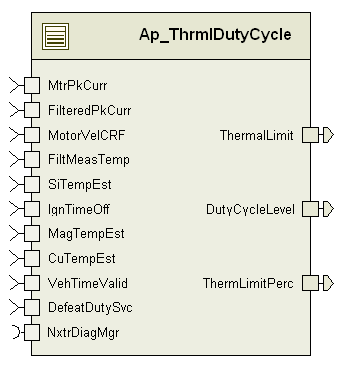
# Module –

# High-Level Description

This module computes a duty cycle limit based on system temperatures. It also outputs a unity scalar value to scale the assist command and a value representing the percentage of reduction.

# Figures

## Component Diagram



# Variable Data Dictionary

For details on module input / output variable, refer to the Data Dictionary for the application. Input / output variable names are listed here for reference.

|  |  |  |
| --- | --- | --- |
| Module Inputs | Module Outputs | |
| MtrPkCurr\_AmpSq\_f32 | | ThermalLimit\_MtrNm\_f32 |
| FilteredPkCurr\_AmpSq\_f32 | | DutyCycleLevel\_Uls\_f32 |
| MotorVelCRF\_MtrRadpS\_f32 | | ThermLimitPerc\_Uls\_f32 |
| FiltMeasTemp\_DegC\_f32 | |  |
| SiTempEst\_DegC\_f32 | |  |
| MagTempEst\_DegC\_f32 | |  |
| CuTempEst\_DegC\_f32 | |  |
| DiagStsDefTemp \_Cnt\_lgc | |  |
| DefeatDutySvc\_Cnt\_lgc | |  |
| IgnTimeOff\_Cnt\_u32 | |  |
| VehTimeValid\_Cnt\_lgc | |  |

## Module Internal Variables

This section identifies the name, range and resolutions for module specific data created by this module. If there are no range restrictions on the variable, the term “FULL” is placed into the table for legal range.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable Name | | Resolution | Legal Range  (min) | Legal Range  (max) | Software Segment |
| TrqCmdTblYRam\_MtrNm\_M\_u9p7[8] | | 2-7 | 0 | 8.8 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| AbsTempFltAcc\_Cnt\_M\_u16 | | 1 | FULL | FULL | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| Filter1KSV\_M\_str | | LPF32KSV\_Str |  |  | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
|  | SV\_Uls\_f32 | Single Precision Float | 0 | 31250 |  |
|  | K\_Uls\_f32 | Single Precision Float | 0.326433727109184 | 0.326433727109184 |  |
| Filter2KSV\_M\_str | | LPF32KSV\_Str |  |  | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
|  | SV\_Uls\_f32 | Single Precision Float | 0 | 31250 |  |
|  | K\_Uls\_f32 | Single Precision Float | 0.0387462804956383 | 0.0387462804956383 |  |
| Filter3KSV\_M\_str | | LPF32KSV\_Str |  |  | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
|  | SV\_Uls\_f32 | Single Precision Float | 0 | 31250 |  |
|  | K\_Uls\_f32 | Single Precision Float | 0.0039438912246419 | 0.0039438912246419 |  |
| Filter4KSV\_M\_str | | LPF32KSV\_Str |  |  | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
|  | SV\_Uls\_f32 | Single Precision Float | 0 | 31250 |  |
|  | K\_Uls\_f32 | Single Precision Float | 0.0020922033873435 | 0.0020922033873435 |  |
| Filter5KSV\_M\_str | | LPF32KSV\_Str |  |  | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
|  | SV\_Uls\_f32 | Single Precision Float | 0 | 125000 |  |
|  | K\_Uls\_f32 | Single Precision Float | 0.000395090818303087 | 0.000395090818303087 |  |
| Filter6KSV\_M\_str | | LPF32KSV\_Str |  |  | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_UNSPECIFIED |
|  | SV\_Uls\_f32 | Single Precision Float | 0 | 125000 |  |
|  | K\_Uls\_f32 | Single Precision Float | 0.000157067296319927 | 0.000157067296319927 |  |
| AbsTempLimit\_MtrNm\_M\_f32 | | Single Precision Float | 0 | 8.8 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_32 |
| Mult12Temp\_DegC\_D\_f32 | | Single Precision Float | -50 | 150 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_32 |
| Mult36Temp\_DegC\_D\_f32 | | Single Precision Float | -50 | 150 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_32 |
| MaxOut\_AmpSq\_D\_u16p0 | | 1 | 0 | 200 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| ThermLim\_MtrNm\_D\_f32 | | Single Precision Float | 0 | 8.8 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_32 |
| Mult1\_Uls\_D\_u3p13 | | 2-13 | 0 | 0.5 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| Mult2\_Uls\_D\_u3p13 | | 2-13 | 0 | 0.5 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| Mult3\_Uls\_D\_u3p13 | | 2-13 | 0 | 0.5 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| Mult4\_Uls\_D\_u3p13 | | 2-13 | 0 | 0.5 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| Mult5\_Uls\_D\_u3p13 | | 2-13 | 0 | 2 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| Mult6\_Uls\_D\_u3p13 | | 2-13 | 0 | 2 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| LastTblVal\_MtrNm\_D\_u9p7 | | 2-7 | 0 | 8.8 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| LastTblValSlew\_MtrNm\_D\_u9p7 | | 2-7 | 0 | 8.8 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_16 |
| AbsTempLimit\_MtrNm\_D\_f32 | | Single Precision Float | 0 | 8.8 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_32 |
| ThrmLoadLmtTblYVal\_MtrNm\_D\_f32 | | Single Precision Float | 0.01 | 8.8 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_CLEARED\_32 |
| eFilter3ValueTyH\_Cnt\_M\_u8 | | 1 | 0 | 200 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_SAVED\_ZONEH\_8 |
| eFilter4ValueTyH\_Cnt\_M\_u8 | | 1 | 0 | 200 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_SAVED\_ZONEH\_8 |
| eFilter5ValueTyH\_Cnt\_M\_u8 | | 1 | 0 | 200 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_SAVED\_ZONEH\_8 |
| eFilter6ValueTyH\_Cnt\_M\_u8 | | 1 | 0 | 200 | THRMLDUTYCYCLE\_START\_SEC\_VAR\_SAVED\_ZONEH\_8 |
|  | |  |  |  |  |

### User defined typedef definition/declaration

This section documents any user types uniquely used for the module.

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

# Constant Data Dictionary

## Calibration Constants

This section lists the calibrations used by the module. For details on calibration constants, refer to the Data Dictionary for the application.

|  |
| --- |
| Constant Name |
| k\_EOCCtrlTemp\_DegC\_f32 |
| k\_CtrlTempSlc\_Cnt\_lgc |
| k\_MtrPrTempSlc\_Cnt\_lgc |
| k\_AbsMtrVelBkt\_MtrRadps\_f32 |
| t\_MultTblX\_DegC\_s15p0[5] |
| t\_Mult1NSTblY\_Uls\_u3p13[5] |
| t\_Mult2NSTblY\_Uls\_u3p13[5] |
| t\_Mult3NSTblY\_Uls\_u3p13[5] |
| t\_Mult4NSTblY\_Uls\_u3p13[5] |
| t\_Mult5NSTblY\_Uls\_u3p13[5] |
| t\_Mult6NSTblY\_Uls\_u3p13[5] |
| t\_Mult1STblY\_Uls\_u3p13[5] |
| t\_Mult2STblY\_Uls\_u3p13[5] |
| t\_Mult3STblY\_Uls\_u3p13[5] |
| t\_Mult4STblY\_Uls\_u3p13[5] |
| t\_Mult5STblY\_Uls\_u3p13[5] |
| t\_Mult6STblY\_Uls\_u3p13[5] |
| t\_LastTblValNS\_MtrNm\_u9p7[5] |
| t\_LastTblValS\_MtrNm\_u9p7[5] |
| k\_TrqCmdSlewDown\_MtrNm\_u9p7 |
| k\_TrqCmdSlewUp\_MtrNm\_u9p7 |
| k\_SlowFltTempSlc\_Cnt\_lgc |
| t\_AbsTmpTblX\_DegC\_s15p0[2] |
| t\_AbsTmpTblY\_MtrNm\_u9p7[2] |
| k\_AbsTmpTrqSlewLmt\_MtrNm\_f32 |
| k\_MultTempSlc\_Cnt\_lgc |
| k\_AbsTempDiag\_Cnt\_str |
| k\_DutyCycFltTrshld\_AmpSq\_u16p0 |
| t\_ThrmLoadLmtTblX\_AmpSq\_u16p0[8] |
| t\_ThrmLoadLmtTblY\_MtrNm\_u9p7[8] |
| k\_DefaultIgnOffTime\_Sec\_f32 |

## Program (fixed) Constants

### Embedded Constants

All embedded constants whose values are provided in Eng units will be evaluated to the equivalent counts by using the FPM\_InitFixedPoint\_m() macro within the #define statement.

#### Local

|  |  |  |  |
| --- | --- | --- | --- |
| Constant Name | Resolution | Units | Value |
| D\_FILT1LPFKN\_HZ\_F32 | Single Precision Float | Hz | 1/(2\*pi\*1.59) |
| D\_FILT2LPFKN\_HZ\_F32 | Single Precision Float | Hz | 1/(2\*pi\*15.9) |
| D\_FILT3LPFKN\_HZ\_F32 | Single Precision Float | Hz | 1/(2\*pi\*159) |
| D\_FILT4LPFKN\_HZ\_F32 | Single Precision Float | Hz | 1/(2\*pi\*300) |
| D\_FILT5LPFKN\_HZ\_F32 | Single Precision Float | Hz | 1/(2\*pi\*1590) |
| D\_FILT6LPFKN\_HZ\_F32 | Single Precision Float | Hz | 1/(2\*pi\*4000) |
| D\_1PERC\_ULS\_F32 | Single Precision Float | Unitless | 0.01 |
| D\_FILTOUTLIM\_ULS\_F32 | Single Precision Float | Unitless | 200.0 |
| D\_DEFEATDUTYCYCLELEVEL\_ULS\_F32 | Single Precision Float | Unitless | 0.0 |
| D\_DEFEATTHERMLIMITPERC\_ULS\_F32 | Single Precision Float | Unitless | 0.0 |
| D\_DEFEATTHERMLIMIT\_MTRNM\_F32 | Single Precision Float | MtrNm | 8.8 |
| D\_TAU3\_SEC\_F32 | Single Precision Float | Sec | 159 |
| D\_TAU4\_SEC\_F32 | Single Precision Float | Sec | 300 |
| D\_TAU5\_SEC\_F32 | Single Precision Float | Sec | 1590 |
| D\_TAU6\_SEC\_F32 | Single Precision Float | Sec | 4000 |

#### Global

This section lists the global constants used by the module. For details on global constants, refer to the Data Dictionary for the application.

|  |
| --- |
| Constant Name |
| D\_MTRTRQCMDHILMT\_MTRNM\_F32 |
| D\_ZERO\_ULS\_F32 |
| D\_ONE\_ULS\_F32 |
| D\_100MS\_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. TableSize\_m
2. FPM\_FixedToFloat\_m
3. FPM\_FloatToFixed\_m
4. LPF\_KUpdate\_f32\_m
5. LPF\_OpUpdate\_f32\_m
6. Abs\_f32\_m
7. IntplVarXY\_u16\_s16Xu16Y\_Cnt
8. IntplVarXY\_u16\_u16Xu16Y\_Cnt
9. Max\_m
10. Min\_m
11. Limit\_m
12. DiagPStep\_m
13. DiagNStep\_m
14. DiagFailed\_m

## Data Hiding Functions

1. None

## Global Functions/Macros Defined by this Module

None

## Local Functions/Macros Used by this MDD only

### Local Function #1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Function Name** | StepVarXY\_u16\_s16Xu16Y\_Cnt | Type | Min | Max | UTP Tol. |
| **Arguments Passed** | TableX | sint16\* | -32,768 | 32,767 | N/A |
|  | TableY | uint16\* | 0 | 65535 | N/A |
|  | Size | uint16 | 1 | 6 | N/A |
|  | input | sint16 | -32,768 | 32,767 | N/A |
| **Return Value** | See description | uint16 | 0 | 65535 | 0 |

#### Description

# Software Module Implementation

## Runtime Environment (RTE) Initial Values

This section lists the initial values of data written by this module but controlled by the RTE. After RTE initialization, the data in this table will contain these values.

|  |  |
| --- | --- |
| Data | Value |
| Rte\_InitValue\_CuTempEst\_DegC\_f32 | 0 |
| Rte\_InitValue\_DutyCycleLevel\_Uls\_f32 | 0 |
| Rte\_InitValue\_FiltMeasTemp\_DegC\_f32 | 0 |
| Rte\_InitValue\_FilteredPkCurr\_AmpSq\_f32 | 0 |
| Rte\_InitValue\_MagTempEst\_DegC\_f32 | 0 |
| Rte\_InitValue\_MotorVelCRF\_MtrRadpS\_f32 | 0 |
| Rte\_InitValue\_MtrPkCurr\_AmpSq\_f32 | 0 |
| Rte\_InitValue\_SiTempEst\_DegC\_f32 | 0 |
| Rte\_InitValue\_ DiagStsDefTemp \_Cnt\_lgc | FALSE |
| Rte\_InitValue\_ThermLimitPerc\_Uls\_f32 | 0 |
| Rte\_InitValue\_ThermalLimit\_MtrNm\_f32 | 8.8 |
| Rte\_InitValue\_DefeatDutySvc\_Cnt\_lgc | FALSE |
| Rte\_InitValue\_ IgnTimeOff\_Cnt\_u32 | 0 |
| Rte\_InitValue\_ VehTimeValid\_Cnt\_lgc | FALSE |

## Initialization Functions

### Init: \_Init1

#### Design Rationale

None

#### Module Outputs

None

#### Store Module Inputs to Local copies

IgnTimeOff\_Sec\_T\_u32 = Rte\_IRead\_ThrmlDutyCycle\_Init1\_IgnTimeOff\_Cnt\_u32()

VehTimeValid\_Cnt\_T\_lgc = Rte\_IRead\_ThrmlDutyCycle\_Init1\_VehTimeValid\_Cnt\_lgc()

#### Module Internal



## Periodic Functions

### Per: \_Per1

#### Design Rationale

None

#### Program Flow Start

Rte\_Call\_ThrmlDutyCycle\_Per1\_CP0\_CheckpointReached()

#### Store Module Inputs to Local copies

CuTempEst\_DegC\_T\_f32 = Rte\_IRead\_ThrmlDutyCycle\_Per1\_CuTempEst\_DegC\_f32()

FiltMeasTemp\_DegC\_T\_f32 = Rte\_IRead\_ThrmlDutyCycle\_Per1\_FiltMeasTemp\_DegC\_f32()

FiltPkCurr\_AmpSq\_T\_f32 = Rte\_IRead\_ThrmlDutyCycle\_Per1\_FilteredPkCurr\_AmpSq\_f32()

MagTempEst\_DegC\_T\_f32 = Rte\_IRead\_ThrmlDutyCycle\_Per1\_MagTempEst\_DegC\_f32()

MotorVelCRF\_MtrRadpS\_T\_f32 = Rte\_IRead\_ThrmlDutyCycle\_Per1\_MotorVelCRF\_MtrRadpS\_f32()

MtrPkCurr\_AmpSq\_T\_f32 = Rte\_IRead\_ThrmlDutyCycle\_Per1\_MtrPkCurr\_AmpSq\_f32()

SiTempEst\_DegC\_T\_f32 = Rte\_IRead\_ThrmlDutyCycle\_Per1\_SiTempEst\_DegC\_f32()

DefeatDutySvc\_Cnt\_T\_lgc = Rte\_IRead\_ThrmlDutyCycle\_Per1\_DefeatDutySvc\_Cnt\_lgc\_Cnt\_lgc();

PrevAbsTempLimit\_MtrNm\_T\_f32 = AbsTempLimit\_MtrNm\_M\_f32

AbsMotorVelCRF\_MtrRadpS\_T\_f32 = Abs\_f32\_m(MotorVelCRF\_MtrRadpS\_T\_f32)Rte\_Call\_NxtrDiagMgr\_GetNTCFailed(NTC\_Num\_Thermistor, &DiagStsDefTemp\_Cnt\_T\_lgc)

#### Temperature Selection



#### Load Limiting – Multiplier



#### Load Limiting – Max Filter Percentage



#### Load Limiting – Thermal Load Limit



#### Temperature Limiting



#### Temperature Limiting Status



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

AbsTempLimit\_MtrNm\_M\_f32 = AbsTempLimitSlew\_MtrNm\_T\_f32

Mult12Temp\_DegC\_D\_f32 = Mult12Temp\_DegC\_T\_f32

Mult36Temp\_DegC\_D\_f32 = Mult36Temp\_DegC\_T\_f32

MaxOut\_AmpSq\_D\_u16p0 = MaxOut\_Uls\_T\_u16p0

ThermLim\_MtrNm\_D\_f32 = ThermalLoadLmt\_MtrNm\_T\_f32

Mult1\_Uls\_D\_u3p13 = Mult1\_Uls\_T\_u3p13

Mult2\_Uls\_D\_u3p13 = Mult2\_Uls\_T\_u3p13

Mult3\_Uls\_D\_u3p13 = Mult3\_Uls\_T\_u3p13

Mult4\_Uls\_D\_u3p13 = Mult4\_Uls\_T\_u3p13

Mult5\_Uls\_D\_u3p13 = Mult5\_Uls\_T\_u3p13

Mult6\_Uls\_D\_u3p13 = Mult6\_Uls\_T\_u3p13

LastTblVal\_MtrNm\_D\_u9p7 = LastTblValRaw\_MtrNm\_T\_u9p7

LastTblValSlew\_MtrNm\_D\_u9p7 = LastTblVal\_MtrNm\_T\_u9p7

AbsTempLimit\_MtrNm\_D\_f32 = AbsTempLimit\_MtrNm\_T\_f32

ThrmLoadLmtTblYVal\_MtrNm\_D\_f32 = DivFactor\_MtrNm\_T\_f32

Rte\_IWrite\_ThrmlDutyCycle\_Per1\_DutyCycleLevel\_Uls\_f32(MaxSlowFilt\_Uls\_T\_f32)

Rte\_IWrite\_ThrmlDutyCycle\_Per1\_ThermLimitPerc\_Uls\_f32(ThermLimitPerc\_Uls\_T\_f32)

Rte\_IWrite\_ThrmlDutyCycle\_Per1\_ThermalLimit\_MtrNm\_f32(ThermalLimit\_MtrNm\_T\_f32)

#### Program Flow End

Rte\_Call\_ThrmlDutyCycle\_Per1\_CP1\_CheckpointReached()

## Fault Recovery Functions

None

## Shutdown Functions

None

## Interrupt Functions

None

## Serial Communication Functions

None

# Execution Requirements

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

This table serves as reference for the Scheduler design

|  |  |  |
| --- | --- | --- |
| Function Name | Calling Frequency | System State(s) in which the function is called |
| ThrmlDutyCycle\_Init1 | On Event | On Init |
| ThrmlDutyCycle\_Per1 | 100 ms | ALL |

## Execution Requirements for Serial Communication Functions

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

# Memory Map Definition Requirements

## Sub Modules (Functions)

This table identifies the software segments for functions identified in this module.

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

## Local Functions

This table identifies the software segments for local functions identified in this module.

|  |  |
| --- | --- |
| Name of Sub Module | Software Segment |
| None |  |

# 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 | 1.0 | Initial Version (implements SF-09 v001) | 21-May-12 | OT |
| 2 | 2.0 | Updated initial value of AssistThermScalar output, added limit on maxout terms to prevent overflow per new FDD design | 30-May-12 | LWW |
| 3 | 3.0 | Updated values of 6 filter embedded data constants- Anom 3445 | 16-June-12 | NRAR |
| 4 | 4.0 | Updated to SF-09 v003 | 09-Jul-12 | OT |
| 5 | 5.0 | Updated to SF-09 v004 | 09-Aug-12 | BWL |
| 6 | 6.0 | MDD fixes per unit test review. | 10-Aug-12 | BWL |
| 7 | 7.0 | Added checkpoints and memmap software segment is updated for static variables | 24-Sep-12 | Selva |
| 8 | 8.0 | Replaced multiplier interpolation with step function. | 16-Oct-12 | BWL |
| 9 | 9.0 | Updated to SF-09 v006 | 29-Jan-13 | Selva |
| 10 | 10 | Corrected Diag\_Status reading function | 31-Jan-13 | Selva |
| 11 | 11 | Updated to SF-09 v007 | 20-Feb-13 | SP |
| 12 | 12 | Fix Anomoly 4517 | 28-Feb-13 | Selva |
| 13 | 13,14 | Updated to SF-09 v008`  Tessy Unit test fixes | 09-Apr-13 | Selva |