setting = FALSE
THEN
    act1 : Error_NoNeu_CloseClutch_Setting := TRUE
END

    NoNeu_CloseClutch_Releasing  $\triangle$ 
    STATUS
    ordinary
REFINES
    NoNeu_CloseClutch_Releasing
WHEN
    grd1 : NoNeu_SetGear_ReleasingClutch = TRUE
    grd2 : Error_NoNeu_CloseClutch_Releasing = FALSE
    grd3 : NoNeu_CloseClutch_Releasing = FALSE
    grd4 : Channel_Close = TRUE
THEN
    act1 : NoNeu_CloseClutch_Releasing := TRUE
    act2 : Channel_NoNeu_CloseClutch_Releasing := TRUE
END

    Error_NoNeu_CloseClutch_Releasing  $\triangle$ 
    extended
    STATUS
    ordinary
REFINES
    Error_NoNeu_CloseClutch_Releasing
WHEN
    grd1 : NoNeu_SetGear_ReleasingClutch = TRUE
    grd2 : Error_NoNeu_CloseClutch_Releasing = FALSE
    grd3 : NoNeu_CloseClutch_Releasing = FALSE
THEN
    act1 : Error_NoNeu_CloseClutch_Releasing := TRUE
END

    Engine_Request_SyncSpeed  $\triangle$ 
    STATUS
    ordinary
REFINES
    Engine_Request_SyncSpeed
WHEN
    grd1 : Channel_RequestFromNeu = TRUE  $\vee$  Channel_NoNeu_Release_NoClutch = TRUE
    grd2 : Engine_Request_SyncSpeed = FALSE
THEN
    act1 : Engine_Request_SyncSpeed := TRUE
    act2 : Engine_Request_SyncSpeedT := Engine_time
    act3 : Channel_Request_SyncSpeed := TRUE
    act4 : Channel_Request_SyncSpeedT := Channel_time
END

    Engine_SyncSpeed  $\triangle$ 
    STATUS
    ordinary
REFINES
    Engine_SyncSpeed
WHEN
    grd1 : Engine_Request_SyncSpeed = TRUE
    grd2 : Engine_SyncSpeed = FALSE
    grd3 : Engine_WaitForSyncClutch = FALSE
THEN
    act1 : Engine_SyncSpeed := TRUE
    act2 : Engine_SyncSpeedT := Engine_time
    act3 : Channel_SyncSpeed := TRUE
    act4 : Channel_SyncSpeedT := Channel_time
END

    Engine_WaitForSyncClutch  $\triangle$ 
    extended
    STATUS
```

## Gear Controller Case-study (Time Added Manually)

```
ordinary
REFINES
Engine_WaitForSyncClutch
WHEN
  grd1 : Engine_Request_SyncSpeed = TRUE
  grd2 : Engine_SyncSpeed = FALSE
  grd3 : Engine_WaitForSyncClutch = FALSE
THEN
  act1 : Engine_WaitForSyncClutch :=TRUE
END

Engine_Request_ZeroTorque ≐
STATUS
ordinary
REFINES
Engine_Request_ZeroTorque
WHEN
  grd1 : Channel_RequestToNeu = TRUE ∨ Channel_RequestNoNeu = TRUE
  grd2 : Engine_Request_ZeroTorque = FALSE
THEN
  act1 : Engine_Request_ZeroTorque :=TRUE
  act2 : Engine_Request_ZeroTorqueT :=Engine_time
  act3 : Channel_Request_ZeroTorque :=TRUE
  act4 : Channel_Request_ZeroTorqueT :=Channel_time
END

Engine_ZeroTorque ≐
STATUS
ordinary
REFINES
Engine_ZeroTorque
WHEN
  grd1 : Engine_Request_ZeroTorque = TRUE
  grd2 : Engine_ZeroTorque = FALSE
  grd3 : Engine_WaitForZeroClutch = FALSE
THEN
  act1 : Engine_ZeroTorque :=TRUE
  act2 : Engine_ZeroTorqueT :=Engine_time
  act3 : Channel_ZeroTorque :=TRUE
  act4 : Channel_ZeroTorqueT :=Channel_time
END

Engine_WaitForZeroClutch ≐
extended
STATUS
ordinary
REFINES
Engine_WaitForZeroClutch
WHEN
  grd1 : Engine_Request_ZeroTorque = TRUE
  grd2 : Engine_ZeroTorque = FALSE
  grd3 : Engine_WaitForZeroClutch = FALSE
THEN
  act1 : Engine_WaitForZeroClutch :=TRUE
END

Clutch_Request_Open ≐
STATUS
ordinary
REFINES
Clutch_Request_Open
WHEN
  Channel_FromNeu_RequestOpenClutch = TRUE ∨ Channel_ToNeu_RequestOpenClutch = TRUE ∨
  grd1 : Channel_NoNeu_RequestOpenClutch_Releasing = TRUE ∨
  Channel_NoNeu_RequestOpenClutch_Setting = TRUE
  grd2 : Clutch_Request_Open = FALSE
THEN
  act1 : Clutch_Request_Open :=TRUE
  act2 : Clutch_Request_OpenT :=Clutch_time
```

## Gear Controller Case-study (Time Added Manually)

```
act3 : Channel_Request_Open := TRUE
act4 : Channel_Request_OpenT := Channel_time
END
```

**Clutch\_Open**  $\triangle$   
**STATUS**

**ordinary**

**REFINES**

Clutch\_Open

**WHEN**

```
grd1 : Clutch_Request_Open = TRUE
grd2 : Clutch_Open = FALSE
grd3 : Error_Clutch_Open = FALSE
```

**THEN**

```
act1 : Clutch_Open := TRUE
act2 : Clutch_OpenT := Clutch_time
act3 : Channel_Open := TRUE
act4 : Channel_OpenT := Channel_time
```

**END**

**Error\_Clutch\_Open**  $\triangle$   
**extended**

**STATUS**

**ordinary**

**REFINES**

Error\_Clutch\_Open

**WHEN**

```
grd1 : Clutch_Request_Open = TRUE
grd2 : Clutch_Open = FALSE
grd3 : Error_Clutch_Open = FALSE
```

**THEN**

```
act1 : Error_Clutch_Open := TRUE
```

**END**

**Clutch\_Request\_Close**  $\triangle$   
**STATUS**

**ordinary**

**REFINES**

Clutch\_Request\_Close

**WHEN**

```
Channel_FromNeu_SetGear_Clutch = TRUE  $\vee$ 
grd1 : Channel_ToNeu_Release_Clutch = TRUE  $\vee$ 
      Channel_NoNeu_SetGear_ReleasingClutch = TRUE  $\vee$ 
      Channel_NoNeu_SetGear_SettingClutch = TRUE
grd2 : Clutch_Request_Close = FALSE
```

**THEN**

```
act1 : Clutch_Request_Close := TRUE
act2 : Clutch_Request_CloseT := Clutch_time
act3 : Channel_Request_Close := TRUE
act4 : Channel_Request_CloseT := Channel_time
```

**END**

**Clutch\_Close**  $\triangle$   
**STATUS**

**ordinary**

**REFINES**

Clutch\_Close

**WHEN**

```
grd1 : Clutch_Request_Close = TRUE
grd2 : Clutch_Close = FALSE
grd3 : Error_Clutch_Close = FALSE
```

**THEN**

```
act1 : Clutch_Close := TRUE
act2 : Clutch_CloseT := Clutch_time
act3 : Channel_Close := TRUE
act4 : Channel_CloseT := Channel_time
```

**END**

**Error\_Clutch\_Close**  $\triangle$

## Gear Controller Case-study (Time Added Manually)

```
    extended
      STATUS
    ordinary
  REFINES
    Error_Clutch_Close
  WHEN
    grd1 : Clutch_Request_Close = TRUE
    grd2 : Clutch_Close = FALSE
    grd3 : Error_Clutch_Close = FALSE
  THEN
    act1 : Error_Clutch_Close :=TRUE
  END
```

```
  Gear_Request_Release ≙
    STATUS
  ordinary
  REFINES
    Gear_Request_Release
  WHEN
    grd1 : Channel_ToNeu_ZeroTorque = TRUE ∨ Channel_ToNeu_OpenClutch = TRUE ∨
           Channel_NoNeu_ZeroTorque = TRUE ∨ Channel_NoNeu_OpenClutch_Releasing= TRUE
    grd2 : Gear_Request_Release = FALSE
  THEN
    act1 : Gear_Request_Release :=TRUE
    act2 : Gear_Request_ReleaseT :=Gear_time
    act3 : Channel_Request_Release :=TRUE
    act4 : Channel_Request_ReleaseT :=Channel_time
  END
```

```
  Gear_Release ≙
    STATUS
  ordinary
  REFINES
    Gear_Release
  WHEN
    grd1 : Gear_Request_Release = TRUE
    grd2 : Gear_Release = FALSE
    grd3 : Error_Gear_Release = FALSE
  THEN
    act1 : Gear_Release :=TRUE
    act2 : Gear_ReleaseT :=Gear_time
    act3 : Channel_Release :=TRUE
    act4 : Channel_ReleaseT :=Channel_time
  END
```

```
  Error_Gear_Release ≙
    extended
      STATUS
    ordinary
  REFINES
    Error_Gear_Release
  WHEN
    grd1 : Gear_Request_Release = TRUE
    grd2 : Gear_Release = FALSE
    grd3 : Error_Gear_Release = FALSE
  THEN
    act1 : Error_Gear_Release :=TRUE
  END
```

```
  Gear_Request_Set ≙
    STATUS
  ordinary
  REFINES
    Gear_Request_Set
  WHEN
    Channel_FromNeu_SyncSpeed = TRUE ∨ Channel_FromNeu_OpenClutch = TRUE ∨
    grd1 : Channel_NoNeu_Release_Clutch = TRUE ∨ Channel_NoNeu_SyncSpeed = TRUE ∨
           Channel_NoNeu_OpenClutch_Setting = TRUE
    grd2 : Gear_Request_Set = FALSE
```

## Gear Controller Case-study (Time Added Manually)

**THEN**

act1 : Gear\_Request\_Set := TRUE  
act2 : Gear\_Request\_SetT := Gear\_time  
act3 : Channel\_Request\_Set := TRUE  
act4 : Channel\_Request\_SetT := Channel\_time

**END**

**Gear\_Set**  $\triangleq$   
**STATUS**

**ordinary**

**REFINES**

Gear\_Set

**WHEN**

grd1 : Gear\_Request\_Set = TRUE  
grd2 : Gear\_Set = FALSE  
grd3 : Error\_Gear\_Set = FALSE

**THEN**

act1 : Gear\_Set := TRUE  
act2 : Gear\_SetT := Gear\_time  
act3 : Channel\_Set := TRUE  
act4 : Channel\_SetT := Channel\_time

**END**

**Error\_Gear\_Set**  $\triangleq$   
**extended**  
**STATUS**

**ordinary**

**REFINES**

Error\_Gear\_Set

**WHEN**

grd1 : Gear\_Request\_Set = TRUE  
grd2 : Gear\_Set = FALSE  
grd3 : Error\_Gear\_Set = FALSE

**THEN**

act1 : Error\_Gear\_Set := TRUE

**END**

**FINAL**  $\triangleq$   
**extended**  
**STATUS**

**ordinary**

**REFINES**

FINAL

**WHEN**

*FromNeu\_SetGear\_NoClutch = TRUE  $\vee$  NoNeu\_SetGear\_NoClutch = TRUE  $\vee$   
ToNeu\_Release\_NoClutch = TRUE  $\vee$  FromNeu\_CloseClutch = TRUE  $\vee$   
NoNeu\_CloseClutch\_Setting = TRUE  $\vee$  NoNeu\_CloseClutch\_Releasing = TRUE  $\vee$   
ToNeu\_CloseClutch = TRUE*

**THEN**

act1 : RequestFromNeu := FALSE  
act2 : RequestNoNeu := FALSE  
act3 : RequestToNeu := FALSE  
act4 : FromNeu\_SyncSpeed := FALSE  
act5 : FromNeu\_OpenClutch := FALSE  
act6 : FromNeu\_SetGear\_NoClutch := FALSE  
act7 : FromNeu\_SetGear\_Clutch := FALSE  
act8 : FromNeu\_CloseClutch := FALSE  
act9 : ToNeu\_Release\_NoClutch := FALSE  
act10 : ToNeu\_CloseClutch := FALSE  
act11 : ToNeu\_ZeroTorque := FALSE  
act12 : ToNeu\_OpenClutch := FALSE  
act13 : ToNeu\_Release\_Clutch := FALSE  
act14 : NoNeu\_ZeroTorque := FALSE  
act15 : NoNeu\_OpenClutch\_Releasing := FALSE  
act16 : NoNeu\_Release\_NoClutch := FALSE  
act17 : NoNeu\_Release\_Clutch := FALSE  
act18 : NoNeu\_SyncSpeed := FALSE  
act19 : NoNeu\_OpenClutch\_Setting := FALSE  
act20 : NoNeu\_SetGear\_NoClutch := FALSE



## Gear Controller Case-study (Time Added Manually)

```
act21 : NoNeu_SetGear_ReleasingClutch := FALSE
act22 : NoNeu_SetGear_SettingClutch := FALSE
act23 : NoNeu_CloseClutch_Setting := FALSE
act24 : NoNeu_CloseClutch_Releasing := FALSE
act25 : Engine_SyncSpeed := FALSE
act26 : Engine_WaitForSyncClutch := FALSE
act27 : Engine_ZeroTorque := FALSE
act28 : Engine_WaitForZeroClutch := FALSE
act29 : Clutch_Open := FALSE
act30 : Clutch_Close := FALSE
act31 : Gear_Release := FALSE
act32 : Gear_Set := FALSE
act33 : FromNeu_RequestOpenClutch := FALSE
act34 : ToNeu_RequestOpenClutch := FALSE
act35 : NoNeu_RequestOpenClutch_Releasing := FALSE
act36 : NoNeu_RequestOpenClutch_Setting := FALSE
act37 : Engine_Request_SyncSpeed := FALSE // Engine Flgas
act38 : Engine_Request_ZeroTorque := FALSE // Engine Flgas
act39 : Clutch_Request_Open := FALSE // Clutch Flags
act40 : Clutch_Request_Close := FALSE // Clutch Flags
act41 : Gear_Request_Release := FALSE // Gear Flags
act42 : Gear_Request_Set := FALSE // Gear Flags
act43 : Channel_RequestFromNeu := FALSE // ChannelFlags
act44 : Channel_FromNeu_SyncSpeed := FALSE // ChannelSenario1
act45 : Channel_FromNeu_RequestOpenClutch := FALSE // Channel Senario1 Flag
act46 : Channel_FromNeu_OpenClutch := FALSE // ChannelFlage
act47 : Channel_FromNeu_SetGear_Clutch := FALSE // ChannelFlage
act48 : Channel_FromNeu_SetGear_NoClutch := FALSE // ChannelFlage
act49 : Channel_FromNeu_CloseClutch := FALSE // ChannelFlage
act50 : Channel_RequestToNeu := FALSE // ChannelFlags
act51 : Channel_ToNeu_ZeroTorque := FALSE // ChannelSenario3 Flage
act52 : Channel_ToNeu_RequestOpenClutch := FALSE // ChannelSenario3 Flage
act53 : Channel_ToNeu_OpenClutch := FALSE // ChannelSenario3 Flage
act54 : Channel_ToNeu_Release_Clutch := FALSE // Channel Senario3 Flage
act55 : Channel_ToNeu_Release_NoClutch := FALSE // Channel Senario3 Flage
act56 : Channel_ToNeu_CloseClutch := FALSE // Channel Senario3 Flage
act57 : Channel_RequestNoNeu := FALSE // ChannelFlags
act58 : Channel_NoNeu_ZeroTorque := FALSE // ChannelSenario2 Flage
act59 : Channel_NoNeu_Release_NoClutch := FALSE // ChannelSenario2 Flage
act60 : Channel_NoNeu_RequestOpenClutch_Releasing := FALSE // Channel Senario2 Flage
act61 : Channel_NoNeu_OpenClutch_Releasing := FALSE // ChannelSenario2 Flage
act62 : Channel_NoNeu_Release_Clutch := FALSE // ChannelSenario2 Flage
act63 : Channel_NoNeu_SyncSpeed := FALSE // ChannelSenario2 Flage
act64 : Channel_NoNeu_RequestOpenClutch_Setting := FALSE // Channel Senario2 Flage
act65 : Channel_NoNeu_OpenClutch_Setting := FALSE // ChannelSenario2 Flage
act66 : Channel_NoNeu_SetGear_ReleasingClutch := FALSE // ChannelSenario2 Flage
act67 : Channel_NoNeu_SetGear_SettingClutch := FALSE // ChannelSenario2 Flage
act68 : Channel_NoNeu_SetGear_NoClutch := FALSE // ChannelSenario2 Flage
act69 : Channel_NoNeu_CloseClutch_Releasing := FALSE // ChannelSenario2 Flage
act70 : Channel_NoNeu_CloseClutch_Setting := FALSE // ChannelSenario2 Flage
act71 : Channel_Request_SyncSpeed := FALSE // Channel Engine Flags
act72 : Channel_Request_ZeroTorque := FALSE // Channel Engine Flgas
act73 : Channel_SyncSpeed := FALSE // Channel Engine Flags
act74 : Channel_ZeroTorque := FALSE // Channel Engine Flgas
act75 : Channel_Request_Open := FALSE // Channel Clutch Flags
act76 : Channel_Request_Close := FALSE // Channel Clutch Flags
act77 : Channel_Open := FALSE // Channel Clutch Flags
act78 : Channel_Close := FALSE // Channel Clutch Flags
act79 : Channel_Request_Release := FALSE // Channel Gear Flags
act80 : Channel_Request_Set := FALSE // Channel Gear Flags
act81 : Channel_Release := FALSE // Channel Gear Flags
act82 : Channel_Set := FALSE // Channel Gear Flags
```

END

Tick\_Tock ≙  
STATUS

ordinary

REFINES

Tick\_Tock

ANY

## Gear Controller Case-study (Time Added Manually)

```

tick
WHERE
grd1 : tick > 0
grd2 : RequestFromNeu = TRUE  $\wedge$  FromNeu_RequestOpenClutch= FALSE  $\wedge$  // Scenario1
      FromNeu_SyncSpeed = FALSE  $\Rightarrow$  time+tick  $\leq$  Sync_DL+RequestFromNeuT
grd3 : FromNeu_RequestOpenClutch = TRUE  $\wedge$  FromNeu_OpenClutch= FALSE  $\wedge$ 
      Error_FromNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+FromNeu_RequestOpenClutchT
grd4 : FromNeu_OpenClutch = TRUE  $\wedge$  FromNeu_SetGear_Clutch= FALSE  $\wedge$ 
      Error_FromNeu_SetGear_Clutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_OpenClutchT
grd5 : FromNeu_SyncSpeed = TRUE  $\wedge$  FromNeu_SetGear_NoClutch= FALSE  $\wedge$ 
      Error_FromNeu_SetGear_NoClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_SyncSpeedT
grd6 : FromNeu_SetGear_Clutch = TRUE  $\wedge$  FromNeu_CloseClutch= FALSE  $\wedge$  // Scenario
      Error_FromNeu_CloseClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+FromNeu_Set n1
      Gear_ClutchT
grd7 : RequestToNeu = TRUE  $\wedge$  ToNeu_RequestOpenClutch= FALSE  $\wedge$  // Scenario3
      ToNeu_ZeroTorque= FALSE  $\Rightarrow$  time+tick  $\leq$  Zero_DL+RequestToNeuT
grd8 : ToNeu_RequestOpenClutch = TRUE  $\wedge$  ToNeu_OpenClutch= FALSE  $\wedge$ 
      Error_ToNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+ToNeu_RequestOpenClutchT
grd9 : ToNeu_ZeroTorque = TRUE  $\wedge$  ToNeu_Release_NoClutch= FALSE  $\wedge$ 
      Error_ToNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_ZeroTorqueT
grd10 : ToNeu_OpenClutch = TRUE  $\wedge$  ToNeu_Release_Clutch= FALSE  $\wedge$ 
      Error_ToNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL +ToNeu_OpenClutchT
grd11 : ToNeu_Release_Clutch = TRUE  $\wedge$  ToNeu_CloseClutch= FALSE  $\wedge$  // Scenario
      Error_ToNeu_CloseClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+ToNeu_Release 3
      _ClutchT
grd12 : RequestNoNeu = TRUE  $\wedge$  NoNeu_ZeroTorque = FALSE  $\wedge$  // Scenario2
      NoNeu_RequestOpenClutch_Releasing = FALSE
       $\Rightarrow$  time+tick  $\leq$  Zero_DL +RequestNoNeuT
grd13 : NoNeu_RequestOpenClutch_Releasing = TRUE  $\wedge$ 
      NoNeu_OpenClutch_Releasing = FALSE  $\wedge$ 
      Error_NoNeu_OpenClutch_Releasing = FALSE
       $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL +NoNeu_RequestOpenClutch_ReleasingT
grd14 : NoNeu_ZeroTorque = TRUE  $\wedge$  NoNeu_Release_NoClutch= FALSE  $\wedge$ 
      Error_NoNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_ZeroTorqueT
grd15 : NoNeu_Release_NoClutch = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$ 
      NoNeu_RequestOpenClutch_Setting = FALSE
       $\Rightarrow$  time+tick  $\leq$  Sync_DL+NoNeu_Release_NoClutchT
grd16 : NoNeu_RequestOpenClutch_Setting = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$ 
      Error_NoNeu_OpenClutch_Setting = FALSE
       $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+NoNeu_RequestOpenClutch_SettingT
grd17 : NoNeu_SyncSpeed = TRUE  $\wedge$  NoNeu_SetGear_NoClutch= FALSE  $\wedge$  // Scenario2
      Error_NoNeu_SetGear_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_Sy _1
      ncSpeedT
grd18 : NoNeu_OpenClutch_Setting = TRUE  $\wedge$  NoNeu_SetGear_SettingClutch= FALSE  $\wedge$ 
      Error_NoNeu_SetGear_SettingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_OpenClutch_Settin
      gT
grd19 : NoNeu_SetGear_SettingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Setting= FALSE  $\wedge$  // Scenario
      Error_NoNeu_CloseClutch_Setting= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNeu_ 2_2
      SetGear_SettingClutchT
grd20 : NoNeu_OpenClutch_Releasing = TRUE  $\wedge$  NoNeu_Release_Clutch= FALSE  $\wedge$ 
      Error_NoNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_OpenClutch_ReleasingT
grd21 : NoNeu_Release_Clutch = TRUE  $\wedge$  NoNeu_SetGear_ReleasingClutch= FALSE  $\wedge$ 
      Error_NoNeu_SetGear_ReleasingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_Release_Clutch
      T
grd22 : NoNeu_SetGear_ReleasingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Releasing= FALSE  $\wedge$  // Senari
      Error_NoNeu_CloseClutch_Releasing= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNe 02_3
      u_SetGear_ReleasingClutchT
grd23 : Channel_RequestFromNeu = TRUE  $\wedge$  Channel_Request_SyncSpeed = FALSE // Engine Channel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_RequestFromNeuT + Channel_DL

```

## Gear Controller Case-study (Time Added Manually)

```

grd24 : Channel_NoNeu_Release_NoClutch = TRUE  $\wedge$  Channel_Request_SyncSpeed = FALSE // Engine Channel
      SE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_Release_NoClutchT + Channel_DL
grd25 : Channel_RequestToNeu = TRUE  $\wedge$  Channel_Request_ZeroTorque = FALSE // EngineChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_RequestToNeuT + Channel_DL
grd26 : Channel_RequestNoNeu = TRUE  $\wedge$  Channel_Request_ZeroTorque = FALSE // EngineChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_RequestNoNeuT + Channel_DL
grd27 : Channel_ZeroTorque = TRUE  $\wedge$  Channel_ToNeu_ZeroTorque = FALSE  $\wedge$  Channel_NoNeu // EngineChannel
      u_ZeroTorque = FALSE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_ZeroTorqueT + Channel_DL
grd28 : Channel_SyncSpeed = TRUE  $\wedge$  Channel_FromNeu_SyncSpeed = FALSE  $\wedge$  Channel_NoNeu // EngineChannel
      eu_SyncSpeed = FALSE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_SyncSpeedT + Channel_DL
grd29 : Channel_FromNeu_RequestOpenClutch = TRUE  $\wedge$  Channel_Request_Open = FALSE // ClutchChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_FromNeu_RequestOpenClutchT + Channel_DL
grd30 : Channel_ToNeu_RequestOpenClutch = TRUE  $\wedge$  Channel_Request_Open = FALSE // ClutchChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_ToNeu_RequestOpenClutchT + Channel_DL
grd31 : Channel_NoNeu_RequestOpenClutch_Releasing = TRUE  $\wedge$  Channel_Request_Open = FALSE // ClutchChannel
      ALSE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_RequestOpenClutch_ReleasingT + Channel_DL
grd32 : Channel_NoNeu_RequestOpenClutch_Setting = TRUE  $\wedge$  Channel_Request_Open = FALSE // ClutchChannel
      LSE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_RequestOpenClutch_SettingT + Channel_DL
grd33 : Channel_FromNeu_SetGear_Clutch = TRUE  $\wedge$  Channel_Request_Close = FALSE // ClutchChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_FromNeu_SetGear_ClutchT + Channel_DL
grd34 : Channel_NoNeu_SetGear_ReleasingClutch = TRUE  $\wedge$  Channel_Request_Close = FALSE // ClutchChannel
      SE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_SetGear_ReleasingClutchT + Channel_DL
grd35 : Channel_NoNeu_SetGear_SettingClutch = TRUE  $\wedge$  Channel_Request_Close = FALSE // ClutchChannel
      E
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_FromNeu_SetGear_ClutchT + Channel_DL
grd36 : Channel_ToNeu_Release_Clutch = TRUE  $\wedge$  Channel_Request_Close = FALSE // ClutchChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_ToNeu_Release_ClutchT + Channel_DL
grd37 : Channel_Open = TRUE  $\wedge$  Channel_FromNeu_OpenClutch = FALSE  $\wedge$  Channel_ToNeu_Open // ClutchChannel
      Clutch = FALSE
       $\wedge$  Channel_NoNeu_OpenClutch_Releasing = FALSE  $\wedge$  Channel_NoNeu_OpenClutch_Setting = FALSE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_OpenT + Channel_DL
grd38 : Channel_Close = TRUE  $\wedge$  Channel_FromNeu_CloseClutch = FALSE  $\wedge$  Channel_ToNeu // ClutchChannel
      CloseClutch = FALSE
       $\wedge$  Channel_NoNeu_CloseClutch_Releasing = FALSE  $\wedge$  Channel_NoNeu_CloseClutch_Setting = FALSE
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_CloseT + Channel_DL
grd39 : Channel_ToNeu_ZeroTorque = TRUE  $\wedge$  Channel_Request_Release = FALSE // GearChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_ToNeu_ZeroTorqueT + Channel_DL
grd40 : Channel_ToNeu_OpenClutch = TRUE  $\wedge$  Channel_Request_Release = FALSE // GearChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_ToNeu_OpenClutchT + Channel_DL
grd41 : Channel_NoNeu_ZeroTorque = TRUE  $\wedge$  Channel_Request_Release = FALSE // GearChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_ZeroTorqueT + Channel_DL
grd42 : Channel_NoNeu_OpenClutch_Releasing = TRUE  $\wedge$  Channel_Request_Release = FALSE // GearChannel
      E
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_OpenClutch_ReleasingT + Channel_DL
grd43 : Channel_NoNeu_SyncSpeed = TRUE  $\wedge$  Channel_Request_Set = FALSE // GearChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_SyncSpeedT + Channel_DL
grd44 : Channel_NoNeu_OpenClutch_Setting = TRUE  $\wedge$  Channel_Request_Set = FALSE // GearChannel
       $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_OpenClutch_SettingT + Channel_DL

```

## Gear Controller Case-study (Time Added Manually)

```

grd45 : Channel_NoNeu_Release_Clutch = TRUE  $\wedge$  Channel_Request_Set = FALSE           // GearChannel
         $\Rightarrow$  Channel_time+tick  $\leq$  Channel_NoNeu_Release_ClutchT + Channel_DL
grd46 : Channel_FromNeu_SyncSpeed = TRUE  $\wedge$  Channel_Set = FALSE                   // GearChannel
         $\Rightarrow$  Channel_time+tick  $\leq$  Channel_FromNeu_SyncSpeedT + Channel_DL
grd47 : Channel_ToNeu_OpenClutch = TRUE  $\wedge$  Channel_Set = FALSE                   // GearChannel
         $\Rightarrow$  Channel_time+tick  $\leq$  Channel_ToNeu_OpenClutchT + Channel_DL
grd48 : Channel_Release = TRUE  $\wedge$  Channel_ToNeu_Release_Clutch = FALSE  $\wedge$  Channel_ToNeu_ // GearCha
        Release_NoClutch = FALSE                                                nnel
        :  $\wedge$  Channel_NoNeu_Release_NoClutch = FALSE  $\wedge$  Channel_NoNeu_Release_Clutch
        = FALSE
         $\Rightarrow$  Channel_time+tick  $\leq$  Channel_ReleaseT + Channel_DL
grd49 : Channel_Set = TRUE  $\wedge$  Channel_FromNeu_SetGear_Clutch = FALSE  $\wedge$  Channel_FromNeu_ // GearCh
        SetGear_NoClutch = FALSE                                                annel
        :  $\wedge$  Channel_NoNeu_SetGear_NoClutch = FALSE  $\wedge$  Channel_NoNeu_SetGear_Releas
        ingClutch = FALSE
         $\wedge$  Channel_NoNeu_SetGear_SettingClutch = FALSE
         $\Rightarrow$  Channel_time+tick  $\leq$  Channel_SetT + Channel_DL
grd50 : Engine_Request_SyncSpeed = TRUE  $\wedge$  Engine_SyncSpeed = FALSE  $\wedge$  Engine_WaitForSyncCl // Engi
        utch = FALSE                                                            ne
         $\Rightarrow$  Engine_time+tick  $\leq$  Engine_Request_SyncSpeedT + Engine_Sync_DL
grd51 : Engine_Request_ZeroTorque = TRUE  $\wedge$  Engine_ZeroTorque = FALSE  $\wedge$  Engine_WaitForZero // Engi
        Clutch = FALSE                                                            ne
         $\Rightarrow$  Engine_time+tick  $\leq$  Engine_Request_ZeroTorqueT + Engine_Zero_DL
grd52 : Clutch_Request_Open = TRUE  $\wedge$  Clutch_Open = FALSE  $\wedge$  Error_Clutch_Open = FALSE // Clutch
         $\Rightarrow$  Clutch_time+tick  $\leq$  Clutch_Request_OpenT + Clutch_Open_DL
grd53 : Clutch_Request_Close = TRUE  $\wedge$  Clutch_Close = FALSE  $\wedge$  Error_Clutch_Close = FALSE // Clutch
         $\Rightarrow$  Clutch_time+tick  $\leq$  Clutch_Request_CloseT + Clutch_Close_DL
grd54 : Gear_Request_Release = TRUE  $\wedge$  Gear_Release = FALSE  $\wedge$  Error_Gear_Release = FALSE // Gear
         $\Rightarrow$  Gear_time+tick  $\leq$  Gear_Request_ReleaseT + Gear_Release_DL
grd55 : Gear_Request_Set = TRUE  $\wedge$  Gear_Set = FALSE  $\wedge$  Error_Gear_Set = FALSE // Gear
         $\Rightarrow$  Gear_time+tick  $\leq$  Gear_Request_SetT + Gear_Set_DL

THEN
act1 : time := time + tick
act2 : Channel_time := Channel_time + tick
act3 : Engine_time := Engine_time + tick
act4 : Gear_time := Gear_time + tick
act5 : Clutch_time := Clutch_time + tick

END

END

```

## Decomposed Machine Controller

### MACHINE

Controller

### SEES

c6

### VARIABLES

time  
isNeu  
RequestFromNeu  
FromNeu\_SyncSpeed  
FromNeu\_RequestOpenClutch  
FromNeu\_OpenClutch  
FromNeu\_SetGear\_NoClutch  
FromNeu\_SetGear\_Clutch  
FromNeu\_CloseClutch  
Error\_FromNeu\_OpenClutch  
Error\_FromNeu\_SetGear\_NoClutch  
Error\_FromNeu\_SetGear\_Clutch  
Error\_FromNeu\_CloseClutch  
RequestFromNeuT  
FromNeu\_OpenClutchT  
FromNeu\_SyncSpeedT  
FromNeu\_SetGear\_ClutchT  
RequestToNeu  
ToNeu\_ZeroTorque  
ToNeu\_RequestOpenClutch  
ToNeu\_OpenClutch  
Error\_ToNeu\_OpenClutch  
ToNeu\_Release\_NoClutch  
Error\_ToNeu\_Release\_NoClutch  
ToNeu\_Release\_Clutch  
Error\_ToNeu\_Release\_Clutch  
ToNeu\_CloseClutch  
Error\_ToNeu\_CloseClutch  
RequestToNeuT  
ToNeu\_ZeroTorqueT  
ToNeu\_OpenClutchT  
ToNeu\_Release\_ClutchT  
RequestNoNeu  
NoNeu\_ZeroTorque  
NoNeu\_Release\_NoClutch  
NoNeu\_RequestOpenClutch\_Releasing  
NoNeu\_OpenClutch\_Releasing  
NoNeu\_Release\_Clutch  
NoNeu\_SyncSpeed  
NoNeu\_RequestOpenClutch\_Setting  
NoNeu\_OpenClutch\_Setting  
NoNeu\_SetGear\_NoClutch  
NoNeu\_SetGear\_ReleasingClutch  
NoNeu\_SetGear\_SettingClutch  
NoNeu\_CloseClutch\_Releasing  
NoNeu\_CloseClutch\_Setting  
Error\_NoNeu\_OpenClutch\_Releasing  
Error\_NoNeu\_Release\_Clutch  
Error\_NoNeu\_Release\_NoClutch  
Error\_NoNeu\_OpenClutch\_Setting  
Error\_NoNeu\_SetGear\_NoClutch  
Error\_NoNeu\_SetGear\_ReleasingClutch  
Error\_NoNeu\_SetGear\_SettingClutch  
Error\_NoNeu\_CloseClutch\_Releasing  
Error\_NoNeu\_CloseClutch\_Setting  
RequestNoNeuT  
NoNeu\_ZeroTorqueT  
NoNeu\_Release\_NoClutchT  
NoNeu\_OpenClutch\_ReleasingT  
NoNeu\_Release\_ClutchT  
NoNeu\_SetGear\_ReleasingClutchT

## Gear Controller Case-study (Time Added Manually)

NoNeu\_SetGear\_SettingClutchT  
NoNeu\_SyncSpeedT  
NoNeu\_OpenClutch\_SettingT  
FromNeu\_RequestOpenClutchT  
ToNeu\_RequestOpenClutchT  
NoNeu\_RequestOpenClutch\_ReleasingT  
NoNeu\_RequestOpenClutch\_SettingT

### INVARIANTS

*typing\_NoNeu\_Release\_NoClutch* : NoNeu\_Release\_NoClutch  $\in$  BOOL  
*typing\_NoNeu\_OpenClutch\_SettingT* : NoNeu\_OpenClutch\_SettingT  $\in$   $\mathbb{Z}$   
*typing\_NoNeu\_OpenClutch\_Setting* : NoNeu\_OpenClutch\_Setting  $\in$  BOOL  
*typing\_NoNeu\_SetGear\_SettingClutch* : NoNeu\_SetGear\_SettingClutch  $\in$  BOOL  
*typing\_NoNeu\_OpenClutch\_ReleasingT* : NoNeu\_OpenClutch\_ReleasingT  $\in$   $\mathbb{Z}$   
*typing\_ToNeu\_RequestOpenClutchT* : ToNeu\_RequestOpenClutchT  $\in$   $\mathbb{Z}$   
*typing\_Error\_ToNeu\_CloseClutch* : Error\_ToNeu\_CloseClutch  $\in$  BOOL  
*typing\_Error\_NoNeu\_SetGear\_SettingClutch* : Error\_NoNeu\_SetGear\_SettingClutch  $\in$  BOOL  
*typing\_FromNeu\_SetGear\_Clutch* : FromNeu\_SetGear\_Clutch  $\in$  BOOL  
*typing\_time* : time  $\in$   $\mathbb{Z}$   
*typing\_ToNeu\_ZeroTorque* : ToNeu\_ZeroTorque  $\in$  BOOL  
*typing\_FromNeu\_SetGear\_ClutchT* : FromNeu\_SetGear\_ClutchT  $\in$   $\mathbb{Z}$   
*typing\_Error\_NoNeu\_OpenClutch\_Setting* : Error\_NoNeu\_OpenClutch\_Setting  $\in$  BOOL  
*typing\_NoNeu\_CloseClutch\_Releasing* : NoNeu\_CloseClutch\_Releasing  $\in$  BOOL  
*typing\_Error\_NoNeu\_Release\_NoClutch* : Error\_NoNeu\_Release\_NoClutch  $\in$  BOOL  
*typing\_FromNeu\_SyncSpeedT* : FromNeu\_SyncSpeedT  $\in$   $\mathbb{Z}$   
*typing\_NoNeu\_OpenClutch\_Releasing* : NoNeu\_OpenClutch\_Releasing  $\in$  BOOL  
*typing\_NoNeu\_Release\_NoClutchT* : NoNeu\_Release\_NoClutchT  $\in$   $\mathbb{Z}$   
*typing\_isNeu* : isNeu  $\in$  BOOL  
*typing\_FromNeu\_OpenClutch* : FromNeu\_OpenClutch  $\in$  BOOL  
*typing\_RequestToNeuT* : RequestToNeuT  $\in$   $\mathbb{Z}$   
*typing\_NoNeu\_ZeroTorque* : NoNeu\_ZeroTorque  $\in$  BOOL  
*typing\_NoNeu\_Release\_ClutchT* : NoNeu\_Release\_ClutchT  $\in$   $\mathbb{Z}$   
*typing\_Error\_NoNeu\_CloseClutch\_Releasing* : Error\_NoNeu\_CloseClutch\_Releasing  $\in$  BOOL  
*typing\_FromNeu\_RequestOpenClutch* : FromNeu\_RequestOpenClutch  $\in$  BOOL  
*typing\_Error\_FromNeu\_SetGear\_Clutch* : Error\_FromNeu\_SetGear\_Clutch  $\in$  BOOL  
*typing\_NoNeu\_ZeroTorqueT* : NoNeu\_ZeroTorqueT  $\in$   $\mathbb{Z}$   
*typing\_NoNeu\_SyncSpeed* : NoNeu\_SyncSpeed  $\in$  BOOL  
*typing\_NoNeu\_RequestOpenClutch\_Setting* : NoNeu\_RequestOpenClutch\_Setting  $\in$  BOOL  
*typing\_RequestFromNeuT* : RequestFromNeuT  $\in$   $\mathbb{Z}$   
*typing\_FromNeu\_RequestOpenClutchT* : FromNeu\_RequestOpenClutchT  $\in$   $\mathbb{Z}$   
*typing\_Error\_ToNeu\_Release\_NoClutch* : Error\_ToNeu\_Release\_NoClutch  $\in$  BOOL  
*typing\_NoNeu\_SetGear\_NoClutch* : NoNeu\_SetGear\_NoClutch  $\in$  BOOL  
*typing\_FromNeu\_OpenClutchT* : FromNeu\_OpenClutchT  $\in$   $\mathbb{Z}$   
*typing\_RequestNoNeu* : RequestNoNeu  $\in$  BOOL  
*typing\_ToNeu\_RequestOpenClutch* : ToNeu\_RequestOpenClutch  $\in$  BOOL  
*typing\_ToNeu\_CloseClutch* : ToNeu\_CloseClutch  $\in$  BOOL  
*typing\_ToNeu\_OpenClutchT* : ToNeu\_OpenClutchT  $\in$   $\mathbb{Z}$   
*typing\_Error\_FromNeu\_CloseClutch* : Error\_FromNeu\_CloseClutch  $\in$  BOOL  
*typing\_Error\_ToNeu\_OpenClutch* : Error\_ToNeu\_OpenClutch  $\in$  BOOL  
*typing\_Error\_FromNeu\_OpenClutch* : Error\_FromNeu\_OpenClutch  $\in$  BOOL  
*typing\_ToNeu\_Release\_Clutch* : ToNeu\_Release\_Clutch  $\in$  BOOL  
*typing\_ToNeu\_ZeroTorqueT* : ToNeu\_ZeroTorqueT  $\in$   $\mathbb{Z}$   
*typing\_NoNeu\_RequestOpenClutch\_ReleasingT* : NoNeu\_RequestOpenClutch\_ReleasingT  $\in$   $\mathbb{Z}$   
*typing\_NoNeu\_SetGear\_SettingClutchT* : NoNeu\_SetGear\_SettingClutchT  $\in$   $\mathbb{Z}$   
*typing\_FromNeu\_CloseClutch* : FromNeu\_CloseClutch  $\in$  BOOL  
*typing\_RequestNoNeuT* : RequestNoNeuT  $\in$   $\mathbb{Z}$   
*typing\_Error\_ToNeu\_Release\_Clutch* : Error\_ToNeu\_Release\_Clutch  $\in$  BOOL  
*typing\_Error\_NoNeu\_Release\_Clutch* : Error\_NoNeu\_Release\_Clutch  $\in$  BOOL  
*typing\_Error\_NoNeu\_SetGear\_ReleasingClutch* : Error\_NoNeu\_SetGear\_ReleasingClutch  $\in$  BOOL  
*typing\_ToNeu\_OpenClutch* : ToNeu\_OpenClutch  $\in$  BOOL  
*typing\_ToNeu\_Release\_NoClutch* : ToNeu\_Release\_NoClutch  $\in$  BOOL  
*typing\_NoNeu\_SetGear\_ReleasingClutchT* : NoNeu\_SetGear\_ReleasingClutchT  $\in$   $\mathbb{Z}$   
*typing\_FromNeu\_SetGear\_NoClutch* : FromNeu\_SetGear\_NoClutch  $\in$  BOOL  
*typing\_NoNeu\_SyncSpeedT* : NoNeu\_SyncSpeedT  $\in$   $\mathbb{Z}$   
*typing\_NoNeu\_SetGear\_ReleasingClutch* : NoNeu\_SetGear\_ReleasingClutch  $\in$  BOOL  
*typing\_ToNeu\_Release\_ClutchT* : ToNeu\_Release\_ClutchT  $\in$   $\mathbb{Z}$   
*typing\_Error\_FromNeu\_SetGear\_NoClutch* : Error\_FromNeu\_SetGear\_NoClutch  $\in$  BOOL  
*typing\_NoNeu\_RequestOpenClutch\_SettingT* : NoNeu\_RequestOpenClutch\_SettingT  $\in$   $\mathbb{Z}$   
*typing\_Error\_NoNeu\_OpenClutch\_Releasing* : Error\_NoNeu\_OpenClutch\_Releasing  $\in$  BOOL  
*typing\_NoNeu\_RequestOpenClutch\_Releasing* : NoNeu\_RequestOpenClutch\_Releasing  $\in$  BOOL



## Gear Controller Case-study (Time Added Manually)

*typing\_RequestToNeu* : RequestToNeu ∈ BOOL  
*typing\_NoNeu\_CloseClutch\_Setting* : NoNeu\_CloseClutch\_Setting ∈ BOOL  
*typing\_NoNeu\_Release\_Clutch* : NoNeu\_Release\_Clutch ∈ BOOL  
*typing\_RequestFromNeu* : RequestFromNeu ∈ BOOL  
*typing\_FromNeu\_SyncSpeed* : FromNeu\_SyncSpeed ∈ BOOL  
*typing\_Error\_NoNeu\_SetGear\_NoClutch* : Error\_NoNeu\_SetGear\_NoClutch ∈ BOOL  
*typing\_Error\_NoNeu\_CloseClutch\_Setting* : Error\_NoNeu\_CloseClutch\_Setting ∈ BOOL  
*m0\_inv2* : time ∈ ℕ  
*m1\_inv6* : RequestFromNeu = TRUE ⇒ RequestToNeu = FALSE ∧ RequestNoNeu = FALSE  
*m1\_inv7* : RequestToNeu = TRUE ⇒ RequestFromNeu = FALSE ∧ RequestNoNeu = FALSE  
*m1\_inv8* : RequestNoNeu = TRUE ⇒ RequestFromNeu = FALSE ∧ RequestToNeu = FALSE  
*m1\_inv15* : {RequestFromNeuT, RequestNoNeuT, RequestToNeuT} ⊆ ℕ  
          {FromNeu\_SyncSpeed, FromNeu\_OpenClutch, FromNeu\_SetGear\_NoClutch, FromNeu\_SetGear\_Clutch,  
*m5\_inv1* :       FromNeu\_CloseClutch, Error\_FromNeu\_OpenClutch, Error\_FromNeu\_SetGear\_NoClutch,  
                  Error\_FromNeu\_SetGear\_Clutch, Error\_FromNeu\_CloseClutch} ∈ ℙ(BOOL)  
*m5\_inv2* : {FromNeu\_OpenClutchT, FromNeu\_SyncSpeedT, FromNeu\_SetGear\_ClutchT} ⊆ ℕ  
*m5\_inv5* : FromNeu\_SyncSpeed = TRUE ∨ FromNeu\_OpenClutch = TRUE ⇒ RequestFromNeu = TRUE  
*m5\_inv6* : FromNeu\_SetGear\_Clutch = TRUE ⇒ FromNeu\_OpenClutch = TRUE  
*m5\_inv7* : FromNeu\_SetGear\_NoClutch = TRUE ⇒ FromNeu\_SyncSpeed = TRUE  
*m5\_inv8* : FromNeu\_SyncSpeed = TRUE ⇒ FromNeu\_OpenClutch = FALSE ∧ Error\_FromNeu\_OpenClutch = FALSE  
*m5\_inv9* : FromNeu\_CloseClutch = TRUE ⇒ FromNeu\_SetGear\_Clutch = TRUE  
*m5\_inv10* : FromNeu\_OpenClutch=FALSE ⇒ FromNeu\_CloseClutch = FALSE  
*m5\_inv13* : FromNeu\_SetGear\_Clutch = TRUE ⇒ Error\_FromNeu\_SetGear\_Clutch = FALSE  
*m5\_inv14* : FromNeu\_SetGear\_NoClutch = TRUE ⇒ Error\_FromNeu\_SetGear\_NoClutch = FALSE  
*m5\_inv15* : FromNeu\_CloseClutch = TRUE ⇒ Error\_FromNeu\_CloseClutch = FALSE  
*m5\_inv16* : FromNeu\_OpenClutch = TRUE ⇒ Error\_FromNeu\_OpenClutch = FALSE  
*m5\_inv17* : RequestFromNeu = TRUE ∧ Error\_FromNeu\_SetGear\_Clutch = TRUE ⇒ FromNeu\_OpenClutch = TRUE  
*m5\_inv18* : RequestFromNeu = TRUE ∧ Error\_FromNeu\_SetGear\_NoClutch = TRUE ⇒ FromNeu\_SyncSpeed = TRUE  
*m5\_inv19* : RequestFromNeu = TRUE ∧ Error\_FromNeu\_CloseClutch = TRUE ⇒ FromNeu\_SetGear\_Clutch = TRUE  
*m5\_inv20* : FromNeu\_SyncSpeed = TRUE ⇒ FromNeu\_SyncSpeedT ≤ RequestFromNeuT + SyncOpen\_DL  
*m5\_inv21* : FromNeu\_OpenClutch = TRUE ⇒ FromNeu\_OpenClutchT ≤ RequestFromNeuT + SyncOpen\_DL  
*m5\_inv22* : FromNeu\_SetGear\_Clutch = TRUE ⇒ FromNeu\_SetGear\_ClutchT ≤ FromNeu\_OpenClutchT + SetGear\_DL  
*m5\_inv23* : RequestFromNeu = TRUE ∧ FromNeu\_SyncSpeed= FALSE ∧  
          FromNeu\_OpenClutch = FALSE ∧ Error\_FromNeu\_OpenClutch = FALSE ⇒ time ≤ SyncOpen\_DL+Re  
          questFromNeuT  
*m5\_inv24* :       FromNeu\_OpenClutch = TRUE ∧ FromNeu\_SetGear\_Clutch= FALSE ∧  
                  Error\_FromNeu\_SetGear\_Clutch = FALSE ⇒ time ≤ SetGear\_DL+FromNeu\_OpenClutchT  
          {ToNeu\_ZeroTorque, ToNeu\_OpenClutch, Error\_ToNeu\_OpenClutch, ToNeu\_Release\_NoClutch, Error\_ToNeu  
*m6\_inv1* :       \_Release\_NoClutch,  
          ToNeu\_Release\_Clutch, Error\_ToNeu\_Release\_Clutch, ToNeu\_CloseClutch, Error\_ToNeu\_CloseClutch} ∈  
          ℙ(BOOL)  
*m6\_inv2* : {ToNeu\_ZeroTorqueT, ToNeu\_OpenClutchT, ToNeu\_Release\_ClutchT} ⊆ ℕ  
*m6\_inv5* : ToNeu\_ZeroTorque = TRUE ∨ ToNeu\_OpenClutch = TRUE ⇒ RequestToNeu = TRUE  
*m6\_inv6* : ToNeu\_Release\_NoClutch = TRUE ⇒ ToNeu\_ZeroTorque = TRUE  
*m6\_inv7* : ToNeu\_Release\_Clutch = TRUE ⇒ ToNeu\_OpenClutch = TRUE  
*m6\_inv8* : ToNeu\_ZeroTorque = TRUE ⇒ ToNeu\_OpenClutch = FALSE ∧ Error\_ToNeu\_OpenClutch = FALSE  
*m6\_inv9* : ToNeu\_CloseClutch = TRUE ⇒ ToNeu\_Release\_Clutch = TRUE  
*m6\_inv10* : ToNeu\_OpenClutch=FALSE ⇒ ToNeu\_CloseClutch = FALSE  
*m6\_inv13* : ToNeu\_Release\_Clutch = TRUE ⇒ Error\_ToNeu\_Release\_Clutch = FALSE  
*m6\_inv14* : ToNeu\_Release\_NoClutch = TRUE ⇒ Error\_ToNeu\_Release\_NoClutch = FALSE  
*m6\_inv15* : ToNeu\_CloseClutch = TRUE ⇒ Error\_ToNeu\_CloseClutch = FALSE  
*m6\_inv16* : ToNeu\_OpenClutch = TRUE ⇒ Error\_ToNeu\_OpenClutch = FALSE  
*m6\_inv17* : RequestToNeu = TRUE ∧ Error\_ToNeu\_Release\_Clutch = TRUE ⇒ ToNeu\_OpenClutch = TRUE  
*m6\_inv18* : RequestToNeu = TRUE ∧ Error\_ToNeu\_Release\_NoClutch = TRUE ⇒ ToNeu\_ZeroTorque = TRUE  
*m6\_inv19* : RequestToNeu = TRUE ∧ Error\_ToNeu\_CloseClutch = TRUE ⇒ ToNeu\_Release\_Clutch = TRUE  
*m6\_inv20* : ToNeu\_ZeroTorque = TRUE ⇒ ToNeu\_ZeroTorqueT ≤ RequestToNeuT + ZeroOpen\_DL  
*m6\_inv21* : ToNeu\_OpenClutch = TRUE ⇒ ToNeu\_OpenClutchT ≤ RequestToNeuT + ZeroOpen\_DL  
*m6\_inv22* : ToNeu\_Release\_Clutch = TRUE ⇒ ToNeu\_Release\_ClutchT ≤ ToNeu\_OpenClutchT + Release\_DL  
*m6\_inv23* : RequestToNeu = TRUE ∧ ToNeu\_ZeroTorque= FALSE ∧  
          ToNeu\_OpenClutch = FALSE ∧ Error\_ToNeu\_OpenClutch = FALSE ⇒ time ≤ ZeroOpen\_DL+Request  
          ToNeuT  
*m6\_inv24* :       ToNeu\_OpenClutch = TRUE ∧ ToNeu\_Release\_Clutch= FALSE ∧  
                  Error\_ToNeu\_Release\_Clutch = FALSE ⇒ time ≤ Release\_DL+ToNeu\_OpenClutchT  
*m7\_inv1* : {NoNeu\_ZeroTorque, NoNeu\_OpenClutch\_Releasing, Error\_NoNeu\_OpenClutch\_Releasing, NoNeu\_Release\_  
          NoClutch,  
          Error\_NoNeu\_Release\_NoClutch, NoNeu\_Release\_Clutch, Error\_NoNeu\_Release\_Clutch,

## Gear Controller Case-study (Time Added Manually)

$\text{NoNeu\_SyncSpeed, NoNeu\_OpenClutch\_Setting, Error\_NoNeu\_OpenClutch\_Setting,}$   
 $\text{NoNeu\_SetGear\_NoClutch, Error\_NoNeu\_SetGear\_NoClutch, NoNeu\_SetGear\_ReleasingClutch,}$   
 $\text{NoNeu\_SetGear\_SettingClutch, Error\_NoNeu\_SetGear\_ReleasingClutch, Error\_NoNeu\_SetGear\_SettingCl}$   
 $\text{utch,}$   
 $\text{NoNeu\_CloseClutch\_Setting, Error\_NoNeu\_CloseClutch\_Releasing, Error\_NoNeu\_CloseClutch\_Setting,}$   
 $\text{NoNeu\_CloseClutch\_Releasing} \} \in \mathbb{P}(\text{BOOL})$   
 $\{\text{NoNeu\_ZeroTorqueT, NoNeu\_Release\_NoClutchT,}$   
 $\text{NoNeu\_OpenClutch\_ReleasingT, NoNeu\_Release\_ClutchT,}$   
 $\text{NoNeu\_SyncSpeedT, NoNeu\_OpenClutch\_SettingT,}$   
 $\text{NoNeu\_SetGear\_ReleasingClutchT, NoNeu\_SetGear\_SettingClutchT,}$   
 $\text{NoNeu\_OpenClutch\_ReleasingT, NoNeu\_OpenClutch\_SettingT} \} \subseteq \mathbb{N}$

$m7\_inv2 : \text{NoNeu\_SyncSpeedT, NoNeu\_OpenClutch\_SettingT,}$   
 $\text{NoNeu\_SetGear\_ReleasingClutchT, NoNeu\_SetGear\_SettingClutchT,}$   
 $\text{NoNeu\_OpenClutch\_ReleasingT, NoNeu\_OpenClutch\_SettingT} \subseteq \mathbb{N}$

$m7\_inv8 : \text{NoNeu\_ZeroTorque} = \text{TRUE} \vee \text{NoNeu\_OpenClutch\_Releasing} = \text{TRUE} \Rightarrow \text{RequestNoNeu} = \text{TRUE}$   
 $m7\_inv9 : \text{NoNeu\_Release\_NoClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_ZeroTorque} = \text{TRUE}$   
 $m7\_inv10 : \text{NoNeu\_Release\_Clutch} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_Releasing} = \text{TRUE}$   
 $m7\_inv11 : \text{NoNeu\_ZeroTorque} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_Releasing} = \text{FALSE} \wedge \text{Error\_NoNeu\_OpenClutch\_Relea}$   
 $\text{sing} = \text{FALSE}$   
 $m7\_inv14 : \text{NoNeu\_Release\_Clutch} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_Release\_Clutch} = \text{FALSE}$   
 $m7\_inv15 : \text{NoNeu\_Release\_NoClutch} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_Release\_NoClutch} = \text{FALSE}$   
 $m7\_inv16 : \text{NoNeu\_OpenClutch\_Releasing} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_OpenClutch\_Releasing} = \text{FALSE}$   
 $m7\_inv17 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_Release\_Clutch} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_Releasing} = \text{TRU}$   
 $\text{E}$   
 $m7\_inv18 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_Release\_NoClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_ZeroTorque} = \text{TRUE}$   
 $m7\_inv19 : \text{NoNeu\_SyncSpeed} = \text{TRUE} \vee \text{NoNeu\_OpenClutch\_Setting} = \text{TRUE} \Rightarrow \text{NoNeu\_Release\_NoClutch} = \text{TRUE}$   
 $m7\_inv20 : \text{NoNeu\_SetGear\_ReleasingClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_Release\_Clutch} = \text{TRUE}$   
 $m7\_inv21 : \text{NoNeu\_SetGear\_SettingClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_Setting} = \text{TRUE}$   
 $m7\_inv22 : \text{NoNeu\_SetGear\_NoClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_SyncSpeed} = \text{TRUE}$   
 $m7\_inv23 : \text{NoNeu\_SyncSpeed} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_Setting} = \text{FALSE} \wedge \text{Error\_NoNeu\_OpenClutch\_Setting} =$   
 $\text{FALSE}$   
 $m7\_inv24 : \text{NoNeu\_CloseClutch\_Releasing} = \text{TRUE} \Rightarrow \text{NoNeu\_SetGear\_ReleasingClutch} = \text{TRUE}$   
 $m7\_inv25 : \text{NoNeu\_CloseClutch\_Setting} = \text{TRUE} \Rightarrow \text{NoNeu\_SetGear\_SettingClutch} = \text{TRUE}$   
 $m7\_inv28 : \text{NoNeu\_SetGear\_ReleasingClutch} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_SetGear\_ReleasingClutch} = \text{FALSE}$   
 $m7\_inv29 : \text{NoNeu\_SetGear\_SettingClutch} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_SetGear\_SettingClutch} = \text{FALSE}$   
 $m7\_inv30 : \text{NoNeu\_SetGear\_NoClutch} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_SetGear\_NoClutch} = \text{FALSE}$   
 $m7\_inv31 : \text{NoNeu\_CloseClutch\_Releasing} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_CloseClutch\_Releasing} = \text{FALSE}$   
 $m7\_inv32 : \text{NoNeu\_CloseClutch\_Setting} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_CloseClutch\_Setting} = \text{FALSE}$   
 $m7\_inv34 : \text{NoNeu\_OpenClutch\_Setting} = \text{TRUE} \Rightarrow \text{Error\_NoNeu\_OpenClutch\_Setting} = \text{FALSE}$   
 $m7\_inv35 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_SetGear\_ReleasingClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_Release\_Clutch} = \text{TRU}$   
 $\text{E}$   
 $m7\_inv36 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_SetGear\_SettingClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_Setting} = \text{T}$   
 $\text{RUE}$   
 $m7\_inv37 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_SetGear\_NoClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_SyncSpeed} = \text{TRUE}$   
 $m7\_inv38 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_CloseClutch\_Releasing} = \text{TRUE} \Rightarrow \text{NoNeu\_SetGear\_ReleasingClutch}$   
 $\text{h} = \text{TRUE}$   
 $m7\_inv39 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_CloseClutch\_Setting} = \text{TRUE} \Rightarrow \text{NoNeu\_SetGear\_SettingClutch} =$   
 $\text{TRUE}$   
 $m7\_inv40 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{Error\_NoNeu\_OpenClutch\_Setting} = \text{TRUE} \Rightarrow \text{NoNeu\_Release\_NoClutch} = \text{TRU}$   
 $\text{E}$   
 $m7\_inv41 : \text{NoNeu\_Release\_Clutch} = \text{TRUE} \Rightarrow \text{NoNeu\_SyncSpeed} = \text{FALSE} \wedge \text{NoNeu\_OpenClutch\_Setting} = \text{FALSE}$   
 $m7\_inv42 : \text{NoNeu\_ZeroTorque} = \text{TRUE} \Rightarrow \text{NoNeu\_ZeroTorqueT} \leq \text{RequestNoNeuT} + \text{Zero\_EX}$   
 $m7\_inv43 : \text{NoNeu\_OpenClutch\_Releasing} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_ReleasingT} \leq \text{RequestNoNeuT} + \text{ZeroOpen\_}$   
 $\text{DL}$   
 $m7\_inv44 : \text{NoNeu\_SyncSpeed} = \text{TRUE} \Rightarrow \text{NoNeu\_SyncSpeedT} \leq \text{NoNeu\_Release\_NoClutchT} + \text{Sync\_EX}$   
 $m7\_inv45 : \text{NoNeu\_OpenClutch\_Setting} = \text{TRUE} \Rightarrow \text{NoNeu\_OpenClutch\_SettingT} \leq \text{NoNeu\_Release\_NoClutchT} + \text{Sync}$   
 $\text{Open\_DL}$   
 $m7\_inv46 : \text{NoNeu\_SetGear\_ReleasingClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_SetGear\_ReleasingClutchT} \leq \text{NoNeu\_Release\_ClutchT} +$   
 $\text{SetGear\_DL}$   
 $m7\_inv47 : \text{NoNeu\_SetGear\_SettingClutch} = \text{TRUE} \Rightarrow \text{NoNeu\_SetGear\_SettingClutchT} \leq \text{NoNeu\_OpenClutch\_SettingT} +$   
 $\text{SetGear\_DL}$   
 $m7\_inv48 : \text{RequestNoNeu} = \text{TRUE} \wedge \text{NoNeu\_ZeroTorque} = \text{FALSE} \wedge$   
 $\text{NoNeu\_OpenClutch\_Releasing} = \text{FALSE} \wedge \text{Error\_NoNeu\_OpenClutch\_Releasing} = \text{FALSE} \Rightarrow \text{time} \leq \text{Zer}$   
 $\text{oOpen\_DL} + \text{RequestNoNeuT}$   
 $m7\_inv49 : \text{NoNeu\_Release\_NoClutch} = \text{TRUE} \wedge \text{NoNeu\_SyncSpeed} = \text{FALSE} \wedge \text{NoNeu\_OpenClutch\_Setting} = \text{FALSE}$   
 $\wedge$   
 $\text{Error\_NoNeu\_OpenClutch\_Setting} = \text{FALSE} \Rightarrow \text{time} \leq \text{SyncOpen\_DL} + \text{NoNeu\_Release\_NoClutchT}$   
 $m7\_inv50 : \text{NoNeu\_Release\_Clutch} = \text{TRUE} \wedge \text{NoNeu\_SetGear\_ReleasingClutch} = \text{FALSE} \wedge$   
 $\text{Error\_NoNeu\_SetGear\_ReleasingClutch} = \text{FALSE} \Rightarrow \text{time} \leq \text{SetGear\_DL} + \text{NoNeu\_Release\_ClutchT}$



## Gear Controller Case-study (Time Added Manually)

```

m7_inv51 : NoNeu_OpenClutch_Setting = TRUE  $\wedge$  NoNeu_SetGear_SettingClutch= FALSE  $\wedge$ 
           Error_NoNeu_SetGear_SettingClutch= FALSE  $\Rightarrow$  time  $\leq$  SetGear_DL+NoNeu_OpenClutch_SettingT
m7_inv52 : NoNeu_ZeroTorque = TRUE  $\wedge$  NoNeu_Release_NoClutch= FALSE  $\wedge$ 
           Error_NoNeu_Release_NoClutch= FALSE  $\Rightarrow$  time  $\leq$  Release_DL+NoNeu_ZeroTorqueT
m7_inv55 : NoNeu_Release_NoClutch = TRUE  $\Rightarrow$  NoNeu_Release_NoClutchT  $\leq$  NoNeu_ZeroTorqueT + Release_DL
m8_inv4 : {FromNeu_RequestOpenClutchT, ToNeu_RequestOpenClutchT,
           NoNeu_RequestOpenClutch_ReleasingT, NoNeu_RequestOpenClutch_SettingT}  $\subseteq$   $\mathbb{N}$ 
m8_inv5 : FromNeu_RequestOpenClutch = TRUE  $\Rightarrow$  FromNeu_SyncSpeed = FALSE  $\wedge$  RequestFromNeu = TRUE
m8_inv6 : FromNeu_RequestOpenClutch = FALSE  $\Rightarrow$  FromNeu_OpenClutch = FALSE  $\wedge$  Error_FromNeu_OpenClutch =
           FALSE
m8_inv7 : ToNeu_RequestOpenClutch = TRUE  $\Rightarrow$  ToNeu_ZeroTorque = FALSE  $\wedge$  RequestToNeu = TRUE
m8_inv8 : ToNeu_RequestOpenClutch = FALSE  $\Rightarrow$  ToNeu_OpenClutch = FALSE  $\wedge$  Error_ToNeu_OpenClutch = FALSE
m8_inv9 : NoNeu_RequestOpenClutch_Releasing = TRUE  $\Rightarrow$  NoNeu_ZeroTorque = FALSE  $\wedge$  RequestNoNeu = TRUE
m8_inv10 : NoNeu_RequestOpenClutch_Releasing = FALSE  $\Rightarrow$  NoNeu_OpenClutch_Releasing = FALSE  $\wedge$  Error_NoNeu_
           OpenClutch_Releasing = FALSE
m8_inv11 : NoNeu_RequestOpenClutch_Setting = TRUE  $\Rightarrow$  NoNeu_SyncSpeed = FALSE  $\wedge$  NoNeu_Release_NoClutch
           = TRUE
m8_inv12 : NoNeu_RequestOpenClutch_Setting = FALSE  $\Rightarrow$  NoNeu_OpenClutch_Setting = FALSE  $\wedge$  Error_NoNeu_Open
           Clutch_Setting = FALSE
m8_inv13 : FromNeu_RequestOpenClutch = TRUE  $\Rightarrow$  FromNeu_RequestOpenClutchT  $\leq$  RequestFromNeuT + Sync_DL
m8_inv14 : ToNeu_RequestOpenClutch = TRUE  $\Rightarrow$  ToNeu_RequestOpenClutchT  $\leq$  RequestToNeuT + Zero_DL
m8_inv15 : NoNeu_RequestOpenClutch_Releasing = TRUE  $\Rightarrow$  NoNeu_RequestOpenClutch_ReleasingT  $\leq$  RequestNoNeu
           T + Zero_DL
m8_inv16 : NoNeu_RequestOpenClutch_Setting = TRUE  $\Rightarrow$  NoNeu_RequestOpenClutch_SettingT  $\leq$  NoNeu_Release_NoCl
           lutchT + Sync_DL
m8_inv17 : RequestFromNeu = TRUE  $\wedge$  FromNeu_RequestOpenClutch= FALSE  $\wedge$ 
           FromNeu_SyncSpeed = FALSE  $\Rightarrow$  time  $\leq$  Sync_DL+RequestFromNeuT
m8_inv18 : RequestToNeu = TRUE  $\wedge$  ToNeu_RequestOpenClutch= FALSE  $\wedge$ 
           ToNeu_ZeroTorque= FALSE  $\Rightarrow$  time  $\leq$  Zero_DL+RequestToNeuT
           RequestNoNeu = TRUE  $\wedge$  NoNeu_ZeroTorque = FALSE  $\wedge$ 
m8_inv19 : NoNeu_RequestOpenClutch_Releasing = FALSE
            $\Rightarrow$  time  $\leq$  Zero_DL+RequestNoNeuT
           NoNeu_Release_NoClutch = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$ 
m8_inv20 : NoNeu_RequestOpenClutch_Setting = FALSE
            $\Rightarrow$  time  $\leq$  Sync_DL+NoNeu_Release_NoClutchT

```

### EVENTS

INITIALISATION  $\triangleq$

STATUS

ordinary

### BEGIN

```

act1 : time := 0
act2 : isNeu := TRUE
act3 : RequestNoNeu := FALSE
act4 : RequestToNeu := FALSE
act5 : RequestFromNeu := FALSE
act6 : RequestFromNeuT := 0
act7 : RequestNoNeuT := 0
act8 : RequestToNeuT := 0
act9 : FromNeu_SyncSpeed := FALSE
act10 : FromNeu_OpenClutch := FALSE
act11 : FromNeu_SetGear_NoClutch := FALSE
act12 : FromNeu_SetGear_Clutch := FALSE
act13 : FromNeu_CloseClutch := FALSE
act14 : Error_FromNeu_OpenClutch := FALSE
act15 : Error_FromNeu_SetGear_NoClutch := FALSE
act16 : Error_FromNeu_SetGear_Clutch := FALSE
act17 : Error_FromNeu_CloseClutch := FALSE
act18 : FromNeu_OpenClutchT := 0
act19 : FromNeu_SyncSpeedT := 0
act20 : FromNeu_SetGear_ClutchT := 0
act21 : ToNeu_ZeroTorque := FALSE
act22 : ToNeu_OpenClutch := FALSE
act23 : Error_ToNeu_OpenClutch := FALSE
act24 : ToNeu_Release_NoClutch := FALSE
act25 : Error_ToNeu_Release_NoClutch := FALSE

```

## Gear Controller Case-study (Time Added Manually)

```
act26 : ToNeu_Release_Clutch:= FALSE
act27 : Error_ToNeu_Release_Clutch :=FALSE
act28 : ToNeu_CloseClutch:= FALSE
act29 : Error_ToNeu_CloseClutch:= FALSE
act30 : ToNeu_ZeroTorqueT :=0
act31 : ToNeu_OpenClutchT :=0
act32 : ToNeu_Release_ClutchT:= 0
act33 : NoNeu_ZeroTorque:= FALSE
act34 : NoNeu_OpenClutch_Releasing:= FALSE
act35 : NoNeu_Release_NoClutch:= FALSE
act36 : NoNeu_Release_Clutch:= FALSE
act37 : NoNeu_SyncSpeed :=FALSE
act38 : NoNeu_OpenClutch_Setting :=FALSE
act39 : NoNeu_SetGear_NoClutch:= FALSE
act40 : NoNeu_SetGear_ReleasingClutch:= FALSE
act41 : NoNeu_SetGear_SettingClutch:= FALSE
act42 : NoNeu_CloseClutch_Releasing:= FALSE
act43 : NoNeu_CloseClutch_Setting:= FALSE
act44 : Error_NoNeu_OpenClutch_Releasing:= FALSE
act45 : Error_NoNeu_Release_NoClutch:= FALSE
act46 : Error_NoNeu_Release_Clutch:= FALSE
act47 : Error_NoNeu_OpenClutch_Setting :=FALSE
act48 : Error_NoNeu_SetGear_NoClutch:= FALSE
act49 : Error_NoNeu_SetGear_ReleasingClutch:= FALSE
act50 : Error_NoNeu_SetGear_SettingClutch:= FALSE
act51 : Error_NoNeu_CloseClutch_Releasing :=FALSE
act52 : Error_NoNeu_CloseClutch_Setting :=FALSE
act53 : NoNeu_ZeroTorqueT:= 0
act54 : NoNeu_Release_NoClutchT :=0
act55 : NoNeu_OpenClutch_ReleasingT:= 0
act56 : NoNeu_Release_ClutchT :=0
act57 : NoNeu_SyncSpeedT :=0
act58 : NoNeu_OpenClutch_SettingT:= 0
act59 : NoNeu_SetGear_ReleasingClutchT :=0
act60 : NoNeu_SetGear_SettingClutchT :=0
act73 : FromNeu_RequestOpenClutch :=FALSE
act74 : ToNeu_RequestOpenClutch :=FALSE
act75 : NoNeu_RequestOpenClutch_Releasing :=FALSE
act76 : NoNeu_RequestOpenClutch_Setting :=FALSE
act77 : FromNeu_RequestOpenClutchT :=0
act78 : ToNeu_RequestOpenClutchT :=0
act79 : NoNeu_RequestOpenClutch_ReleasingT :=0
act80 : NoNeu_RequestOpenClutch_SettingT :=0
```

END

### RequestFromNeu $\triangleleft$

STATUS

ordinary

WHEN

```
grd1 : RequestFromNeu = FALSE
grd2 : RequestNoNeu = FALSE
grd3 : RequestToNeu = FALSE
grd4 : isNeu = TRUE
```

THEN

```
act1 : RequestFromNeu := TRUE
act2 : RequestFromNeuT := time
```

END

### RequestNoNeu $\triangleleft$

STATUS

ordinary

WHEN

```
grd1 : RequestFromNeu = FALSE
grd2 : RequestNoNeu = FALSE
grd3 : RequestToNeu = FALSE
grd4 : isNeu = FALSE
```

THEN

```
act1 : RequestNoNeu := TRUE
act2 : RequestNoNeuT := time
```

## Gear Controller Case-study (Time Added Manually)

END

**RequestToNeu**  $\triangleq$

**STATUS**

ordinary

WHEN

grd1 : RequestFromNeu = FALSE  
grd2 : RequestNoNeu = FALSE  
grd3 : RequestToNeu = FALSE  
grd4 : isNeu = FALSE

THEN

act1 : RequestToNeu := TRUE  
act2 : RequestToNeuT := time

END

**FromNeu\_SyncSpeed**  $\triangleq$

**STATUS**

ordinary

WHEN

grd1 : RequestFromNeu = TRUE  
grd2 : FromNeu\_SyncSpeed = FALSE  
grd3 : FromNeu\_RequestOpenClutch = FALSE  
grd5 : time  $\leq$  RequestFromNeuT + Sync\_EX

THEN

act1 : FromNeu\_SyncSpeed := TRUE  
act2 : FromNeu\_SyncSpeedT := time

END

**FromNeu\_RequestOpenClutch**  $\triangleq$

**STATUS**

ordinary

WHEN

grd1 : RequestFromNeu = TRUE  
grd2 : FromNeu\_SyncSpeed = FALSE  
grd3 : FromNeu\_RequestOpenClutch = FALSE  
grd4 : time  $\geq$  RequestFromNeuT + OpenClutch\_Zero\_DE

THEN

act1 : FromNeu\_RequestOpenClutch := TRUE  
act2 : FromNeu\_RequestOpenClutchT := time

END

**FromNeu\_OpenClutch**  $\triangleq$

**STATUS**

ordinary

WHEN

grd1 : FromNeu\_RequestOpenClutch = TRUE  
grd2 : Error\_FromNeu\_OpenClutch = FALSE  
grd3 : FromNeu\_OpenClutch = FALSE

THEN

act1 : FromNeu\_OpenClutch := TRUE  
act2 : FromNeu\_OpenClutchT := time

END

**Error\_FromNeu\_OpenClutch**  $\triangleq$

**STATUS**

ordinary

WHEN

grd1 : FromNeu\_RequestOpenClutch = TRUE  
grd2 : Error\_FromNeu\_OpenClutch = FALSE  
grd3 : FromNeu\_OpenClutch = FALSE

THEN

act1 : Error\_FromNeu\_OpenClutch := TRUE

END

**FromNeu\_SetGear\_NoClutch**  $\triangleq$

**STATUS**

ordinary

WHEN

grd1 : FromNeu\_SyncSpeed = TRUE  
grd2 : Error\_FromNeu\_SetGear\_NoClutch = FALSE

## Gear Controller Case-study (Time Added Manually)

```
    grd3 : FromNeu_SetGear_NoClutch = FALSE
THEN
    act1 : FromNeu_SetGear_NoClutch := TRUE
    act2 : isNeu := FALSE
END
```

```
Error_FromNeu_SetGear_NoClutch  $\triangle$ 
    STATUS
```

```
    ordinary
```

```
WHEN
    grd1 : FromNeu_SyncSpeed = TRUE
    grd2 : Error_FromNeu_SetGear_NoClutch = FALSE
    grd3 : FromNeu_SetGear_NoClutch = FALSE
THEN
    act1 : Error_FromNeu_SetGear_NoClutch := TRUE
END
```

```
FromNeu_SetGear_Clutch  $\triangle$ 
    STATUS
```

```
    ordinary
```

```
WHEN
    grd1 : FromNeu_OpenClutch = TRUE
    grd2 : Error_FromNeu_SetGear_Clutch = FALSE
    grd3 : FromNeu_SetGear_Clutch = FALSE
THEN
    act1 : FromNeu_SetGear_Clutch := TRUE
    act2 : FromNeu_SetGear_ClutchT := time
END
```

```
Error_FromNeu_SetGear_Clutch  $\triangle$ 
    STATUS
```

```
    ordinary
```

```
WHEN
    grd1 : FromNeu_OpenClutch = TRUE
    grd2 : Error_FromNeu_SetGear_Clutch = FALSE
    grd3 : FromNeu_SetGear_Clutch = FALSE
THEN
    act1 : Error_FromNeu_SetGear_Clutch := TRUE
END
```

```
FromNeu_CloseClutch  $\triangle$ 
    STATUS
```

```
    ordinary
```

```
WHEN
    grd1 : FromNeu_SetGear_Clutch = TRUE
    grd2 : Error_FromNeu_CloseClutch = FALSE
    grd3 : FromNeu_CloseClutch = FALSE
THEN
    act1 : FromNeu_CloseClutch := TRUE
    act2 : isNeu := FALSE
END
```

```
Error_FromNeu_CloseClutch  $\triangle$ 
    STATUS
```

```
    ordinary
```

```
WHEN
    grd1 : FromNeu_SetGear_Clutch = TRUE
    grd2 : Error_FromNeu_CloseClutch = FALSE
    grd3 : FromNeu_CloseClutch = FALSE
THEN
    act1 : Error_FromNeu_CloseClutch := TRUE
END
```

```
ToNeu_ZeroTorque  $\triangle$ 
    STATUS
```

```
    ordinary
```

```
WHEN
    grd1 : RequestToNeu = TRUE
    grd2 : ToNeu_ZeroTorque = FALSE
    grd3 : ToNeu_RequestOpenClutch = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
    grd5 : time ≤ RequestToNeuT + Zero_EX
THEN
    act1 : ToNeu_ZeroTorque := TRUE
    act2 : ToNeu_ZeroTorqueT := time
END

ToNeu_RequestOpenClutch ≙
    STATUS
    ordinary
WHEN
    grd1 : RequestToNeu = TRUE
    grd2 : ToNeu_ZeroTorque = FALSE
    grd3 : ToNeu_RequestOpenClutch = FALSE
    grd4 : time ≥ RequestToNeuT + OpenClutch_Zero_DE
THEN
    act1 : ToNeu_RequestOpenClutch := TRUE
    act2 : ToNeu_RequestOpenClutchT := time
END

ToNeu_OpenClutch ≙
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_RequestOpenClutch = TRUE
    grd2 : ToNeu_OpenClutch = FALSE
    grd3 : Error_ToNeu_OpenClutch = FALSE
THEN
    act1 : ToNeu_OpenClutch := TRUE
    act2 : ToNeu_OpenClutchT := time
END

Error_ToNeu_OpenClutch ≙
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_RequestOpenClutch = TRUE
    grd2 : ToNeu_OpenClutch = FALSE
    grd3 : Error_ToNeu_OpenClutch = FALSE
THEN
    act1 : Error_ToNeu_OpenClutch := TRUE
END

ToNeu_Release_NoClutch ≙
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_ZeroTorque = TRUE
    grd2 : ToNeu_Release_NoClutch = FALSE
    grd3 : Error_ToNeu_Release_NoClutch = FALSE
THEN
    act1 : ToNeu_Release_NoClutch := TRUE
    act2 : isNeu := TRUE
END

Error_ToNeu_Release_NoClutch ≙
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_ZeroTorque = TRUE
    grd2 : ToNeu_Release_NoClutch = FALSE
    grd3 : Error_ToNeu_Release_NoClutch = FALSE
THEN
    act1 : Error_ToNeu_Release_NoClutch := TRUE
END

ToNeu_Release_Clutch ≙
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_OpenClutch = TRUE
```

## Gear Controller Case-study (Time Added Manually)

```
    grd2 : ToNeu_Release_Clutch = FALSE
    grd3 : Error_ToNeu_Release_Clutch = FALSE
THEN
    act1 : ToNeu_Release_Clutch := TRUE
    act2 : ToNeu_Release_ClutchT := time
END

Error_ToNeu_Release_Clutch  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_OpenClutch = TRUE
    grd2 : ToNeu_Release_Clutch = FALSE
    grd3 : Error_ToNeu_Release_Clutch = FALSE
THEN
    act1 : Error_ToNeu_Release_Clutch := TRUE
END

ToNeu_CloseClutch  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_Release_Clutch = TRUE
    grd2 : ToNeu_CloseClutch = FALSE
    grd3 : Error_ToNeu_CloseClutch = FALSE
THEN
    act1 : ToNeu_CloseClutch := TRUE
    act2 : isNeu := TRUE
END

Error_ToNeu_CloseClutch  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 : ToNeu_Release_Clutch = TRUE
    grd2 : ToNeu_CloseClutch = FALSE
    grd3 : Error_ToNeu_CloseClutch = FALSE
THEN
    act1 : Error_ToNeu_CloseClutch := TRUE
END

NoNeu_ZeroTorque  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 : RequestNoNeu = TRUE
    grd2 : NoNeu_ZeroTorque = FALSE
    grd3 : NoNeu_RequestOpenClutch_Releasing = FALSE
    grd4 : time  $\leq$  RequestNoNeuT + Zero_EX
THEN
    act1 : NoNeu_ZeroTorque := TRUE
    act2 : NoNeu_ZeroTorqueT := time
END

NoNeu_RequestOpenClutch_Releasing  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 : RequestNoNeu = TRUE
    grd2 : NoNeu_ZeroTorque = FALSE
    grd3 : NoNeu_RequestOpenClutch_Releasing = FALSE
    grd4 : time  $\geq$  RequestNoNeuT + OpenClutch_Zero_DE
THEN
    act1 : NoNeu_RequestOpenClutch_Releasing := TRUE
    act2 : NoNeu_RequestOpenClutch_ReleasingT := time
END

NoNeu_OpenClutch_Releasing  $\triangle$ 
    STATUS
    ordinary
```

## Gear Controller Case-study (Time Added Manually)

```
WHEN
  grd1 : NoNeu_OpenClutch_Releasing = TRUE
  grd2 : NoNeu_OpenClutch_Releasing = FALSE
  grd3 : Error_NoNeu_OpenClutch_Releasing = FALSE
```

```
THEN
  act1 : NoNeu_OpenClutch_Releasing := TRUE
  act2 : NoNeu_OpenClutch_ReleasingT := time
```

```
END
```

**Error\_NoNeu\_OpenClutch\_Releasing**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_RequestOpenClutch_Releasing = TRUE
  grd2 : NoNeu_OpenClutch_Releasing = FALSE
  grd3 : Error_NoNeu_OpenClutch_Releasing = FALSE
```

```
THEN
  act1 : Error_NoNeu_OpenClutch_Releasing := TRUE
```

```
END
```

**NoNeu\_Release\_NoClutch**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_ZeroTorque = TRUE
  grd2 : NoNeu_Release_NoClutch = FALSE
  grd3 : Error_NoNeu_Release_NoClutch = FALSE
```

```
THEN
  act1 : NoNeu_Release_NoClutch := TRUE
  act2 : NoNeu_Release_NoClutchT := time
```

```
END
```

**Error\_NoNeu\_Release\_NoClutch**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_ZeroTorque = TRUE
  grd2 : NoNeu_Release_NoClutch = FALSE
  grd3 : Error_NoNeu_Release_NoClutch = FALSE
```

```
THEN
  act1 : Error_NoNeu_Release_NoClutch := TRUE
```

```
END
```

**NoNeu\_Release\_Clutch**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_OpenClutch_Releasing = TRUE
  grd2 : NoNeu_Release_Clutch = FALSE
  grd3 : Error_NoNeu_Release_Clutch = FALSE
```

```
THEN
  act1 : NoNeu_Release_Clutch := TRUE
  act2 : NoNeu_Release_ClutchT := time
```

```
END
```

**Error\_NoNeu\_Release\_Clutch**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_OpenClutch_Releasing = TRUE
  grd2 : NoNeu_Release_Clutch = FALSE
  grd3 : Error_NoNeu_Release_Clutch = FALSE
```

```
THEN
  act1 : Error_NoNeu_Release_Clutch := TRUE
```

```
END
```

**NoNeu\_SyncSpeed**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
```

## Gear Controller Case-study (Time Added Manually)

```
    grd1 : NoNeu_Release_NoClutch = TRUE
    grd2 : NoNeu_SyncSpeed = FALSE
    grd3 : NoNeu_RequestOpenClutch_Setting = FALSE
    grd5 : time ≤ NoNeu_Release_NoClutchT + Sync_EX
THEN
    act1 : NoNeu_SyncSpeed := TRUE
    act2 : NoNeu_SyncSpeedT := time
END

NoNeu_RequestOpenClutch_Setting ≙
    STATUS
    ordinary
WHEN
    grd1 : NoNeu_Release_NoClutch = TRUE
    grd2 : NoNeu_SyncSpeed = FALSE
    grd3 : NoNeu_RequestOpenClutch_Setting = FALSE
    grd4 : time ≥ NoNeu_Release_NoClutchT + OpenClutch_Sync_DE
THEN
    act1 : NoNeu_RequestOpenClutch_Setting := TRUE
    act2 : NoNeu_RequestOpenClutch_SettingT := time
END

NoNeu_OpenClutch_Setting ≙
    STATUS
    ordinary
WHEN
    grd1 : NoNeu_RequestOpenClutch_Setting = TRUE
    grd2 : Error_NoNeu_OpenClutch_Setting = FALSE
    grd3 : NoNeu_OpenClutch_Setting = FALSE
THEN
    act1 : NoNeu_OpenClutch_Setting := TRUE
    act2 : NoNeu_OpenClutch_SettingT := time
END

Error_NoNeu_OpenClutch_Setting ≙
    STATUS
    ordinary
WHEN
    grd1 : NoNeu_RequestOpenClutch_Setting = TRUE
    grd2 : Error_NoNeu_OpenClutch_Setting = FALSE
    grd3 : NoNeu_OpenClutch_Setting = FALSE
THEN
    act1 : Error_NoNeu_OpenClutch_Setting := TRUE
END

NoNeu_SetGear_NoClutch ≙
    STATUS
    ordinary
WHEN
    grd1 : NoNeu_SyncSpeed = TRUE
    grd2 : Error_NoNeu_SetGear_NoClutch = FALSE
    grd3 : NoNeu_SetGear_NoClutch = FALSE
THEN
    act1 : NoNeu_SetGear_NoClutch := TRUE
END

Error_NoNeu_SetGear_NoClutch ≙
    STATUS
    ordinary
WHEN
    grd1 : NoNeu_SyncSpeed = TRUE
    grd2 : Error_NoNeu_SetGear_NoClutch = FALSE
    grd3 : NoNeu_SetGear_NoClutch = FALSE
THEN
    act1 : Error_NoNeu_SetGear_NoClutch := TRUE
END

NoNeu_SetGear_ReleasingClutch ≙
    STATUS
    ordinary
```



## Gear Controller Case-study (Time Added Manually)

```
WHEN
  grd1 : NoNeu_Release_Clutch = TRUE
  grd2 : Error_NoNeu_SetGear_ReleasingClutch = FALSE
  grd3 : NoNeu_SetGear_ReleasingClutch = FALSE
THEN
  act1 : NoNeu_SetGear_ReleasingClutch := TRUE
  act2 : NoNeu_SetGear_ReleasingClutchT := time
END
```

**Error\_NoNeu\_SetGear\_ReleasingClutch**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_Release_Clutch = TRUE
  grd2 : Error_NoNeu_SetGear_ReleasingClutch = FALSE
  grd3 : NoNeu_SetGear_ReleasingClutch = FALSE
THEN
  act1 : Error_NoNeu_SetGear_ReleasingClutch := TRUE
END
```

**NoNeu\_SetGear\_SettingClutch**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_OpenClutch_Setting = TRUE
  grd2 : Error_NoNeu_SetGear_SettingClutch = FALSE
  grd3 : NoNeu_SetGear_SettingClutch = FALSE
THEN
  act1 : NoNeu_SetGear_SettingClutch := TRUE
  act2 : NoNeu_SetGear_SettingClutchT := time
END
```

**Error\_NoNeu\_SetGear\_SettingClutch**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_OpenClutch_Setting = TRUE
  grd2 : Error_NoNeu_SetGear_SettingClutch = FALSE
  grd3 : NoNeu_SetGear_SettingClutch = FALSE
THEN
  act1 : Error_NoNeu_SetGear_SettingClutch := TRUE
END
```

**NoNeu\_CloseClutch\_Setting**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_SetGear_SettingClutch = TRUE
  grd2 : Error_NoNeu_CloseClutch_Setting = FALSE
  grd3 : NoNeu_CloseClutch_Setting = FALSE
THEN
  act1 : NoNeu_CloseClutch_Setting := TRUE
END
```

**Error\_NoNeu\_CloseClutch\_Setting**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_SetGear_SettingClutch = TRUE
  grd2 : Error_NoNeu_CloseClutch_Setting = FALSE
  grd3 : NoNeu_CloseClutch_Setting = FALSE
THEN
  act1 : Error_NoNeu_CloseClutch_Setting := TRUE
END
```

**NoNeu\_CloseClutch\_Releasing**  $\triangle$   
**STATUS**

**ordinary**

```
WHEN
  grd1 : NoNeu_SetGear_ReleasingClutch = TRUE
```

## Gear Controller Case-study (Time Added Manually)

```

    grd2 : Error_NoNeu_CloseClutch_Releasing = FALSE
    grd3 : NoNeu_CloseClutch_Releasing = FALSE
THEN
    act1 : NoNeu_CloseClutch_Releasing := TRUE
END

Error_NoNeu_CloseClutch_Releasing  $\triangleq$ 
    STATUS
    ordinary
WHEN
    grd1 : NoNeu_SetGear_ReleasingClutch = TRUE
    grd2 : Error_NoNeu_CloseClutch_Releasing = FALSE
    grd3 : NoNeu_CloseClutch_Releasing = FALSE
THEN
    act1 : Error_NoNeu_CloseClutch_Releasing := TRUE
END

FINAL  $\triangleq$ 
    STATUS
    ordinary
WHEN
    FromNeu_SetGear_NoClutch = TRUE  $\vee$  NoNeu_SetGear_NoClutch = TRUE  $\vee$ 
    grd1 : ToNeu_Release_NoClutch = TRUE  $\vee$  FromNeu_CloseClutch = TRUE  $\vee$ 
    NoNeu_CloseClutch_Setting = TRUE  $\vee$  NoNeu_CloseClutch_Releasing = TRUE  $\vee$ 
    ToNeu_CloseClutch = TRUE
THEN
    act1 : RequestFromNeu := FALSE
    act2 : RequestNoNeu := FALSE
    act3 : RequestToNeu := FALSE
    act4 : FromNeu_SyncSpeed := FALSE
    act5 : FromNeu_OpenClutch := FALSE
    act6 : FromNeu_SetGear_NoClutch := FALSE
    act7 : FromNeu_SetGear_Clutch := FALSE
    act8 : FromNeu_CloseClutch := FALSE
    act9 : ToNeu_Release_NoClutch := FALSE
    act10 : ToNeu_CloseClutch := FALSE
    act11 : ToNeu_ZeroTorque := FALSE
    act12 : ToNeu_OpenClutch := FALSE
    act13 : ToNeu_Release_Clutch := FALSE
    act14 : NoNeu_ZeroTorque := FALSE
    act15 : NoNeu_OpenClutch_Releasing := FALSE
    act16 : NoNeu_Release_NoClutch := FALSE
    act17 : NoNeu_Release_Clutch := FALSE
    act18 : NoNeu_SyncSpeed := FALSE
    act19 : NoNeu_OpenClutch_Setting := FALSE
    act20 : NoNeu_SetGear_NoClutch := FALSE
    act21 : NoNeu_SetGear_ReleasingClutch := FALSE
    act22 : NoNeu_SetGear_SettingClutch := FALSE
    act23 : NoNeu_CloseClutch_Setting := FALSE
    act24 : NoNeu_CloseClutch_Releasing := FALSE
    act33 : FromNeu_RequestOpenClutch := FALSE
    act34 : ToNeu_RequestOpenClutch := FALSE
    act35 : NoNeu_RequestOpenClutch_Releasing := FALSE
    act36 : NoNeu_RequestOpenClutch_Setting := FALSE
END

Tick_Tock  $\triangleq$ 
    STATUS
    ordinary
ANY
    tick
WHERE
    typing_tick : tick  $\in \mathbb{Z}$ 
    grd1 : tick > 0
    grd2 : RequestFromNeu = TRUE  $\wedge$  FromNeu_RequestOpenClutch = FALSE  $\wedge$ 
    FromNeu_SyncSpeed = FALSE  $\Rightarrow$  time+tick  $\leq$  Sync_DL+RequestFromNeuT
    grd3 : FromNeu_RequestOpenClutch = TRUE  $\wedge$  FromNeu_OpenClutch = FALSE  $\wedge$ 
    Error_FromNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+FromNeu_RequestOpenClutchT

```

## Gear Controller Case-study (Time Added Manually)

```
grd4 : FromNeu_OpenClutch = TRUE  $\wedge$  FromNeu_SetGear_Clutch= FALSE  $\wedge$ 
      Error_FromNeu_SetGear_Clutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_OpenClutchT
grd5 : FromNeu_SyncSpeed = TRUE  $\wedge$  FromNeu_SetGear_NoClutch= FALSE  $\wedge$ 
      Error_FromNeu_SetGear_NoClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+FromNeu_SyncSpeedT
grd6 : FromNeu_SetGear_Clutch = TRUE  $\wedge$  FromNeu_CloseClutch= FALSE  $\wedge$ 
      Error_FromNeu_CloseClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+FromNeu_SetGear_ClutchT
grd7 : RequestToNeu = TRUE  $\wedge$  ToNeu_RequestOpenClutch= FALSE  $\wedge$ 
      ToNeu_ZeroTorque= FALSE  $\Rightarrow$  time+tick  $\leq$  Zero_DL+RequestToNeuT
grd8 : ToNeu_RequestOpenClutch = TRUE  $\wedge$  ToNeu_OpenClutch= FALSE  $\wedge$ 
      Error_ToNeu_OpenClutch = FALSE  $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+ToNeu_RequestOpenClutchT
grd9 : ToNeu_ZeroTorque = TRUE  $\wedge$  ToNeu_Release_NoClutch= FALSE  $\wedge$ 
      Error_ToNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+ToNeu_ZeroTorqueT
grd10 : ToNeu_OpenClutch = TRUE  $\wedge$  ToNeu_Release_Clutch= FALSE  $\wedge$ 
      Error_ToNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL +ToNeu_OpenClutchT
grd11 : ToNeu_Release_Clutch = TRUE  $\wedge$  ToNeu_CloseClutch= FALSE  $\wedge$ 
      Error_ToNeu_CloseClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+ToNeu_Release_ClutchT
grd12 : RequestNoNeu = TRUE  $\wedge$  NoNeu_ZeroTorque = FALSE  $\wedge$ 
      NoNeu_RequestOpenClutch_Releasing = FALSE
       $\Rightarrow$  time+tick  $\leq$  Zero_DL +RequestNoNeuT
      NoNeu_RequestOpenClutch_Releasing = TRUE  $\wedge$ 
grd13 : NoNeu_OpenClutch_Releasing = FALSE  $\wedge$ 
      Error_NoNeu_OpenClutch_Releasing = FALSE
       $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL +NoNeu_RequestOpenClutch_ReleasingT
grd14 : NoNeu_ZeroTorque = TRUE  $\wedge$  NoNeu_Release_NoClutch= FALSE  $\wedge$ 
      Error_NoNeu_Release_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_ZeroTorqueT
      NoNeu_Release_NoClutch = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$ 
grd15 : NoNeu_RequestOpenClutch_Setting = FALSE
       $\Rightarrow$  time+tick  $\leq$  Sync_DL+NoNeu_Release_NoClutchT
      NoNeu_RequestOpenClutch_Setting = TRUE  $\wedge$  NoNeu_SyncSpeed= FALSE  $\wedge$ 
grd16 : Error_NoNeu_OpenClutch_Setting = FALSE
       $\Rightarrow$  time+tick  $\leq$  OpenClutch_DL+NoNeu_RequestOpenClutch_SettingT
grd17 : NoNeu_SyncSpeed = TRUE  $\wedge$  NoNeu_SetGear_NoClutch= FALSE  $\wedge$ 
      Error_NoNeu_SetGear_NoClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_SyncSpeedT
grd18 : NoNeu_OpenClutch_Setting = TRUE  $\wedge$  NoNeu_SetGear_SettingClutch= FALSE  $\wedge$ 
      Error_NoNeu_SetGear_SettingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_OpenClutch_SettingT
grd19 : NoNeu_SetGear_SettingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Setting= FALSE  $\wedge$ 
      Error_NoNeu_CloseClutch_Setting= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNeu_SetGear_SettingClutchT
grd20 : NoNeu_OpenClutch_Releasing = TRUE  $\wedge$  NoNeu_Release_Clutch= FALSE  $\wedge$ 
      Error_NoNeu_Release_Clutch= FALSE  $\Rightarrow$  time+tick  $\leq$  Release_DL+NoNeu_OpenClutch_ReleasingT
grd21 : NoNeu_Release_Clutch = TRUE  $\wedge$  NoNeu_SetGear_ReleasingClutch= FALSE  $\wedge$ 
      Error_NoNeu_SetGear_ReleasingClutch= FALSE  $\Rightarrow$  time+tick  $\leq$  SetGear_DL+NoNeu_Release_ClutchT
grd22 : NoNeu_SetGear_ReleasingClutch = TRUE  $\wedge$  NoNeu_CloseClutch_Releasing= FALSE  $\wedge$ 
      Error_NoNeu_CloseClutch_Releasing= FALSE  $\Rightarrow$  time+tick  $\leq$  CloseClutch_DL+NoNeu_SetGear_ReleasingClutchT
```

**THEN**

```
act1 : time := time + tick
```

**END**

**END**

## Decomposed Machine Channel

**MACHINE**  
Channel

**SEES**  
c6

**VARIABLES**  
Channel\_RequestFromNeu

## Gear Controller Case-study (Time Added Manually)

Channel\_FromNeu\_SyncSpeed  
Channel\_FromNeu\_RequestOpenClutch  
Channel\_FromNeu\_OpenClutch  
Channel\_FromNeu\_SetGear\_Clutch  
Channel\_FromNeu\_SetGear\_NoClutch  
Channel\_FromNeu\_CloseClutch  
Channel\_RequestFromNeuT  
Channel\_FromNeu\_OpenClutchT  
Channel\_FromNeu\_SyncSpeedT  
Channel\_FromNeu\_SetGear\_ClutchT  
Channel\_FromNeu\_RequestOpenClutchT  
Channel\_RequestToNeu  
Channel\_ToNeu\_ZeroTorque  
Channel\_ToNeu\_RequestOpenClutch  
Channel\_ToNeu\_OpenClutch  
Channel\_ToNeu\_Release\_Clutch  
Channel\_ToNeu\_Release\_NoClutch  
Channel\_ToNeu\_CloseClutch  
Channel\_RequestToNeuT  
Channel\_ToNeu\_ZeroTorqueT  
Channel\_ToNeu\_OpenClutchT  
Channel\_ToNeu\_Release\_ClutchT  
Channel\_ToNeu\_RequestOpenClutchT  
Channel\_RequestNoNeu  
Channel\_NoNeu\_ZeroTorque  
Channel\_NoNeu\_Release\_NoClutch  
Channel\_NoNeu\_RequestOpenClutch\_Releasing  
Channel\_NoNeu\_OpenClutch\_Releasing  
Channel\_NoNeu\_Release\_Clutch  
Channel\_NoNeu\_SyncSpeed  
Channel\_NoNeu\_RequestOpenClutch\_Setting  
Channel\_NoNeu\_OpenClutch\_Setting  
Channel\_NoNeu\_SetGear\_ReleasingClutch  
Channel\_NoNeu\_SetGear\_SettingClutch  
Channel\_NoNeu\_SetGear\_NoClutch  
Channel\_NoNeu\_CloseClutch\_Releasing  
Channel\_NoNeu\_CloseClutch\_Setting  
Channel\_RequestNoNeuT  
Channel\_NoNeu\_ZeroTorqueT  
Channel\_NoNeu\_Release\_NoClutchT  
Channel\_NoNeu\_OpenClutch\_ReleasingT  
Channel\_NoNeu\_Release\_ClutchT  
Channel\_NoNeu\_SetGear\_ReleasingClutchT  
Channel\_NoNeu\_SetGear\_SettingClutchT  
Channel\_NoNeu\_SyncSpeedT  
Channel\_NoNeu\_OpenClutch\_SettingT  
Channel\_NoNeu\_RequestOpenClutch\_ReleasingT  
Channel\_NoNeu\_RequestOpenClutch\_SettingT  
Channel\_Request\_SyncSpeed  
Channel\_Request\_ZeroTorque  
Channel\_SyncSpeed  
Channel\_ZeroTorque  
Channel\_SyncSpeedT  
Channel\_ZeroTorqueT  
Channel\_Request\_SyncSpeedT  
Channel\_Request\_ZeroTorqueT  
Channel\_Request\_Open  
Channel\_Request\_Close  
Channel\_Open  
Channel\_Close  
Channel\_OpenT  
Channel\_CloseT  
Channel\_Request\_OpenT  
Channel\_Request\_CloseT  
Channel\_Request\_Release  
Channel\_Request\_Set  
Channel\_Release  
Channel\_Set  
Channel\_ReleaseT  
Channel\_SetT  
Channel\_Request\_ReleaseT  
Channel\_Request\_SetT  
Channel\_time

### INVARIANTS

*typing\_Channel\_time* : Channel\_time  $\in \mathbb{Z}$   
*typing\_Channel\_ZeroTorqueT* : Channel\_ZeroTorqueT  $\in \mathbb{Z}$   
*typing\_Channel\_RequestNoNeuT* : Channel\_RequestNoNeuT  $\in \mathbb{Z}$   
*typing\_Channel\_RequestToNeu* : Channel\_RequestToNeu  $\in \text{BOOL}$   
*typing\_Channel\_ToNeu\_OpenClutch* : Channel\_ToNeu\_OpenClutch  $\in \text{BOOL}$   
*typing\_Channel\_NoNeu\_SetGear\_SettingClutch* : Channel\_NoNeu\_SetGear\_SettingClutch  $\in \text{BOOL}$

## Gear Controller Case-study (Time Added Manually)

```
typing_Channel_Request_Release :Channel_Request_Release ∈ BOOL
typing_Channel_Request_SyncSpeed :Channel_Request_SyncSpeed ∈ BOOL
typing_Channel_OpenT :Channel_OpenT ∈ ℤ
typing_Channel_FromNeu_OpenClutchT :Channel_FromNeu_OpenClutchT ∈ ℤ
typing_Channel_NoNeu_ZeroTorqueT :Channel_NoNeu_ZeroTorqueT ∈ ℤ
typing_Channel_ToNeu_Release_ClutchT :Channel_ToNeu_Release_ClutchT ∈ ℤ
typing_Channel_CloseT :Channel_CloseT ∈ ℤ
typing_Channel_NoNeu_OpenClutch_SettingT :Channel_NoNeu_OpenClutch_SettingT ∈ ℤ
typing_Channel_ToNeu_Release_NoClutch :Channel_ToNeu_Release_NoClutch ∈ BOOL
typing_Channel_NoNeu_SyncSpeed :Channel_NoNeu_SyncSpeed ∈ BOOL
typing_Channel_Set :Channel_Set ∈ BOOL
typing_Channel_ToNeu_ZeroTorque :Channel_ToNeu_ZeroTorque ∈ BOOL
typing_Channel_NoNeu_CloseClutch_Releasing :Channel_NoNeu_CloseClutch_Releasing ∈ BOOL
typing_Channel_NoNeu_SetGear_ReleasingClutch :Channel_NoNeu_SetGear_ReleasingClutch ∈ BOOL
typing_Channel_SyncSpeed :Channel_SyncSpeed ∈ BOOL
typing_Channel_NoNeu_RequestOpenClutch_Setting :Channel_NoNeu_RequestOpenClutch_Setting ∈ BOOL
typing_Channel_Request_Set :Channel_Request_Set ∈ BOOL
typing_Channel_RequestFromNeuT :Channel_RequestFromNeuT ∈ ℤ
typing_Channel_ReleaseT :Channel_ReleaseT ∈ ℤ
typing_Channel_Request_Open :Channel_Request_Open ∈ BOOL
typing_Channel_ToNeu_Release_Clutch :Channel_ToNeu_Release_Clutch ∈ BOOL
typing_Channel_FromNeu_RequestOpenClutch :Channel_FromNeu_RequestOpenClutch ∈ BOOL
typing_Channel_NoNeu_OpenClutch_ReleasingT :Channel_NoNeu_OpenClutch_ReleasingT ∈ ℤ
typing_Channel_NoNeu_Release_ClutchT :Channel_NoNeu_Release_ClutchT ∈ ℤ
typing_Channel_NoNeu_RequestOpenClutchT :Channel_NoNeu_RequestOpenClutchT ∈ ℤ
typing_Channel_NoNeu_RequestOpenClutch_Releasing :Channel_NoNeu_RequestOpenClutch_Releasing ∈ BOOL
typing_Channel_SyncSpeedT :Channel_SyncSpeedT ∈ ℤ
typing_Channel_ToNeu_ZeroTorqueT :Channel_ToNeu_ZeroTorqueT ∈ ℤ
typing_Channel_FromNeu_SetGear_ClutchT :Channel_FromNeu_SetGear_ClutchT ∈ ℤ
typing_Channel_FromNeu_SetGear_NoClutch :Channel_FromNeu_SetGear_NoClutch ∈ BOOL
typing_Channel_Release :Channel_Release ∈ BOOL
typing_Channel_Request_OpenT :Channel_Request_OpenT ∈ ℤ
typing_Channel_FromNeu_SyncSpeedT :Channel_FromNeu_SyncSpeedT ∈ ℤ
typing_Channel_ToNeu_RequestOpenClutch :Channel_ToNeu_RequestOpenClutch ∈ BOOL
typing_Channel_NoNeu_ZeroTorque :Channel_NoNeu_ZeroTorque ∈ BOOL
typing_Channel_ToNeu_RequestOpenClutchT :Channel_ToNeu_RequestOpenClutchT ∈ ℤ
typing_Channel_Request_ReleaseT :Channel_Request_ReleaseT ∈ ℤ
typing_Channel_ZeroTorque :Channel_ZeroTorque ∈ BOOL
typing_Channel_NoNeu_Release_Clutch :Channel_NoNeu_Release_Clutch ∈ BOOL
typing_Channel_NoNeu_Release_NoClutchT :Channel_NoNeu_Release_NoClutchT ∈ ℤ
typing_Channel_Open :Channel_Open ∈ BOOL
typing_Channel_Request_ZeroTorqueT :Channel_Request_ZeroTorqueT ∈ ℤ
typing_Channel_Request_ZeroTorque :Channel_Request_ZeroTorque ∈ BOOL
typing_Channel_NoNeu_RequestOpenClutch_SettingT :Channel_NoNeu_RequestOpenClutch_SettingT ∈ ℤ
typing_Channel_NoNeu_OpenClutch_Releasing :Channel_NoNeu_OpenClutch_Releasing ∈ BOOL
typing_Channel_NoNeu_SetGear_SettingClutchT :Channel_NoNeu_SetGear_SettingClutchT ∈ ℤ
typing_Channel_NoNeu_SyncSpeedT :Channel_NoNeu_SyncSpeedT ∈ ℤ
typing_Channel_Request_Close :Channel_Request_Close ∈ BOOL
typing_Channel_ToNeu_OpenClutchT :Channel_ToNeu_OpenClutchT ∈ ℤ
typing_Channel_ToNeu_CloseClutch :Channel_ToNeu_CloseClutch ∈ BOOL
typing_Channel_NoNeu_SetGear_NoClutch :Channel_NoNeu_SetGear_NoClutch ∈ BOOL
typing_Channel_RequestToNeuT :Channel_RequestToNeuT ∈ ℤ
typing_Channel_NoNeu_CloseClutch_Setting :Channel_NoNeu_CloseClutch_Setting ∈ BOOL
typing_Channel_FromNeu_OpenClutch :Channel_FromNeu_OpenClutch ∈ BOOL
typing_Channel_Close :Channel_Close ∈ BOOL
typing_Channel_RequestFromNeu :Channel_RequestFromNeu ∈ BOOL
typing_Channel_Request_CloseT :Channel_Request_CloseT ∈ ℤ
typing_Channel_SetT :Channel_SetT ∈ ℤ
typing_Channel_NoNeu_Release_NoClutch :Channel_NoNeu_Release_NoClutch ∈ BOOL
typing_Channel_Request_SyncSpeedT :Channel_Request_SyncSpeedT ∈ ℤ
typing_Channel_FromNeu_CloseClutch :Channel_FromNeu_CloseClutch ∈ BOOL
typing_Channel_FromNeu_SetGear_Clutch :Channel_FromNeu_SetGear_Clutch ∈ BOOL
typing_Channel_NoNeu_SetGear_ReleasingClutchT :Channel_NoNeu_SetGear_ReleasingClutchT ∈ ℤ
typing_Channel_RequestNoNeu :Channel_RequestNoNeu ∈ BOOL
typing_Channel_FromNeu_SyncSpeed :Channel_FromNeu_SyncSpeed ∈ BOOL
typing_Channel_NoNeu_OpenClutch_Setting :Channel_NoNeu_OpenClutch_Setting ∈ BOOL
typing_Channel_Request_SetT :Channel_Request_SetT ∈ ℤ
typing_Channel_NoNeu_RequestOpenClutch_ReleasingT :Channel_NoNeu_RequestOpenClutch_ReleasingT ∈ ℤ
{Channel_RequestFromNeu, Channel_FromNeu_SyncSpeed ,
Channel_FromNeu_RequestOpenClutch ,Channel_FromNeu_OpenClutch ,
Channel_FromNeu_SetGear_Clutch ,Channel_FromNeu_SetGear_NoClutch ,
Channel_FromNeu_CloseClutch , Channel_RequestToNeu ,
Channel_ToNeu_ZeroTorque ,Channel_ToNeu_RequestOpenClutch,
Channel_ToNeu_OpenClutch ,Channel_ToNeu_Release_Clutch,
Channel_ToNeu_Release_NoClutch, Channel_ToNeu_CloseClutch,
Channel_RequestNoNeu,Channel_NoNeu_ZeroTorque,
Channel_NoNeu_Release_NoClutch ,Channel_NoNeu_RequestOpenClutch_Releasing,
Channel_NoNeu_OpenClutch_Releasing,Channel_NoNeu_Release_Clutch,
```

## Gear Controller Case-study (Time Added Manually)

Channel\_NoNeu\_SyncSpeed,Channel\_NoNeu\_RequestOpenClutch\_Setting ,  
Channel\_NoNeu\_OpenClutch\_Setting,Channel\_NoNeu\_SetGear\_ReleasingClutch,  
Channel\_NoNeu\_SetGear\_SettingClutch,Channel\_NoNeu\_SetGear\_NoClutch,  
Channel\_NoNeu\_CloseClutch\_Releasing,Channel\_NoNeu\_CloseClutch\_Setting,  
Channel\_Request\_SyncSpeed,Channel\_Request\_ZeroTorque,  
Channel\_SyncSpeed,Channel\_ZeroTorque,Channel\_Request\_Open,  
Channel\_Request\_Close,Channel\_Open, Channel\_Close,  
Channel\_Request\_Release,Channel\_Request\_Set,Channel\_Release,  
Channel\_Set}  $\in \mathbb{P}(\text{BOOL})$

### EVENTS

#### INITIALISATION $\triangleq$

#### STATUS

#### ordinary

### BEGIN

```
act99 :Channel_RequestFromNeu := FALSE
act100 :Channel_FromNeu_SyncSpeed := FALSE
act101 :Channel_FromNeu_RequestOpenClutch := FALSE
act102 :Channel_FromNeu_OpenClutch := FALSE
act103 :Channel_FromNeu_SetGear_Clutch := FALSE
act104 :Channel_FromNeu_SetGear_NoClutch := FALSE
act105 :Channel_FromNeu_CloseClutch := FALSE
act106 :Channel_RequestToNeu := FALSE
act107 :Channel_ToNeu_ZeroTorque := FALSE
act108 :Channel_ToNeu_RequestOpenClutch := FALSE
act109 :Channel_ToNeu_OpenClutch := FALSE
act110 :Channel_ToNeu_Release_Clutch := FALSE
act111 :Channel_ToNeu_Release_NoClutch := FALSE
act112 :Channel_ToNeu_CloseClutch := FALSE
act113 :Channel_RequestNoNeu := FALSE
act114 :Channel_NoNeu_ZeroTorque := FALSE
act115 :Channel_NoNeu_Release_NoClutch := FALSE
act116 :Channel_NoNeu_RequestOpenClutch_Releasing := FALSE
act117 :Channel_NoNeu_OpenClutch_Releasing := FALSE
act118 :Channel_NoNeu_Release_Clutch := FALSE
act119 :Channel_NoNeu_SyncSpeed := FALSE
act120 :Channel_NoNeu_RequestOpenClutch_Setting := FALSE
act121 :Channel_NoNeu_OpenClutch_Setting := FALSE
act122 :Channel_NoNeu_SetGear_ReleasingClutch := FALSE
act123 :Channel_NoNeu_SetGear_SettingClutch := FALSE
act124 :Channel_NoNeu_SetGear_NoClutch := FALSE
act125 :Channel_NoNeu_CloseClutch_Releasing := FALSE
act126 :Channel_NoNeu_CloseClutch_Setting := FALSE
act127 :Channel_Request_SyncSpeed := FALSE
act128 :Channel_Request_ZeroTorque := FALSE
act129 :Channel_SyncSpeed := FALSE
act130 :Channel_ZeroTorque := FALSE
act131 :Channel_Request_Open := FALSE
act132 :Channel_Request_Close := FALSE
act133 :Channel_Open := FALSE
act134 :Channel_Close := FALSE
act135 :Channel_Request_Release := FALSE
act136 :Channel_Request_Set := FALSE
act137 :Channel_Release := FALSE
act138 :Channel_Set := FALSE
act139 :Channel_OpenT := 0
act140 :Channel_CloseT := 0
act141 :Channel_Request_OpenT := 0
act142 :Channel_Request_CloseT := 0
act143 :Channel_SyncSpeedT := 0
act144 :Channel_ZeroTorqueT := 0
act145 :Channel_Request_SyncSpeedT := 0
act146 :Channel_Request_ZeroTorqueT := 0
act147 :Channel_RequestNoNeuT := 0
act148 :Channel_NoNeu_ZeroTorqueT := 0
act149 :Channel_NoNeu_Release_NoClutchT := 0
act150 :Channel_NoNeu_OpenClutch_ReleasingT := 0
act151 :Channel_NoNeu_Release_ClutchT := 0
act152 :Channel_NoNeu_SetGear_ReleasingClutchT := 0
act153 :Channel_NoNeu_SetGear_SettingClutchT := 0
act154 :Channel_NoNeu_SyncSpeedT := 0
act155 :Channel_NoNeu_OpenClutch_SettingT := 0
act156 :Channel_NoNeu_RequestOpenClutch_ReleasingT := 0
act157 :Channel_NoNeu_RequestOpenClutch_SettingT := 0
act158 :Channel_RequestToNeuT := 0
act159 :Channel_ToNeu_ZeroTorqueT := 0
act160 :Channel_ToNeu_OpenClutchT := 0
act161 :Channel_ToNeu_Release_ClutchT := 0
act162 :Channel_ToNeu_RequestOpenClutchT := 0
```

## Gear Controller Case-study (Time Added Manually)

```
act163 :Channel_RequestFromNeuT := 0
act164 :Channel_FromNeu_OpenClutchT := 0
act165 :Channel_FromNeu_SyncSpeedT := 0
act166 :Channel_FromNeu_SetGear_ClutchT := 0
act167 :Channel_FromNeu_RequestOpenClutchT := 0
act168 :Channel_ReleaseT := 0
act169 :Channel_SetT := 0
act170 :Channel_Request_ReleaseT := 0
act171 :Channel_Request_SetT := 0
act172 :Channel_time := 0
```

END

**RequestFromNeu**  $\triangle$

STATUS

ordinary

BEGIN

```
act3 :Channel_RequestFromNeu := TRUE
act4 :Channel_RequestFromNeuT := Channel_time
```

END

**RequestNoNeu**  $\triangle$

STATUS

ordinary

BEGIN

```
act3 :Channel_RequestNoNeu := TRUE
act4 :Channel_RequestNoNeuT := Channel_time
```

END

**RequestToNeu**  $\triangle$

STATUS

ordinary

BEGIN

```
act3 :Channel_RequestToNeu := TRUE
act4 :Channel_RequestToNeuT := Channel_time
```

END

**FromNeu\_SyncSpeed**  $\triangle$

STATUS

ordinary

WHEN

```
grd4 :Channel_SyncSpeed = TRUE
```

THEN

```
act3 :Channel_FromNeu_SyncSpeed := TRUE
act4 :Channel_FromNeu_SyncSpeedT := Channel_time
```

END

**FromNeu\_RequestOpenClutch**  $\triangle$

STATUS

ordinary

BEGIN

```
act3 :Channel_FromNeu_RequestOpenClutch := TRUE
act4 :Channel_FromNeu_RequestOpenClutchT := Channel_time
```

END

**FromNeu\_OpenClutch**  $\triangle$

STATUS

ordinary

WHEN

```
grd4 :Channel_Open = TRUE
```

THEN

```
act3 :Channel_FromNeu_OpenClutch := TRUE
act4 :Channel_FromNeu_OpenClutchT := Channel_time
```

END

**FromNeu\_SetGear\_NoClutch**  $\triangle$

STATUS

ordinary

WHEN

```
grd4 :Channel_Set = TRUE
```

THEN

```
act3 :Channel_FromNeu_SetGear_NoClutch := TRUE
```

END

**FromNeu\_SetGear\_Clutch**  $\triangle$

STATUS

ordinary

WHEN

```
grd4 :Channel_Set= TRUE
```

THEN



## Gear Controller Case-study (Time Added Manually)

```
act3 :Channel_FromNeu_SetGear_Clutch := TRUE
act4 :Channel_FromNeu_SetGear_ClutchT := Channel_time
END
```

```
FromNeu_CloseClutch  $\triangle$ 
STATUS
```

```
ordinary
WHEN
  grd4 :Channel_Close = TRUE
THEN
  act3 :Channel_FromNeu_CloseClutch := TRUE
END
```

```
ToNeu_ZeroTorque  $\triangle$ 
STATUS
```

```
ordinary
WHEN
  grd4 :Channel_ZeroTorque = TRUE
THEN
  act3 :Channel_ToNeu_ZeroTorque := TRUE
  act4 :Channel_ToNeu_ZeroTorqueT := Channel_time
END
```

```
ToNeu_RequestOpenClutch  $\triangle$ 
STATUS
```

```
ordinary
BEGIN
  act3 :Channel_ToNeu_RequestOpenClutch := TRUE
  act4 :Channel_ToNeu_RequestOpenClutchT := Channel_time
END
```

```
ToNeu_OpenClutch  $\triangle$ 
STATUS
```

```
ordinary
WHEN
  grd4 :Channel_Open = TRUE
THEN
  act3 :Channel_ToNeu_OpenClutch := TRUE
  act4 :Channel_ToNeu_OpenClutchT := Channel_time
END
```

```
ToNeu_Release_NoClutch  $\triangle$ 
STATUS
```

```
ordinary
WHEN
  grd4 :Channel_Release = TRUE
THEN
  act3 :Channel_ToNeu_Release_NoClutch := TRUE
END
```

```
ToNeu_Release_Clutch  $\triangle$ 
STATUS
```

```
ordinary
WHEN
  grd4 :Channel_Release = TRUE
THEN
  act3 :Channel_ToNeu_Release_Clutch := TRUE
  act4 :Channel_ToNeu_Release_ClutchT := Channel_time
END
```

```
ToNeu_CloseClutch  $\triangle$ 
STATUS
```

```
ordinary
WHEN
  grd4 :Channel_Close = TRUE
THEN
  act3 :Channel_ToNeu_CloseClutch := TRUE
END
```

```
NoNeu_ZeroTorque  $\triangle$ 
STATUS
```

```
ordinary
WHEN
  grd5 :Channel_ZeroTorque = TRUE
THEN
  act3 :Channel_NoNeu_ZeroTorque := TRUE
  act4 :Channel_NoNeu_ZeroTorqueT := Channel_time
END
```



## Gear Controller Case-study (Time Added Manually)

```
NoNeu_RequestOpenClutch_Releasing  $\triangle$   
STATUS  
ordinary  
BEGIN  
act3 :Channel_NoNeu_RequestOpenClutch_Releasing := TRUE  
act4 :Channel_NoNeu_RequestOpenClutch_ReleasingT := Channel_time  
END
```

```
NoNeu_OpenClutch_Releasing  $\triangle$   
STATUS  
ordinary  
WHEN  
grd4 :Channel_Open = TRUE  
THEN  
act3 :Channel_NoNeu_OpenClutch_Releasing := TRUE  
act4 :Channel_NoNeu_OpenClutch_ReleasingT := Channel_time  
END
```

```
NoNeu_Release_NoClutch  $\triangle$   
STATUS  
ordinary  
WHEN  
grd4 :Channel_Release = TRUE  
THEN  
act3 :Channel_NoNeu_Release_NoClutch := TRUE  
act4 :Channel_NoNeu_Release_NoClutchT := Channel_time  
END
```

```
NoNeu_Release_Clutch  $\triangle$   
STATUS  
ordinary  
WHEN  
grd4 :Channel_Release = TRUE  
THEN  
act3 :Channel_NoNeu_Release_Clutch := TRUE  
act4 :Channel_NoNeu_Release_ClutchT := Channel_time  
END
```

```
NoNeu_SyncSpeed  $\triangle$   
STATUS  
ordinary  
WHEN  
grd4 :Channel_SyncSpeed= TRUE  
THEN  
act3 :Channel_NoNeu_SyncSpeed := TRUE  
act4 :Channel_NoNeu_SyncSpeedT := Channel_time  
END
```

```
NoNeu_RequestOpenClutch_Setting  $\triangle$   
STATUS  
ordinary  
BEGIN  
act3 :Channel_NoNeu_RequestOpenClutch_Setting := TRUE  
act4 :Channel_NoNeu_RequestOpenClutch_SettingT := Channel_time  
END
```

```
NoNeu_OpenClutch_Setting  $\triangle$   
STATUS  
ordinary  
WHEN  
grd4 :Channel_Open = TRUE  
THEN  
act3 :Channel_NoNeu_OpenClutch_Setting := TRUE  
act4 :Channel_NoNeu_OpenClutch_SettingT := Channel_time  
END
```

```
NoNeu_SetGear_NoClutch  $\triangle$   
STATUS  
ordinary  
WHEN  
grd4 :Channel_Set = TRUE  
THEN  
act2 :Channel_NoNeu_SetGear_NoClutch := TRUE  
END
```

```
NoNeu_SetGear_ReleasingClutch  $\triangle$   
STATUS  
ordinary  
WHEN
```

## Gear Controller Case-study (Time Added Manually)

```
    grd4 :Channel_Set = TRUE
THEN
    act3 :Channel_NoNeu_SetGear_ReleasingClutch := TRUE
    act4 :Channel_NoNeu_SetGear_ReleasingClutchT := Channel_time
END

    NoNeu_SetGear_SettingClutch  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd4 :Channel_Set = TRUE
THEN
    act3 :Channel_NoNeu_SetGear_SettingClutch := TRUE
    act4 :Channel_NoNeu_SetGear_SettingClutchT := Channel_time
END

    NoNeu_CloseClutch_Setting  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd4 :Channel_Close = TRUE
THEN
    act2 :Channel_NoNeu_CloseClutch_Setting := TRUE
END

    NoNeu_CloseClutch_Releasing  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd4 :Channel_Close = TRUE
THEN
    act2 :Channel_NoNeu_CloseClutch_Releasing := TRUE
END

    Engine_Request_SyncSpeed  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Channel_RequestFromNeu = TRUE  $\vee$  Channel_NoNeu_Release_NoClutch = TRUE
THEN
    act3 :Channel_Request_SyncSpeed := TRUE
    act4 :Channel_Request_SyncSpeedT := Channel_time
END

    Engine_SyncSpeed  $\triangle$ 
    STATUS
    ordinary
BEGIN
    act3 :Channel_SyncSpeed := TRUE
    act4 :Channel_SyncSpeedT := Channel_time
END

    Engine_Request_ZeroTorque  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Channel_RequestToNeu = TRUE  $\vee$  Channel_RequestNoNeu = TRUE
THEN
    act3 :Channel_Request_ZeroTorque := TRUE
    act4 :Channel_Request_ZeroTorqueT := Channel_time
END

    Engine_ZeroTorque  $\triangle$ 
    STATUS
    ordinary
BEGIN
    act3 :Channel_ZeroTorque := TRUE
    act4 :Channel_ZeroTorqueT := Channel_time
END

    Clutch_Request_Open  $\triangle$ 
    STATUS
    ordinary
WHEN
    Channel_FromNeu_RequestOpenClutch = TRUE  $\vee$  Channel_ToNeu_RequestOpenClutch = TRUE  $\vee$ 
    grd1 :Channel_NoNeu_RequestOpenClutch_Releasing = TRUE  $\vee$ 
    Channel_NoNeu_RequestOpenClutch_Setting = TRUE
THEN
```

## Gear Controller Case-study (Time Added Manually)

```
act3:Channel_Request_Open := TRUE
act4:Channel_Request_OpenT := Channel_time
END

Clutch_Open  $\triangle$ 
  STATUS
  ordinary
BEGIN
act3:Channel_Open := TRUE
act4:Channel_OpenT := Channel_time
END

Clutch_Request_Close  $\triangle$ 
  STATUS
  ordinary
WHEN
  Channel_FromNeu_SetGear_Clutch = TRUE  $\vee$ 
  Channel_ToNeu_Release_Clutch = TRUE  $\vee$ 
  grd1: Channel_NoNeu_SetGear_ReleasingClutch = TRUE  $\vee$ 
  Channel_NoNeu_SetGear_SettingClutch= TRUE
THEN
act3:Channel_Request_Close := TRUE
act4:Channel_Request_CloseT := Channel_time
END

Clutch_Close  $\triangle$ 
  STATUS
  ordinary
BEGIN
act3:Channel_Close := TRUE
act4:Channel_CloseT := Channel_time
END

Gear_Request_Release  $\triangle$ 
  STATUS
  ordinary
WHEN
  grd1: Channel_ToNeu_ZeroTorque = TRUE  $\vee$  Channel_ToNeu_OpenClutch = TRUE  $\vee$ 
  Channel_NoNeu_ZeroTorque = TRUE  $\vee$  Channel_NoNeu_OpenClutch_Releasing= TRUE
THEN
act3:Channel_Request_Release := TRUE
act4:Channel_Request_ReleaseT := Channel_time
END

Gear_Release  $\triangle$ 
  STATUS
  ordinary
BEGIN
act3:Channel_Release := TRUE
act4:Channel_ReleaseT := Channel_time
END

Gear_Request_Set  $\triangle$ 
  STATUS
  ordinary
WHEN
  Channel_FromNeu_SyncSpeed = TRUE  $\vee$  Channel_FromNeu_OpenClutch = TRUE  $\vee$ 
  grd1: Channel_NoNeu_Release_Clutch = TRUE  $\vee$  Channel_NoNeu_SyncSpeed = TRUE  $\vee$ 
  Channel_NoNeu_OpenClutch_Setting = TRUE
THEN
act3:Channel_Request_Set := TRUE
act4:Channel_Request_SetT := Channel_time
END

Gear_Set  $\triangle$ 
  STATUS
  ordinary
BEGIN
act3:Channel_Set := TRUE
act4:Channel_SetT := Channel_time
END

FINAL  $\triangle$ 
  STATUS
  ordinary
BEGIN
act43:Channel_RequestFromNeu := FALSE
act44:Channel_FromNeu_SyncSpeed := FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
act45 :Channel_FromNeu_RequestOpenClutch := FALSE
act46 :Channel_FromNeu_OpenClutch := FALSE
act47 :Channel_FromNeu_SetGear_Clutch := FALSE
act48 :Channel_FromNeu_SetGear_NoClutch := FALSE
act49 :Channel_FromNeu_CloseClutch := FALSE
act50 :Channel_RequestToNeu := FALSE
act51 :Channel_ToNeu_ZeroTorque := FALSE
act52 :Channel_ToNeu_RequestOpenClutch := FALSE
act53 :Channel_ToNeu_OpenClutch := FALSE
act54 :Channel_ToNeu_Release_Clutch := FALSE
act55 :Channel_ToNeu_Release_NoClutch := FALSE
act56 :Channel_ToNeu_CloseClutch := FALSE
act57 :Channel_RequestNoNeu := FALSE
act58 :Channel_NoNeu_ZeroTorque := FALSE
act59 :Channel_NoNeu_Release_NoClutch := FALSE
act60 :Channel_NoNeu_RequestOpenClutch_Releasing := FALSE
act61 :Channel_NoNeu_OpenClutch_Releasing := FALSE
act62 :Channel_NoNeu_Release_Clutch := FALSE
act63 :Channel_NoNeu_SyncSpeed := FALSE
act64 :Channel_NoNeu_RequestOpenClutch_Setting := FALSE
act65 :Channel_NoNeu_OpenClutch_Setting := FALSE
act66 :Channel_NoNeu_SetGear_ReleasingClutch := FALSE
act67 :Channel_NoNeu_SetGear_SettingClutch := FALSE
act68 :Channel_NoNeu_SetGear_NoClutch := FALSE
act69 :Channel_NoNeu_CloseClutch_Releasing := FALSE
act70 :Channel_NoNeu_CloseClutch_Setting := FALSE
act71 :Channel_Request_SyncSpeed := FALSE
act72 :Channel_Request_ZeroTorque := FALSE
act73 :Channel_SyncSpeed := FALSE
act74 :Channel_ZeroTorque := FALSE
act75 :Channel_Request_Open := FALSE
act76 :Channel_Request_Close := FALSE
act77 :Channel_Open := FALSE
act78 :Channel_Close := FALSE
act79 :Channel_Request_Release := FALSE
act80 :Channel_Request_Set := FALSE
act81 :Channel_Release := FALSE
act82 :Channel_Set := FALSE
```

END

Tick\_Tock  $\triangle$

STATUS

ordinary

ANY

tick

WHERE

*typing\_tick* :tick  $\in \mathbb{Z}$

grd1 :tick > 0

grd23 : Channel\_RequestFromNeu = TRUE  $\wedge$  Channel\_Request\_SyncSpeed = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_RequestFromNeuT + Channel\_DL

grd24 : Channel\_NoNeu\_Release\_NoClutch = TRUE  $\wedge$  Channel\_Request\_SyncSpeed = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_NoNeu\_Release\_NoClutchT + Channel\_DL

grd25 : Channel\_RequestToNeu = TRUE  $\wedge$  Channel\_Request\_ZeroTorque = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_RequestToNeuT + Channel\_DL

grd26 : Channel\_RequestNoNeu = TRUE  $\wedge$  Channel\_Request\_ZeroTorque = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_RequestNoNeuT + Channel\_DL

grd27 : Channel\_ZeroTorque = TRUE  $\wedge$  Channel\_ToNeu\_ZeroTorque = FALSE  $\wedge$  Channel\_NoNeu\_ZeroTorque = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_ZeroTorqueT + Channel\_DL

grd28 : Channel\_SyncSpeed = TRUE  $\wedge$  Channel\_FromNeu\_SyncSpeed = FALSE  $\wedge$  Channel\_NoNeu\_SyncSpeed = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_SyncSpeedT + Channel\_DL

grd29 : Channel\_FromNeu\_RequestOpenClutch = TRUE  $\wedge$  Channel\_Request\_Open = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_FromNeu\_RequestOpenClutchT + Channel\_DL

grd30 : Channel\_ToNeu\_RequestOpenClutch = TRUE  $\wedge$  Channel\_Request\_Open = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_ToNeu\_RequestOpenClutchT + Channel\_DL

grd31 : Channel\_NoNeu\_RequestOpenClutch\_Releasing = TRUE  $\wedge$  Channel\_Request\_Open = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_NoNeu\_RequestOpenClutch\_ReleasingT + Channel\_DL

grd32 : Channel\_NoNeu\_RequestOpenClutch\_Setting = TRUE  $\wedge$  Channel\_Request\_Open = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_NoNeu\_RequestOpenClutch\_SettingT + Channel\_DL

grd33 : Channel\_FromNeu\_SetGear\_Clutch = TRUE  $\wedge$  Channel\_Request\_Close = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_FromNeu\_SetGear\_ClutchT + Channel\_DL

grd34 : Channel\_NoNeu\_SetGear\_ReleasingClutch = TRUE  $\wedge$  Channel\_Request\_Close = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_NoNeu\_SetGear\_ReleasingClutchT + Channel\_DL

grd35 : Channel\_NoNeu\_SetGear\_SettingClutch = TRUE  $\wedge$  Channel\_Request\_Close = FALSE  
 $\Rightarrow$  Channel\_time+tick  $\leq$  Channel\_NoNeu\_SetGear\_SettingClutchT + Channel\_DL

grd36 : Channel\_ToNeu\_Release\_Clutch = TRUE  $\wedge$  Channel\_Request\_Close = FALSE

## Gear Controller Case-study (Time Added Manually)

```
⇒ Channel_time+tick ≤ Channel_ToNeu_Release_ClutchT + Channel_DL
Channel_Open = TRUE ∧ Channel_FromNeu_OpenClutch = FALSE ∧ Channel_ToNeu_OpenClutch = FALSE
grd37 : ∧ Channel_NoNeu_OpenClutch_Releasing = FALSE ∧ Channel_NoNeu_OpenClutch_Setting = FALSE
⇒ Channel_time+tick ≤ Channel_OpenT + Channel_DL
Channel_Close = TRUE ∧ Channel_FromNeu_CloseClutch = FALSE ∧ Channel_ToNeu_CloseClutch = FALSE
grd38 : ∧ Channel_NoNeu_CloseClutch_Releasing = FALSE ∧ Channel_NoNeu_CloseClutch_Setting = FALSE
⇒ Channel_time+tick ≤ Channel_CloseT + Channel_DL
Channel_ToNeu_ZeroTorque = TRUE ∧ Channel_Request_Release = FALSE
grd39 : ⇒ Channel_time+tick ≤ Channel_ToNeu_ZeroTorqueT + Channel_DL
Channel_ToNeu_OpenClutch = TRUE ∧ Channel_Request_Release = FALSE
grd40 : ⇒ Channel_time+tick ≤ Channel_ToNeu_OpenClutchT + Channel_DL
Channel_NoNeu_ZeroTorque = TRUE ∧ Channel_Request_Release = FALSE
grd41 : ⇒ Channel_time+tick ≤ Channel_NoNeu_ZeroTorqueT + Channel_DL
Channel_NoNeu_OpenClutch_Releasing = TRUE ∧ Channel_Request_Release = FALSE
grd42 : ⇒ Channel_time+tick ≤ Channel_NoNeu_OpenClutch_ReleasingT + Channel_DL
Channel_NoNeu_SyncSpeed = TRUE ∧ Channel_Request_Set = FALSE
grd43 : ⇒ Channel_time+tick ≤ Channel_NoNeu_SyncSpeedT + Channel_DL
Channel_NoNeu_OpenClutch_Setting = TRUE ∧ Channel_Request_Set = FALSE
grd44 : ⇒ Channel_time+tick ≤ Channel_NoNeu_OpenClutch_SettingT + Channel_DL
Channel_NoNeu_Release_Clutch = TRUE ∧ Channel_Request_Set = FALSE
grd45 : ⇒ Channel_time+tick ≤ Channel_NoNeu_Release_ClutchT + Channel_DL
Channel_FromNeu_SyncSpeed = TRUE ∧ Channel_Set = FALSE
grd46 : ⇒ Channel_time+tick ≤ Channel_FromNeu_SyncSpeedT + Channel_DL
Channel_ToNeu_OpenClutch = TRUE ∧ Channel_Set = FALSE
grd47 : ⇒ Channel_time+tick ≤ Channel_ToNeu_OpenClutchT + Channel_DL
Channel_Release = TRUE ∧ Channel_ToNeu_Release_Clutch = FALSE ∧ Channel_ToNeu_Release_NoClutch = FALSE
grd48 : ∧ Channel_NoNeu_Release_NoClutch = FALSE ∧ Channel_NoNeu_Release_Clutch = FALSE
⇒ Channel_time+tick ≤ Channel_ReleaseT + Channel_DL
Channel_Set = TRUE ∧ Channel_FromNeu_SetGear_Clutch = FALSE ∧ Channel_FromNeu_SetGear_NoClutch = FALSE
grd49 : ∧ Channel_NoNeu_SetGear_NoClutch = FALSE ∧ Channel_NoNeu_SetGear_ReleasingClutch = FALSE
⇒ Channel_time+tick ≤ Channel_SetT + Channel_DL
```

**THEN**

```
act2 : Channel_time := Channel_time + tick
```

**END**

**END**

## Decomposed Machine Engine

### MACHINE

Engine

### SEES

c6

### VARIABLES

Engine\_SyncSpeed  
Engine\_WaitForSyncClutch  
Engine\_ZeroTorque  
Engine\_WaitForZeroClutch  
Engine\_Request\_SyncSpeed  
Engine\_Request\_ZeroTorque  
Engine\_Request\_SyncSpeedT  
Engine\_Request\_ZeroTorqueT  
Engine\_SyncSpeedT  
Engine\_ZeroTorqueT  
Engine\_time

### INVARIANTS

*typing\_Engine\_time* :Engine\_time  $\in \mathbb{Z}$   
*typing\_Engine\_ZeroTorqueT* :Engine\_ZeroTorqueT  $\in \mathbb{Z}$   
*typing\_Engine\_WaitForZeroClutch* :Engine\_WaitForZeroClutch  $\in \text{BOOL}$   
*typing\_Engine\_Request\_ZeroTorqueT* :Engine\_Request\_ZeroTorqueT  $\in \mathbb{Z}$   
*typing\_Engine\_SyncSpeedT* :Engine\_SyncSpeedT  $\in \mathbb{Z}$   
*typing\_Engine\_Request\_ZeroTorque* :Engine\_Request\_ZeroTorque  $\in \text{BOOL}$   
*typing\_Engine\_Request\_SyncSpeed* :Engine\_Request\_SyncSpeed  $\in \text{BOOL}$   
*typing\_Engine\_ZeroTorque* :Engine\_ZeroTorque  $\in \text{BOOL}$   
*typing\_Engine\_SyncSpeed* :Engine\_SyncSpeed  $\in \text{BOOL}$   
*typing\_Engine\_Request\_SyncSpeedT* :Engine\_Request\_SyncSpeedT  $\in \mathbb{Z}$   
*typing\_Engine\_WaitForSyncClutch* :Engine\_WaitForSyncClutch  $\in \text{BOOL}$

### EVENTS

#### INITIALISATION $\triangle$

##### STATUS

ordinary

#### BEGIN

act61 :Engine\_SyncSpeed := FALSE  
act62 :Engine\_WaitForSyncClutch := FALSE  
act63 :Engine\_ZeroTorque := FALSE  
act64 :Engine\_WaitForZeroClutch := FALSE  
act81 :Engine\_Request\_SyncSpeed := FALSE  
act82 :Engine\_Request\_ZeroTorque := FALSE  
act87 :Engine\_Request\_SyncSpeedT := 0  
act88 :Engine\_Request\_ZeroTorqueT := 0  
act93 :Engine\_SyncSpeedT := 0  
act94 :Engine\_ZeroTorqueT := 0  
act174 :Engine\_time := 0

#### END

#### Engine\_Request\_SyncSpeed $\triangle$

##### STATUS

ordinary

#### WHEN

grd2 :Engine\_Request\_SyncSpeed = FALSE

#### THEN

act1 :Engine\_Request\_SyncSpeed := TRUE  
act2 :Engine\_Request\_SyncSpeedT := Engine\_time

#### END

#### Engine\_SyncSpeed $\triangle$

##### STATUS

ordinary

#### WHEN

grd1 :Engine\_Request\_SyncSpeed = TRUE  
grd2 :Engine\_SyncSpeed = FALSE  
grd3 :Engine\_WaitForSyncClutch = FALSE

#### THEN

act1 :Engine\_SyncSpeed := TRUE  
act2 :Engine\_SyncSpeedT := Engine\_time

#### END

#### Engine\_WaitForSyncClutch $\triangle$

##### STATUS

ordinary

#### WHEN

grd1 :Engine\_Request\_SyncSpeed = TRUE  
grd2 :Engine\_SyncSpeed = FALSE

## Gear Controller Case-study (Time Added Manually)

```
    grd3 :Engine_WaitForSyncClutch = FALSE
THEN
    act1 :Engine_WaitForSyncClutch := TRUE
END

    Engine_Request_ZeroTorque  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd2 :Engine_Request_ZeroTorque = FALSE
THEN
    act1 :Engine_Request_ZeroTorque := TRUE
    act2 :Engine_Request_ZeroTorqueT := Engine_time
END

    Engine_ZeroTorque  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Engine_Request_ZeroTorque = TRUE
    grd2 :Engine_ZeroTorque = FALSE
    grd3 :Engine_WaitForZeroClutch = FALSE
THEN
    act1 :Engine_ZeroTorque := TRUE
    act2 :Engine_ZeroTorqueT := Engine_time
END

    Engine_WaitForZeroClutch  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Engine_Request_ZeroTorque = TRUE
    grd2 :Engine_ZeroTorque = FALSE
    grd3 :Engine_WaitForZeroClutch = FALSE
THEN
    act1 :Engine_WaitForZeroClutch := TRUE
END

    FINAL  $\triangle$ 
    STATUS
    ordinary
BEGIN
    act25 :Engine_SyncSpeed := FALSE
    act26 :Engine_WaitForSyncClutch := FALSE
    act27 :Engine_ZeroTorque := FALSE
    act28 :Engine_WaitForZeroClutch := FALSE
    act37 :Engine_Request_SyncSpeed := FALSE
    act38 :Engine_Request_ZeroTorque := FALSE
END

    Tick_Tock  $\triangle$ 
    STATUS
    ordinary
ANY
    tick
WHERE
    typing_tick :tick  $\in \mathbb{Z}$ 
    grd1 :tick > 0
    grd50 : Engine_Request_SyncSpeed = TRUE  $\wedge$  Engine_SyncSpeed = FALSE  $\wedge$  Engine_WaitForSyncClutch = FALSE
             $\Rightarrow$  Engine_time+tick  $\leq$  Engine_Request_SyncSpeedT + Engine_Sync_DL
    grd51 : Engine_Request_ZeroTorque = TRUE  $\wedge$  Engine_ZeroTorque = FALSE  $\wedge$  Engine_WaitForZeroClutch = FALSE
             $\Rightarrow$  Engine_time+tick  $\leq$  Engine_Request_ZeroTorqueT + Engine_Zero_DL
THEN
    act3 :Engine_time := Engine_time + tick
END

END
```

## Decomposed Machine Gear

### MACHINE

**Gear**

### SEES

c6

### VARIABLES

Gear\_Request\_Release  
Gear\_Request\_Set  
Gear\_Release  
Error\_Gear\_Release  
Gear\_Set  
Error\_Gear\_Set  
Gear\_Request\_ReleaseT  
Gear\_Request\_SetT  
Gear\_ReleaseT  
Gear\_SetT  
Gear\_time

### INVARIANTS

*typing\_Error\_Gear\_Release* :Error\_Gear\_Release ∈ BOOL  
*typing\_Gear\_Request\_ReleaseT* :Gear\_Request\_ReleaseT ∈ ℤ  
*typing\_Error\_Gear\_Set* :Error\_Gear\_Set ∈ BOOL  
*typing\_Gear\_Request\_Set* :Gear\_Request\_Set ∈ BOOL  
*typing\_Gear\_Release* :Gear\_Release ∈ BOOL  
*typing\_Gear\_Request\_SetT* :Gear\_Request\_SetT ∈ ℤ  
*typing\_Gear\_SetT* :Gear\_SetT ∈ ℤ  
*typing\_Gear\_ReleaseT* :Gear\_ReleaseT ∈ ℤ  
*typing\_Gear\_Set* :Gear\_Set ∈ BOOL  
*typing\_Gear\_time* :Gear\_time ∈ ℤ  
*typing\_Gear\_Request\_Release* :Gear\_Request\_Release ∈ BOOL

### EVENTS

#### INITIALISATION $\triangle$

##### STATUS

ordinary

#### BEGIN

act69 :Gear\_Release := FALSE  
act70 :Error\_Gear\_Release := FALSE  
act71 :Gear\_Set := FALSE  
act72 :Error\_Gear\_Set := FALSE  
act85 :Gear\_Request\_Release := FALSE  
act86 :Gear\_Request\_Set := FALSE  
act91 :Gear\_Request\_ReleaseT := 0  
act92 :Gear\_Request\_SetT := 0  
act97 :Gear\_ReleaseT := 0  
act98 :Gear\_SetT := 0  
act173 :Gear\_time := 0

#### END

#### Error\_FromNeu\_SetGear\_NoClutch $\triangle$

##### STATUS

ordinary

#### WHEN

grd4 :Gear\_Set= TRUE

#### THEN

skip

#### END

#### Gear\_Request\_Release $\triangle$

##### STATUS

ordinary

#### WHEN

grd2 :Gear\_Request\_Release = FALSE

#### THEN

act1 :Gear\_Request\_Release := TRUE  
act2 :Gear\_Request\_ReleaseT := Gear\_time

#### END

#### Gear\_Release $\triangle$

##### STATUS

ordinary

#### WHEN

grd1 :Gear\_Request\_Release = TRUE  
grd2 :Gear\_Release = FALSE  
grd3 :Error\_Gear\_Release = FALSE

#### THEN

act1 :Gear\_Release := TRUE



## Gear Controller Case-study (Time Added Manually)

```
    act2 :Gear_ReleaseT := Gear_time
END

Error_Gear_Release  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Gear_Request_Release = TRUE
    grd2 :Gear_Release = FALSE
    grd3 :Error_Gear_Release = FALSE
THEN
    act1 :Error_Gear_Release := TRUE
END

Gear_Request_Set  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd2 :Gear_Request_Set = FALSE
THEN
    act1 :Gear_Request_Set := TRUE
    act2 :Gear_Request_SetT := Gear_time
END

Gear_Set  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Gear_Request_Set = TRUE
    grd2 :Gear_Set = FALSE
    grd3 :Error_Gear_Set = FALSE
THEN
    act1 :Gear_Set := TRUE
    act2 :Gear_SetT := Gear_time
END

Error_Gear_Set  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Gear_Request_Set = TRUE
    grd2 :Gear_Set = FALSE
    grd3 :Error_Gear_Set = FALSE
THEN
    act1 :Error_Gear_Set := TRUE
END

FINAL  $\triangle$ 
    STATUS
    ordinary
BEGIN
    act31 :Gear_Release := FALSE
    act32 :Gear_Set := FALSE
    act41 :Gear_Request_Release := FALSE
    act42 :Gear_Request_Set := FALSE
END

Tick_Tock  $\triangle$ 
    STATUS
    ordinary
ANY
    tick
WHERE
    typing_tick :tick  $\in \mathbb{Z}$ 
    grd1 :tick > 0
    grd54 : Gear_Request_Release = TRUE  $\wedge$  Gear_Release = FALSE  $\wedge$  Error_Gear_Release = FALSE
             $\Rightarrow$  Gear_time+tick  $\leq$  Gear_Request_ReleaseT + Gear_Release_DL
    grd55 : Gear_Request_Set = TRUE  $\wedge$  Gear_Set = FALSE  $\wedge$  Error_Gear_Set = FALSE
             $\Rightarrow$  Gear_time+tick  $\leq$  Gear_Request_SetT + Gear_Set_DL
THEN
    act4 :Gear_time := Gear_time + tick
END

END
```

## Decomposed Machine Clutch

### MACHINE

Clutch

### SEES

c6

### VARIABLES

Clutch\_Request\_Open  
Clutch\_Request\_Close  
Clutch\_Open  
Error\_Clutch\_Open  
Clutch\_Close  
Error\_Clutch\_Close  
Clutch\_Request\_OpenT  
Clutch\_Request\_CloseT  
Clutch\_OpenT  
Clutch\_CloseT  
Clutch\_time

### INVARIANTS

*typing\_Clutch\_Request\_CloseT* : Clutch\_Request\_CloseT  $\in \mathbb{Z}$   
*typing\_Clutch\_Request\_OpenT* : Clutch\_Request\_OpenT  $\in \mathbb{Z}$   
*typing\_Clutch\_Close* : Clutch\_Close  $\in \text{BOOL}$   
*typing\_Clutch\_OpenT* : Clutch\_OpenT  $\in \mathbb{Z}$   
*typing\_Clutch\_Request\_Close* : Clutch\_Request\_Close  $\in \text{BOOL}$   
*typing\_Clutch\_CloseT* : Clutch\_CloseT  $\in \mathbb{Z}$   
*typing\_Error\_Clutch\_Close* : Error\_Clutch\_Close  $\in \text{BOOL}$   
*typing\_Clutch\_time* : Clutch\_time  $\in \mathbb{Z}$   
*typing\_Clutch\_Request\_Open* : Clutch\_Request\_Open  $\in \text{BOOL}$   
*typing\_Error\_Clutch\_Open* : Error\_Clutch\_Open  $\in \text{BOOL}$   
*typing\_Clutch\_Open* : Clutch\_Open  $\in \text{BOOL}$

### EVENTS

#### INITIALISATION $\triangle$

##### STATUS

ordinary

#### BEGIN

act65 : Clutch\_Open := FALSE  
act66 : Error\_Clutch\_Open := FALSE  
act67 : Clutch\_Close := FALSE  
act68 : Error\_Clutch\_Close := FALSE  
act83 : Clutch\_Request\_Open := FALSE  
act84 : Clutch\_Request\_Close := FALSE  
act89 : Clutch\_Request\_OpenT := 0  
act90 : Clutch\_Request\_CloseT := 0  
act95 : Clutch\_OpenT := 0  
act96 : Clutch\_CloseT := 0  
act175 : Clutch\_time := 0

#### END

#### Clutch\_Request\_Open $\triangle$

##### STATUS

ordinary

#### WHEN

grd2 : Clutch\_Request\_Open = FALSE

#### THEN

act1 : Clutch\_Request\_Open := TRUE  
act2 : Clutch\_Request\_OpenT := Clutch\_time

#### END

#### Clutch\_Open $\triangle$

##### STATUS

ordinary

#### WHEN

grd1 : Clutch\_Request\_Open = TRUE  
grd2 : Clutch\_Open = FALSE  
grd3 : Error\_Clutch\_Open = FALSE

#### THEN

act1 : Clutch\_Open := TRUE  
act2 : Clutch\_OpenT := Clutch\_time

#### END

#### Error\_Clutch\_Open $\triangle$

##### STATUS

ordinary

#### WHEN

grd1 : Clutch\_Request\_Open = TRUE  
grd2 : Clutch\_Open = FALSE

## Gear Controller Case-study (Time Added Manually)

```
    grd3 :Error_Clutch_Open = FALSE
THEN
    act1 :Error_Clutch_Open := TRUE
END

    Clutch_Request_Close  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd2 :Clutch_Request_Close = FALSE
THEN
    act1 :Clutch_Request_Close := TRUE
    act2 :Clutch_Request_CloseT := Clutch_time
END

    Clutch_Close  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Clutch_Request_Close = TRUE
    grd2 :Clutch_Close = FALSE
    grd3 :Error_Clutch_Close = FALSE
THEN
    act1 :Clutch_Close := TRUE
    act2 :Clutch_CloseT := Clutch_time
END

    Error_Clutch_Close  $\triangle$ 
    STATUS
    ordinary
WHEN
    grd1 :Clutch_Request_Close = TRUE
    grd2 :Clutch_Close = FALSE
    grd3 :Error_Clutch_Close = FALSE
THEN
    act1 :Error_Clutch_Close := TRUE
END

    FINAL  $\triangle$ 
    STATUS
    ordinary
BEGIN
    act29 :Clutch_Open := FALSE
    act30 :Clutch_Close := FALSE
    act39 :Clutch_Request_Open := FALSE
    act40 :Clutch_Request_Close := FALSE
END

    Tick_Tock  $\triangle$ 
    STATUS
    ordinary
ANY
    tick
WHERE
    typing_tick :tick  $\in \mathbb{Z}$ 
    grd1 :tick > 0
    grd52 : Clutch_Request_Open = TRUE  $\wedge$  Clutch_Open = FALSE  $\wedge$  Error_Clutch_Open = FALSE
             $\Rightarrow$  Clutch_time+tick  $\leq$  Clutch_Request_OpenT + Clutch_Open_DL
    grd53 : Clutch_Request_Close = TRUE  $\wedge$  Clutch_Close = FALSE  $\wedge$  Error_Clutch_Close = FALSE
             $\Rightarrow$  Clutch_time+tick  $\leq$  Clutch_Request_CloseT + Clutch_Close_DL
THEN
    act5 :Clutch_time := Clutch_time + tick
END

END
```

## Decomposed Machine Clutch (Second Level of Abstraction)

### MACHINE

Clutch1

### REFINES

Clutch

### SEES

c7

### VARIABLES

Clutch\_Request\_Open  
Clutch\_Request\_Close  
Clutch\_Open  
Error\_Clutch\_Open  
Clutch\_Close  
Error\_Clutch\_Close  
Clutch\_Request\_OpenT  
Clutch\_Request\_CloseT  
Clutch\_OpenT  
Clutch\_CloseT  
Clutch\_time

### INVARIANTS

inv1 : Error\_Clutch\_Close\_DE ≤ Clutch\_Close\_DL ∨ Clutch\_Close\_DE ≤ Clutch\_Close\_DL  
inv2 : Error\_Clutch\_Open\_DE ≤ Clutch\_Close\_DL ∨ Clutch\_Open\_DE ≤ Clutch\_Open\_DL

### EVENTS

#### INITIALISATION ≙

extended

STATUS

ordinary

#### BEGIN

act65 : Clutch\_Open := FALSE  
act66 : Error\_Clutch\_Open := FALSE  
act67 : Clutch\_Close := FALSE  
act68 : Error\_Clutch\_Close := FALSE  
act83 : Clutch\_Request\_Open := FALSE  
act84 : Clutch\_Request\_Close := FALSE  
act89 : Clutch\_Request\_OpenT := 0  
act90 : Clutch\_Request\_CloseT := 0  
act95 : Clutch\_OpenT := 0  
act96 : Clutch\_CloseT := 0  
act175 : Clutch\_time := 0

#### END

#### Clutch\_Request\_Open ≙

extended

STATUS

ordinary

#### REFINES

Clutch\_Request\_Open

#### WHEN

grd2 : Clutch\_Request\_Open = FALSE

#### THEN

act1 : Clutch\_Request\_Open := TRUE  
act2 : Clutch\_Request\_OpenT := Clutch\_time

#### END

#### Clutch\_Open ≙

extended

STATUS

ordinary

#### REFINES

Clutch\_Open

#### WHEN

grd1 : Clutch\_Request\_Open = TRUE  
grd2 : Clutch\_Open = FALSE  
grd3 : Error\_Clutch\_Open = FALSE  
grd4 : Clutch\_time ≥ Clutch\_Request\_OpenT + Clutch\_Open\_DE

#### THEN

act1 : Clutch\_Open := TRUE  
act2 : Clutch\_OpenT := Clutch\_time

#### END

#### Error\_Clutch\_Open ≙

extended

STATUS

ordinary

#### REFINES

## Gear Controller Case-study (Time Added Manually)

```
Error_Clutch_Open
WHEN
  grd1 :Clutch_Request_Open = TRUE
  grd2 :Clutch_Open = FALSE
  grd3 :Error_Clutch_Open = FALSE
  grd4 :Clutch_time ≥ Clutch_Request_OpenT + Error_Clutch_Open_DE
THEN
  act1 :Error_Clutch_Open := TRUE
END

Clutch_Request_Close ≙
  extended
  STATUS
  ordinary
REFINES
  Clutch_Request_Close
WHEN
  grd2 :Clutch_Request_Close = FALSE
THEN
  act1 :Clutch_Request_Close := TRUE
  act2 :Clutch_Request_CloseT := Clutch_time
END

Clutch_Close ≙
  extended
  STATUS
  ordinary
REFINES
  Clutch_Close
WHEN
  grd1 :Clutch_Request_Close = TRUE
  grd2 :Clutch_Close = FALSE
  grd3 :Error_Clutch_Close = FALSE
  grd4 :Clutch_time ≥ Clutch_Request_OpenT + Clutch_Close_DE
THEN
  act1 :Clutch_Close := TRUE
  act2 :Clutch_CloseT := Clutch_time
END

Error_Clutch_Close ≙
  extended
  STATUS
  ordinary
REFINES
  Error_Clutch_Close
WHEN
  grd1 :Clutch_Request_Close = TRUE
  grd2 :Clutch_Close = FALSE
  grd3 :Error_Clutch_Close = FALSE
  grd4 :Clutch_time ≥ Clutch_Request_OpenT + Error_Clutch_Close_DE
THEN
  act1 :Error_Clutch_Close := TRUE
END

FINAL ≙
  extended
  STATUS
  ordinary
REFINES
  FINAL
BEGIN
  act29 :Clutch_Open := FALSE
  act30 :Clutch_Close := FALSE
  act39 :Clutch_Request_Open := FALSE
  act40 :Clutch_Request_Close := FALSE
END

Tick_Tock ≙
  extended
  STATUS
  ordinary
REFINES
  Tick_Tock
ANY
  tick
WHERE
  typing_tick :tick ∈ ℤ
  grd1 :tick > 0
  grd52 :Clutch_Request_Open = TRUE ∧ Clutch_Open = FALSE ∧ Error_Clutch_Open = FALSE
```

## Gear Controller Case-study (Time Added Manually)

```
⇒ Clutch_time+tick ≤ Clutch_Request_OpenT + Clutch_Open_DL
grd53: Clutch_Request_Close = TRUE ∧ Clutch_Close = FALSE ∧ Error_Clutch_Close = FALSE
⇒ Clutch_time+tick ≤ Clutch_Request_CloseT + Clutch_Close_DL
THEN
act5: Clutch_time := Clutch_time + tick
END
END
```