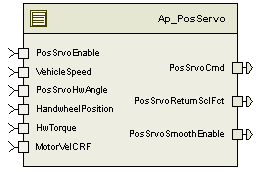
# Module -- Position Tracking Servo

# High-Level Description

This module provides the ability for the EPS system to track a position input command.

# Figures

## Component Diagram



# Variable Data Dictionary

|  |  |  |
| --- | --- | --- |
| Module Inputs | Module Outputs | |
| HandwheelPosition\_HwDeg\_f32 | | PosSrvoCmd\_MtrNm\_f32 |
| VehicleSpeed\_Kph\_f32 | | PosSrvoReturnSclFct\_Uls\_f32 |
| PosSrvoEnable\_Cnt\_lgc | | PosSrvoSmoothEnable\_Uls\_f32 |
| PosSrvoHwAngle\_HwDeg\_f32 | |  |
| HwTorque\_HwNm\_f32 | |  |
| MotorVelCRF\_MtrRadpS\_f32 | |  |

## Module Internal Variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable Name | Resolution | Legal Range  (min) | Legal Range  (max) | Software Segment |
| FiltHwPosKSV\_M\_str | LPF32KSV\_Str |  |  | POSSERVO\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
| FiltHwPosKSV\_M\_str.SV\_Uls\_f32 | Single Precision Floating Point | -900.0 | 900.0 |  |
| FiltHwPosKSV\_M\_str.K\_Uls\_f32 | Single Precision Floating Point | 0.0012558 | 0.2222323 |  |
| FiltHwTrqKSV\_M\_str | LPF32KSV\_Str |  |  | POSSERVO\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
| FiltHwTrqKSV\_M\_str.SV\_Uls\_f32 | Single Precision Floating Point | -10.0 | 10.0 |  |
| FiltHwTrqKSV\_M\_str.K\_Uls\_f32 | Single Precision Floating Point | 0.0012558 | 0.2222323 |  |
| PrkAstRampSV\_Uls\_M\_f32 | Single Precision Floating Point | 0.0 | 1.0 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_32 |
| ITermSV\_HwDeg\_M\_s27p4 | 2^-4 | -72089600 | 72089600 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_32 |
| DTermKSV\_M\_str | LPF32KSV\_Str |  |  | POSSERVO\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
| DTermKSV\_M\_str.SV\_Uls\_f32 | Single Precision Floating Point | -8.8 | 8.8 |  |
| DTermKSV\_M\_str.K\_Uls\_f32 | Single Precision Floating Point | 0.0124877 | 0.7153905 |  |
| PrevCmdError\_HwDeg\_M\_s11p4 | 2^-4 | -1800.0 | 1800.0 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_16 |
| PosSrvoRampComplete\_Cnt\_D\_lgc | n/a | FALSE | TRUE | POSSERVO\_START\_SEC\_VAR\_CLEARED\_BOOLEAN |
| PosSrvoHWATargFilt\_HwDeg\_D\_f32 | Single Precision Floating Point | -900 | 900 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_32 |
| PosSrvoPIDCmd\_MtrNm\_D\_f32 | Single Precision Floating Point | -8.8 | 8.8 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_32 |
| PosServo\_PTerm\_MtrNm\_D\_s24p7 | 2^-7 | -8.8 | 8.8 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_32 |
| PosServo\_ITerm\_MtrNm\_D\_s8p7 | 2^-7 | -8.8 | 8.8 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_16 |
| PosServo\_DTerm\_MtrNm\_D\_s8p7 | 2^-7 | -8.8 | 8.8 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_16 |
| PrevLimitedHwPos\_HwDeg\_M\_f32 | Single Precision Floating Point | -900 | 900 | POSSERVO\_START\_SEC\_VAR\_CLEARED\_32 |

### User defined typedef definition/declaration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Typedef Name | Element Name | User Defined Type | Legal Range  (min) | Legal Range  (max) |
| <None> |  |  |  |  |

# Constant Data Dictionary

## Calibration Constants

|  |
| --- |
| Constant Name |
| t\_PrkAstDGainY\_MtrNmmSpHwDeg\_u7p9[] |
| t\_PrkAstDisableRateX\_HwNm\_u11p5[] |
| t\_PrkAstDisableRateY\_pSec\_u12p4[] |
| t\_PrkAstDmpTrqX\_MtrRadpS\_u11p5[] |
| t2\_PrkAstDmpTrqY\_MtrNm\_u4p12[][] |
| k\_PrkAstDTermKn\_Cnt\_u16 |
| k\_PrkAstEnableRate\_pSec\_f32 |
| t\_PrkAstIGainY\_MtrNmpHwDegS\_u2p14[] |
| t\_PrkAstITermAWLmtY\_MtrNm\_u9p7[] |
| t\_PrkAstPGainX\_HwDeg\_u12p4[] |
| t2\_PrkAstPGainY\_MtrNm\_u9p7[][] |
| k\_PrkAstPIDLimit\_MtrNm\_u9p7 |
| t\_PrkAstSmoothX\_Uls\_u6p10[] |
| t\_PrkAstSmoothY\_Uls\_u6p10[] |
| t\_PrkAstVehSpdBS\_Kph\_u9p7[] |
| k\_PrkAstHwaLPFKn\_Cnt\_u16 |
| k\_PrkAstHwTrqLPFKn\_Cnt\_u16 |
| t\_PosSrvoMaxCmdX\_Kph\_u9p7[] |
| t\_PosSrvoMaxCmdY\_MtrNm\_u5p11[] |
| t\_HwaRateLimit\_HwDegpSec\_u12p4[] |

## Program(fixed) Constants

### Embedded Constants

#### Local

|  |  |  |  |
| --- | --- | --- | --- |
| Constant Name | Resolution | Units | Value |
| D\_CONVERT\_MSPLOOP\_F32 | Single Precision Floating Point | mS / loop | 2.0 |
| D\_PRKASTLOOPRATE\_SEC\_F32 | Single Precision Floating Point | Seconds | 0.002 |
| D\_RECEXECRATE\_PSEC\_U21P11 | 2^-11 | 1 / Seconds | 500.0 |
| D\_POSSERVOMINRAMP\_ULS\_F32 | Single Precision Floating Point | Unitless | 0.0 |
| D\_POSSERVOMAXRAMP\_ULS\_F32 | Single Precision Floating Point | Unitless | 1.0 |
| D\_RAMPCOMPLETE\_ULS\_U6P10 | 2^-10 | Unitelss | 0.0 |
| D\_DTERMMIN\_MTRNM\_F32 | Single Precision Floating Point | MtrNm | -255.0 |
| D\_DTERMMAX\_MTRNM\_F32 | Single Precision Floating Point | MtrNm | 255.0 |

#### Global

|  |
| --- |
| Constant Name |
| D\_2MS\_SEC\_F32 |
|  |

### Module specific Lookup Tables Constants

|  |  |  |  |
| --- | --- | --- | --- |
| Constant Name | Resolution | Value | Software Segment |
| None |  |  |  |

# Functions/Macros used by the Sub-Modules

## Library Functions / Macros

The library and functions / Macros that are called by the various sub modules are identified below,

1. FPM\_InitFixedPoint\_m
2. TableSize\_m
3. FPM\_FloatToFixed\_m
4. FPM\_FixedToFloat\_m
5. LPF\_KUpdate\_f32\_m
6. LPF\_OpUpdate\_f32\_m
7. Abs\_s16\_m
8. Limit\_m
9. Sign\_s16\_m
10. Sign\_f32\_m
11. Abs\_f32\_m
12. IntplVarXY\_u16\_u16Xu16Y\_Cnt
13. BilinearXYM\_u16\_u16Xu16YM\_Cnt

## Data Hiding Functions

1. <None>

## Global Functions/Macros Defined by this Module

None

## Local Functions/Macros Used by this MDD only

### Filter the Desired Handwheel Angle

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Function Name** | FilterDesiredAngle | Type | Min | Max | UT Tolerance |
| **Arguments Passed** | Active\_T\_lgc | boolean | FULL | FULL |  |
|  | RampComplete\_T\_lgc | boolean | FULL | FULL |  |
|  | HwPos\_T\_f32 | float32 | -900.0 | 900.0 |  |
| **Return Value** | TrgtHwAngle\_HwDeg\_T\_f32 | float32 | -900.0 | 900.0 | 6.25E-02 |

#### Description

### Transition Control

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Function Name** | TransitionControl | Type | Min | Max | UT Tolerance |
| **Arguments Passed** | Active\_T\_lgc | boolean | FULL | FULL |  |
|  | pSmoothEnable\_T\_f32 | float32 pointer | 0.0 | 1.0 |  |
|  | pReturnScl\_T\_f32 | float32 pointer | 0.0 | 1.0 |  |
|  | pRampComplete\_T\_lgc | boolean pointer | FULL | FULL |  |
| **Return Value** | N/A |  |  |  |  |

#### Description



### PID Control

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Function Name** | PIDControl | Type | Min | Max | UT Tolerance |
| **Arguments Passed** | Active\_T\_lgc | boolean | FULL | FULL |  |
|  | RampComplete\_T\_lgc | boolean | FULL | FULL |  |
|  | HwPos\_T\_f32 | float32 | -900.0 | 900.0 |  |
|  | DesiredHwAngle\_T\_f32 | float32 | -900.0 | 900.0 |  |
|  | VehSpd\_T\_u9p7 | uint16 | 0.0 | 511.9921875 |  |
| **Return Value** | TmpPrkAssist\_MtrNm\_T\_f32 | float32 | -8.8 | 8.8 | 7.81E-03 |

#### Description







### Output Torque

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Function Name** | OutputTorque | Type | Min | Max | UT Tolerance |
| **Arguments Passed** | PrkAstCmd\_T\_f32 | float32 | -8.8 | 8.8 |  |
|  | SmoothEnable\_T\_f32 | float32 | 0.0 | 1.0 |  |
|  | VehSpd\_T\_u9p7 | uint16 | 0.0 | 511.9921875 |  |
| **Return Value** | PrkAstCmd\_MtrNm\_T\_f32 | float32 | -8.8 | 8.8 | 2.38E-08 |

#### Description



# Software Module Implementation

## Runtime Environment (RTE) Initial Values

|  |  |
| --- | --- |
| Data | Value |
| Rte\_InitValue\_HandwheelPosition\_HwDeg\_f32 | 0 |
| Rte\_InitValue\_HwTorque\_HwNm\_f32 | 0 |
| Rte\_InitValue\_MotorVelCRF\_MtrRadpS\_f32 | 0 |
| Rte\_InitValue\_PosSrvoCmd\_MtrNm\_f32 | 0 |
| Rte\_InitValue\_PosSrvoEnable\_Cnt\_lgc | FALSE |
| Rte\_InitValue\_PosSrvoHwAngle\_HwDeg\_f32 | 0 |
| Rte\_InitValue\_PosSrvoReturnSclFct\_Uls\_f32 | 1 |
| Rte\_InitValue\_PosSrvoSmoothEnable\_Uls\_f32 | 0 |
| Rte\_InitValue\_VehicleSpeed\_Kph\_f32 | 0 |

## Initialization Functions

### Init: PosServo\_Init1

#### Design Rationale

None

#### Module Outputs

None

#### Module Internal

LPF\_KUpdate\_f32\_m(k\_PrkAstHwaLPFKn\_Hz\_f32, D\_2MS\_SEC\_F32, &FiltHwPosKSV\_M\_str)

LPF\_KUpdate\_f32\_m(k\_PrkAstHwTrqLPFKn\_Hz\_f32, D\_2MS\_SEC\_F32, &FiltHwTrqKSV\_M\_str)

LPF\_KUpdate\_f32\_m(k\_PrkAstDTermKn\_Hz\_f32, D\_2MS\_SEC\_F32, &DTermKSV\_M\_str)

## Periodic Functions

### Per: \_Per1

#### Design Rationale

None

#### Program Flow Start

Rte\_Call\_PosServo\_Per1\_CP0\_CheckpointReached

#### Store Module Inputs to Local copies

HwPos\_HwDeg\_T\_f32 = Rte\_IRead\_PosServo\_Per1\_HandwheelPosition\_HwDeg\_f32()

VehSpd\_Kph\_T\_f32 = Rte\_Iread\_PosServo\_Per1\_VehicleSpeed\_Kph\_f32()

VehSpd\_Kph\_T\_u9p7 = FPM\_FloatToFixed\_m(VehSpd\_Kph\_T\_f32, u9p7\_T)

Active\_Cnt\_T\_lgc = Rte\_Iread\_PosServo\_Per1\_PosSrvoEnable\_Cnt\_lgc()

TrgtHwAngle\_HwDeg\_T\_f32 = Rte\_IRead\_PosServo\_Per1\_PosSrvoHwAngle\_HwDeg\_f32()

#### Handle Subfunctions

TransitionControl(Active\_Cnt\_T\_lgc, &SmoothEnable\_Uls\_T\_f32, &ReturnScale\_Uls\_T\_f32,

&RampComplete\_Cnt\_T\_lgc)

HwPosRateLimit\_HwDegpSec\_T\_u12p4 = IntplVarXY\_u16\_u16Xu16Y\_Cnt(

t\_PrkAstVehSpdBS\_Kph\_u9p7,

t\_HwaRateLimit\_HwDegpSec\_u12p4,

TableSize\_m(t\_PrkAstVehSpdBS\_Kph\_u9p7),

VehSpd\_Kph\_T\_u9p7)

HwPosLimit\_HwDeg\_T\_f32 = FPM\_FixedToFloat\_m(HwPosRateLimit\_HwDegpSec\_T\_u12p4, u12p4\_T) \* D\_2MS\_SEC\_F32

if( Active\_Cnt\_T\_lgc == TRUE)

{

LimitedHwPos\_HwDeg\_T\_f32 = Limit\_m(TrgtHwAngle\_HwDeg\_T\_f32, (PrevLimitedHwPos\_HwDeg\_M\_f32 - HwPosLimit\_HwDeg\_T\_f32), (PrevLimitedHwPos\_HwDeg\_M\_f32 + HwPosLimit\_HwDeg\_T\_f32));

}

else

{

LimitedHwPos\_HwDeg\_T\_f32 = Limit\_m(HwPos\_HwDeg\_T\_f32, (PrevLimitedHwPos\_HwDeg\_M\_f32 - HwPosLimit\_HwDeg\_T\_f32), (PrevLimitedHwPos\_HwDeg\_M\_f32 + HwPosLimit\_HwDeg\_T\_f32));

}

PrevLimitedHwPos\_HwDeg\_M\_f32 = LimitedHwPos\_HwDeg\_T\_f32

TrgtAngle\_HwDeg\_T\_f32 = FilterDesiredAngle(Active\_Cnt\_T\_lgc, RampComplete\_Cnt\_T\_lgc,

LimitedHwPos\_HwDeg\_T\_f32)

PrkAstCmd\_MtrNm\_T\_f32 = PIDControl(Active\_Cnt\_T\_lgc, RampComplete\_Cnt\_T\_lgc,

HwPos\_HwDeg\_T\_f32, TrgtAngle\_HwDeg\_T\_f32,

VehSpd\_Kph\_T\_u9p7)

PosSrvoCmd\_MtrNm\_T\_f32 = OutputTorque(PrkAstCmd\_MtrNm\_T\_f32, SmoothEnable\_Uls\_T\_f32,

VehSpd\_Kph\_T\_u9p7)

#### Store Local copy of outputs into Module Outputs

PosSrvoRampComplete\_Cnt\_D\_lgc = RampComplete\_Cnt\_T\_lgc

PosSrvoHWATargFilt\_HwDeg\_D\_f32 = TrgtAngle\_HwDeg\_T\_f32

PosSrvoPIDCmd\_MtrNm\_D\_f32 = PrkAstCmd\_MtrNm\_T\_f32

Rte\_Iwrite\_PosServo\_Per1\_PosSrvoCmd\_MtrNm\_f32 (PosSrvoCmd\_MtrNm\_T\_f32)

Rte\_Iwrite\_PosServo\_Per1\_PosSrvoReturnSclFct\_Uls\_f32(ReturnScale\_Uls\_T\_f32)

Rte\_Iwrite\_PosServo\_Per1\_PosSrvoSmoothEnable\_Uls\_f32(SmoothEnable\_Uls\_T\_f32)

#### Program Flow End

Rte\_Call\_PosServo\_Per1\_CP1\_CheckpointReached

## Fault Recovery Functions

None

## Shutdown Functions

None

## Interrupt Functions

None

## Serial Communication Functions

None

# Execution Requirements

## Execution Sequence of the Module

(Describe in words relevant details about the execution sequence of the different sub modules.)

## Execution Rates for sub-modules called by the Scheduler

|  |  |  |
| --- | --- | --- |
| Function Name | Calling Frequency | System State(s) in which the function is called |
| PosServo\_Init1 | On Event | On Init |
| PosServo\_Per1 | 2 ms | WARM INIT, OPERATE, DISABLE |

## Execution Requirements for Serial Communication Functions

|  |  |
| --- | --- |
| Function Name | Sub-Module called by (Serial Comm Function Name) |
| <None> |  |

# Memory Map Definition Requirements

## Sub Modules (Functions)

|  |  |
| --- | --- |
| Name of Sub Module | Software Segment |
| PosServo\_Init1 | RTE\_START\_SEC\_AP\_POSSERVO\_APPL\_CODE |
| PosServo\_Per1 | RTE\_START\_SEC\_AP\_POSSERVO\_APPL\_CODE |

## Local Functions

|  |  |
| --- | --- |
| Name of Sub Module | Software Segment |
| FilterDesiredAngle | RTE\_START\_SEC\_AP\_POSSERVO\_APPL\_CODE |
| TransitionControl | RTE\_START\_SEC\_AP\_POSSERVO\_APPL\_CODE |
| PIDControl | RTE\_START\_SEC\_AP\_POSSERVO\_APPL\_CODE |
| OutputTorque | RTE\_START\_SEC\_AP\_POSSERVO\_APPL\_CODE |

# Known Issues / Limitations With Design

1. INLINE functions defined in globalmacro.h are not unit tested

# Revision Control Log

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item #** | **Rev #** | **Change Description** | **Date** | **Author Initials** |
| 1 | 1 | Initial version | 07-Jun-11 | YY |
| 2 | 2 | Corrected anomaly 2371 to prevent potential overflow of intermediate D-Term calculation. | 16-Jun-11 | YY |
| 3 | 3 | Initial version for PosServo CBD | 16-Dec-11 | VK |
| 4 | 4 | Changed VehSpd\_T\_u12p4 to u9p7 and changed the precision for the table associated. | 09-Jan-12 | VK |
| 5 | 5 | Changed the range for hand wheel position to be +/-900 throughout and updated the software segment | 02-02-12 | VK |
| 6 | 6 | Updated to SF-20 v002 | 01-Aug-12 | OT |
| 7 | 7 | Fixed UTP Issue (typecasting bilinear interpolation overflow) | 08-Aug-12 | OT |
| 8 | 8 | Fixed more UTP issues (fixed point math overflow) | 10-Aug-12 | OT |
| 9 | 9 | Updated to SF-20 v003 | 29-Aug-12 | KJS |
| 10 | 10.0 | Added checkpoints and memmap software segment is updated for static variables | 21-Sep-12 | Selva |
| 11 | 11 | UTP corrections to MDD | 19-Oct-12 | KJS |
| 12 | 12 | UTP corrections to MDD | 19-Oct-12 | KJS |
| 13 | 13 | Updated to SF v004 | 15-Mar-13 | SP |
| 14 | 14 | Updated to FDD ver 005 | 10-May-13 | Jared |