*LIGO Laboratory / LIGO Scientific Collaboration*

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TwinCAT Library for GPS Receivers

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| **Library** | |
| Title | GpsInterface |
| Version | 1 |
| TwinCAT version | V2.11.0 |
| Name space |  |
| Author | Daniel Sigg |
| Description | Monitors an M12 compatible Motoroal GPS or the Trimble Thunderbolt GPS |
| Error Code | GpsMotorolaStruct:  16#01 — Serial link down  16#02 — Data not valid  16#04 — Waiting for GPS lock  16#08 — GPS initialization error  16#10 — GPS configuration error  GpsMotorolaStruct:  16#01 — Serial link down  16#02 — Data not valid  16#04 — Waiting for GPS lock  16#08 — GPS initialization error  16#10 — GPS configuration error |
| Library Dependencies | Error, SaveRestore, COMlibV2 |

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| **User Interface Type**  TYPE TimeTypeEnum : (TimeTypeGPS, TimeTypeUTC);  END\_TYPE | |
| Type Name | TimeTypeEnum |
| Description | Enumerated type for describing the time scale |
| Definition | Enum |
| Field | Name: TimeTypeGPS  Description: GPS time scale (no leap seconds) |
| Field | Name: TimeTypeUTC  Description: UTC time scale (includes leap seconds) |

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| **User Interface Type**  TYPE GpsMotorolaReceiverModeEnum: (  GpsMotorolaReceiverModeInvalid, GpsMotorolaReceiverModeBadGeometry, GpsMotorolaReceiverModeAcquiringSatellites,  GpsMotorolaReceiverModePositionHold,  GpsMotorolaReceiverModePropagateMode,  GpsMotorolaReceiverMode2DFix,  GpsMotorolaReceiverMode3DFix);  END\_TYPE | |
| Type Name | GpsMotorolaReceiverModeEnum |
| Description | Enumerated type for describing the receiver operating mode |
| Definition | Enum |
| Field | Name: GpsMotorolaReceiverModeInvalid  Description: Invalid |
| Field | Name: GpsMotorolaReceiverModeBadGeometry  Description: Bad geometry solution |
| Field | Name: GpsMotorolaReceiverModeAcquiringSatellites  Description: Acquiring satellites |
| Field | Name: GpsMotorolaReceiverModePositionHold  Description: Position hold |
| Field | Name: GpsMotorolaReceiverModePropagateMode  Description: Propagate mode |
| Field | Name: GpsMotorolaReceiverMode2DFix  Description: Fixed position in horizontal |
| Field | Name: GpsMotorolaReceiverMode3DFix  Description: Fixed 3D position |

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| **User Interface Type**  TYPE GpsMotorolaStruct :  STRUCT  Error: ErrorStruct;  Model: STRING(80);  Id: STRING(10);  Gps: UDINT;  Tow: UDINT;  Week: UDINT;  Leap: INT;  TimeSource: TimeTypeEnum;  TimeValid: BOOL;  UtcOffset: BOOL;  Year: UINT;  Month: UINT;  Day: UINT;  Hour: UINT;  Minute: UINT;  Second: UINT;  DOP: LREAL;  VisSatellites: UINT;  TrackSatellites: UINT;  Status: UINT;  ReceiverMode: GpsMotorolaReceiverModeEnum;  AntennaOpen: BOOL;  AntennaShorted: BOOL;  NotTrackingSattelites: BOOL;  SurveyInProgress: BOOL;  AlmanacIncomplete: BOOL;  NarrowBand: BOOL;  FastAcquisition: BOOL;  FilterReset: BOOL;  PositionLock: BOOL;  DifferentialFix: BOOL;  Temperature: LREAL;  PPSOffset: LREAL;  ClockOffset: LREAL;  Latitude: LREAL;  Longitude: LREAL;  Altitude: LREAL;  Speed3D: LREAL;  Speed2D: LREAL;  Heading: LREAL;  END\_STRUCT  END\_TYPE | |
| Type Name | GpsMotorolaStruct |
| Description | Structure used in the user interface for a Trimble GPS device |
| Definition | STRUCT |
| Ouput Tag | Name: Error  Type: ErroStruct  Description: Set by the error handler |
| Ouput Tag | Name: Model  Type: STRING(80)  Description: Name of GPS model |
| Ouput Tag | Name: Gps  Type: UDINT  Description: GPS time in seconds |
| Ouput Tag | Name: Tow  Type: UDINT  Description: Time of week in seconds |
| Ouput Tag | Name: Week  Type: UDINT  Description: Weeks since January 6, 1980 |
| Ouput Tag | Name: Leap  Type: INT  Description: Number of leap seconds |
| Ouput Tag | Name: TimeSource  Type: TimeTypeEnum  Description: Time scale (UTC includes leap sec) |
| Ouput Tag | Name: TimeValid  Type: BOOL  Description: Time has been set from GPS receiver |
| Ouput Tag | Name: UtcOffset  Type: BOOL  Description: Leap seconds are valid |
| Ouput Tag | Name: Year  Type: UINT  Description: Year (4 digits) |
| Ouput Tag | Name: Month  Type: UINT  Description: Month (1-12) |
| Ouput Tag | Name: Day  Type: UINT  Description: Day (1-31) |
| Ouput Tag | Name: Hour  Type: UINT  Description: Hours (0-23) |
| Ouput Tag | Name: Minute  Type: UINT  Description: Minutes (0-59) |
| Ouput Tag | Name: Second  Type: UINT  Description: Second (0-59) |
| Ouput Tag | Name: DOP  Type: LREAL  Description: Dilution of precision 0 to 99. |
| Ouput Tag | Name: VisSatellites  Type: UINT  Description: Number of visible satellites |
| Ouput Tag | Name: TrackSatellites  Type: UINT  Description: Number of tracked satellites |
| Ouput Tag | Name: Status  Type: UINT  Description: Status word (bits) |
| Ouput Tag | Name: ReceiverMode  Type: GpsMotorolaReceiverModeEnum  Description: Current receiver mode |
| Ouput Tag | Name: AntennaOpen  Type: BOOL  Description: Warning: Antenna cable open |
| Ouput Tag | Name: AntennaShorted  Type: BOOL  Description: Warning: Antenna cable shorted |
| Ouput Tag | Name: NotTrackingSattelites  Type: BOOL  Description: Warning: Not tracking sattelites |
| Ouput Tag | Name: SurveyProgress  Type: BOOL  Description: Warning: Survey in progress |
| Ouput Tag | Name: AlmanacIncomplete  Type: BOOL  Description: Warning: Almanac incomplete |
| Ouput Tag | Name: NarrowBand  Type: BOOL  Description: Narrow band tracking mode |
| Ouput Tag | Name: FastAcquisition  Type: BOOL  Description: Fast acquisition position |
| Ouput Tag | Name: FilterReset  Type: BOOL  Description: Filter reset to raw GPS solution |
| Ouput Tag | Name: PositionLock  Type: BOOL  Description: Position Lock |
| Ouput Tag | Name: DifferentialFix  Type: BOOL  Description: Differential Fix |
| Ouput Tag | Name: Temperature  Type: LREAL  Description: Temperature in C |
| Ouput Tag | Name: PPSOffset  Type: LREAL  Description: PPS offset in ns |
| Ouput Tag | Name: ClockOffset  Type: LREAL  Description: Clock offset in ppb |
| Ouput Tag | Name: Latitude  Type: LREAL  Description: GPS latitude -90° to +90° |
| Ouput Tag | Name: Longitude  Type: LREAL  Description: GPS longitude -180° to +180° |
| Ouput Tag | Name: Altitude  Type: LREAL  Description: GPS height -1000m to +18000m |
| Ouput Tag | Name: Speed3D  Type: LREAL  Description: 3D speed 0 to 514m/s |
| Ouput Tag | Name: Speed3D  Type: LREAL  Description: 2D speed 0 to 514m/s |
| Ouput Tag | Name: Heading  Type: LREAL  Description: Heading 0 to 359.9° |

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| **User Interface Type**  TYPE GpsTrimbleReceiverModeEnum : (  GpsTrimbleReceiverModeInvalid,  GpsTrimbleReceiverModeAutomatic,  GpsTrimbleReceiverModeSingleSattelite,  GpsTrimbleReceiverModeHorizontal,  GpsTrimbleReceiverModeFullPosition,  GpsTrimbleReceiverModeOverDeterminedClock);  END\_TYPE | |
| Type Name | GpsTrimbleReceiverModeEnum |
| Description | Enumerated type for describing the receiver operating mode |
| Definition | Enum |
| Field | Name: GpsTrimbleReceiverModeInvalid  Description: Invalid |
| Field | Name: GpsTrimbleReceiverModeAutomatic  Description: Automatic (2D/3D) |
| Field | Name: GpsTrimbleReceiverModeSingleSattelite  Description: Single Satellite (Time) |
| Field | Name: GpsTrimbleReceiverModeHorizontal  Description: Horizontal (2D) |
| Field | Name: GpsTrimbleReceiverModeFullPosition  Description: Full Position (3D) |
| Field | Name: GpsTrimbleReceiverModeOverDeterminedClock  Description: Over-Determined Clock (Timing) |

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| **User Interface Type**  TYPE GpsTrimbleDiscipliningModeEnum : (  GpsTrimbleDiscipliningModeInvalid,  GpsTrimbleDiscipliningModeNormal,  GpsTrimbleDiscipliningModePowerUp,  GpsTrimbleDiscipliningModeAutoHoldover,  GpsTrimbleDiscipliningModeManualHoldover,  GpsTrimbleDiscipliningModeRecovery,  GpsTrimbleDiscipliningModeDisabled);  END\_TYPE | |
| Type Name | GpsTrimbleDiscipliningModeEnum |
| Description | Enumerated type for describing the clock disciplining mode |
| Definition | Enum |
| Field | Name: GpsTrimbleDiscipliningModeInvalid  Description: Invalid |
| Field | Name: GpsTrimbleDiscipliningModeNormal  Description: Normal (Locked to GPS) |
| Field | Name: GpsTrimbleDiscipliningModePowerUp  Description: Power Up |
| Field | Name: GpsTrimbleDiscipliningModeAutoHoldover  Description: Auto Holdover |
| Field | Name: GpsTrimbleDiscipliningModeManualHoldover  Description: Manual Holdover |
| Field | Name: GpsTrimbleDiscipliningModeRecovery  Description: Recovery |
| Field | Name: GpsTrimbleDiscipliningModeDisabled  Description: Disciplining Disabled |

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| **User Interface Type**  TYPE GpsTrimbleDecodingStatusEnum : (  GpsTrimbleDecodingStatusInvalid,  GpsTrimbleDecodingStatusDoingFixes,  GpsTrimbleDecodingStatusNoGpsTime,  GpsTrimbleDecodingStatusPDOPTooHigh,  GpsTrimbleDecodingStatusNoSattelites,  GpsTrimbleDecodingStatusOnly1Sattelite,  GpsTrimbleDecodingStatusOnly2Sattelites,  GpsTrimbleDecodingStatusOnly3Sattelites,  GpsTrimbleDecodingStatusSatteliteUnusable,  GpsTrimbleDecodingStatusTRAIMRejectFix);  END\_TYPE | |
| Type Name | GpsTrimbleDecodingStatusEnum |
| Description | Enumerated type for describing the decoding status of the GPS receiver |
| Definition | Enum |
| Field | Name: GpsTrimbleDecodingStatusInvalid  Description: Invalid |
| Field | Name: GpsTrimbleDecodingStatusDoingFixes  Description: Doing fixes |
| Field | Name: GpsTrimbleDecodingStatusNoGpsTime  Description: Don't have GPS time |
| Field | Name: GpsTrimbleDecodingStatusPDOPTooHigh  Description: PDOP is too high |
| Field | Name: GpsTrimbleDecodingStatusNoSattelites  Description: No usable sats |
| Field | Name: GpsTrimbleDecodingStatusOnly1Sattelite  Description: Only 1 usable sat |
| Field | Name: GpsTrimbleDecodingStatusOnly2Sattelites  Description: Only 2 usable sats |
| Field | Name: GpsTrimbleDecodingStatusOnly3Sattelites  Description: Only 3 usable sats |
| Field | Name: GpsTrimbleDecodingStatusSatteliteUnusable  Description: The chosen sat is unusable |
| Field | Name: GpsTrimbleDecodingStatusTRAIMRejectFix  Description: TRAIM rejected the fix |

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| **User Interface Type**  TYPE GpsTrimbleDiscipliningActivityEnum : (  GpsTrimbleDiscipliningActivityInvalid,  GpsTrimbleDiscipliningActivityPhaseLocking,  GpsTrimbleDiscipliningActivityOscWarmUp,  GpsTrimbleDiscipliningActivityFreqLocking,  GpsTrimbleDiscipliningActivityPlacingPPS,  GpsTrimbleDiscipliningActivityInitLoopFilter,  GpsTrimbleDiscipliningActivityHoldover,  GpsTrimbleDiscipliningActivityInactive,  GpsTrimbleDiscipliningActivityRecovery,  GpsTrimbleDiscipliningActivityCalibration);  END\_TYPE | |
| Type Name | GpsTrimbleDiscipliningActivityEnum |
| Description | Enumerated type for describing the current activity of the disciplining mechanism |
| Definition | Enum |
| Field | Name: GpsTrimbleDiscipliningActivityInvalid  Description: Invalid |
| Field | Name: GpsTrimbleDiscipliningActivityPhaseLocking  Description: Phase locking |
| Field | Name: GpsTrimbleDiscipliningActivityOscWarmUp  Description: Oscillator warm-up |
| Field | Name: GpsTrimbleDiscipliningActivityFreqLocking  Description: Frequency locking |
| Field | Name: GpsTrimbleDiscipliningActivityPlacingPPS  Description: Placing PPS |
| Field | Name: GpsTrimbleDiscipliningActivityInitLoopFilter  Description: Initializing loop filter |
| Field | Name: GpsTrimbleDiscipliningActivityHoldover  Description: Compensating OCXO (holdover) |
| Field | Name: GpsTrimbleDiscipliningActivityInactive  Description: Inactive |
| Field | Name: GpsTrimbleDiscipliningActivityRecovery  Description: Recovery mode |
| Field | Name: GpsTrimbleDiscipliningActivityCalibration  Description: Calibration/control voltage |

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| **User Interface Type**  TYPE GpsTrimbleStruct :  STRUCT  Error: ErrorStruct;  Model: STRING(80);  Gps: UDINT;  Tow: UDINT;  Week: UDINT;  Leap: INT;  TimeSource: TimeTypeEnum;  PPSSource: TimeTypeEnum;  TimeValid: BOOL;  UtcOffset: BOOL;  TestMode: BOOL;  Year: UINT;  Month: UINT;  Day: UINT;  Hour: UINT;  Minute: UINT;  Second: UINT;  ReceiverMode: GpsTrimbleReceiverModeEnum;  DiscipliningMode: GpsTrimbleDiscipliningModeEnum;  SurveyProgress: UINT;  HoldoverDuration: UDINT;  DacAtRail: BOOL;  DacNearRail: BOOL;  AntennaOpen: BOOL;  AntennaShorted: BOOL;  NotTrackingSattelites: BOOL;  NotDiscipliningOscillator: BOOL;  SurveyInProgress: BOOL;  NoStoredPosition: BOOL;  LeapSecondPending: BOOL;  InTestMode: BOOL;  PositionQuestionable: BOOL;  AlmanacIncomplete: BOOL;  NoPPS: BOOL;  DecodingStatus: GpsTrimbleDecodingStatusEnum;  DiscipliningActivity: GpsTrimbleDiscipliningActivityEnum;  PPSOffset: LREAL;  ClockOffset: LREAL;  DACValue: UDINT;  DACVoltage: LREAL;  Temperature: LREAL;  Latitude: LREAL;  Longitude: LREAL;  Altitude: LREAL;  PPSQuantizationError: LREAL;  END\_STRUCT  END\_TYPE | |
| Type Name | GpsTrimbleStruct |
| Description | Structure used in the user interface for a Trimble GPS device |
| Definition | STRUCT |
| Ouput Tag | Name: Error  Type: ErroStruct  Description: Set by the error handler |
| Ouput Tag | Name: Model  Type: STRING(80)  Description: Name of GPS model |
| Ouput Tag | Name: Gps  Type: UDINT  Description: GPS time in seconds |
| Ouput Tag | Name: Tow  Type: UDINT  Description: Time of week in seconds |
| Ouput Tag | Name: Week  Type: UDINT  Description: Weeks since January 6, 1980 |
| Ouput Tag | Name: Leap  Type: INT  Description: Number of leap seconds |
| Ouput Tag | Name: TimeSource  Type: TimeTypeEnum  Description: Time scale (UTC includes leap sec) |
| Ouput Tag | Name: PPSSource  Type: TimeTypeEnum  Description: Alignment of 1 PPS signal |
| Ouput Tag | Name: TimeValid  Type: BOOL  Description: Time has been set from GPS receiver |
| Ouput Tag | Name: UtcOffset  Type: BOOL  Description: Leap seconds are valid |
| Ouput Tag | Name: TestMode  Type: BOOL  Description: Unit is in test mode |
| Ouput Tag | Name: Year  Type: UINT  Description: Year (4 digits) |
| Ouput Tag | Name: Month  Type: UINT  Description: Month (1-12) |
| Ouput Tag | Name: Day  Type: UINT  Description: Day (1-31) |
| Ouput Tag | Name: Hour  Type: UINT  Description: Hours (0-23) |
| Ouput Tag | Name: Minute  Type: UINT  Description: Minutes (0-59) |
| Ouput Tag | Name: Second  Type: UINT  Description: Second (0-59) |
| Ouput Tag | Name: ReceiverMode  Type: GpsTrimbleReceiverModeEnum  Description: Current receiver mode |
| Ouput Tag | Name: DiscipliningMode  Type: GpsTrimbleDiscipliningModeEnum  Description: Oscillator disciplining mode |
| Ouput Tag | Name: SurveyProgress  Type: UINT  Description: Survey progress in percent |
| Ouput Tag | Name: HoldoverDuration  Type: UDINT  Description: Time ins sec spend in holdover mode |
| Ouput Tag | Name: DacAtRail  Type: BOOL  Description: Critical error: DAC at rail |
| Ouput Tag | Name: DacNearRail  Type: BOOL  Description: Warning: DAC near rail |
| Ouput Tag | Name: AntennaOpen  Type: BOOL  Description: Warning: Antenna cable open |
| Ouput Tag | Name: AntennaShorted  Type: BOOL  Description: Warning: Antenna cable shorted |
| Ouput Tag | Name: NotTrackingSattelites  Type: BOOL  Description: Warning: Not tracking sattelites |
| Ouput Tag | Name: NotDiscipliningOscillator  Type: BOOL  Description: Warning: No XO disciplining |
| Ouput Tag | Name: SurveyInProgress  Type: BOOL  Description: Warning: Survey in progres |
| Ouput Tag | Name: NoStoredPosition  Type: BOOL  Description: Warning: No stored position |
| Ouput Tag | Name: LeapSecondPending  Type: BOOL  Description: Warning: Leap second pending |
| Ouput Tag | Name: InTestMode  Type: BOOL  Description: Warning: GPS in test mode |
| Ouput Tag | Name: PositionQuestionable  Type: BOOL  Description: Warning: Position questionable |
| Ouput Tag | Name: AlmanacIncomplete  Type: BOOL  Description: Warning: Almanac incomplete |
| Ouput Tag | Name: NoPPS  Type: BOOL  Description: Warning: No 1PPS signa |
| Ouput Tag | Name: DecodingStatus  Type: GpsTrimbleDecodingStatusEnum  Description: Decoding status |
| Ouput Tag | Name: DiscipliningActivity  Type: GpsTrimbleDiscipliningActivityEnum  Description: Disciplining activity |
| Ouput Tag | Name: PPSOffset  Type: LREAL  Description: PPS offset in ns |
| Ouput Tag | Name: ClockOffset  Type: LREAL  Description: Clock offset in ppb |
| Ouput Tag | Name: DACValue  Type: UDINT  Description: DAC value (bits) |
| Ouput Tag | Name: DACVoltage  Type: LREAL  Description: DAC value in Volts |
| Ouput Tag | Name: Temperature  Type: LREAL  Description: Temperature in °C |
| Ouput Tag | Name: Latitude  Type: LREAL  Description: GPS latitude -90° to +90° |
| Ouput Tag | Name: Longitude  Type: LREAL  Description: GPS longitude -180° to +180° |
| Ouput Tag | Name: Altitude  Type: LREAL  Description: GPS height -1000m to +18000m |
| Ouput Tag | Name: PPSQuantizationError  Type: LREAL  Description: PPS quantization error in ns |

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| **Function Block**  FUNCTION\_BLOCK GpsTrimbleFB  VAR\_INPUT  Request: SaveRestoreEnum;  END\_VAR  VAR\_OUTPUT  END\_VAR  VAR\_IN\_OUT  Gps: GpsTrimbleStruct; (\* User interface structure \*)  GpsInit: GpsTrimbleStruct; (\* User interface save/restore data \*)  ComPortData: GpsSerialPortBufferStruct;(\* Receive and transmit buffers \*)  END\_VAR | |
| Type Name | GpsTrimbleFB |
| Description | Function block used to interface a Trimble Thunderbolt E GPS device through a serial cable |
| Definition | Function Block |
| Input Argument | Name: Request  Type: SaveRestoreEnum  Description: Request for save/restore/safe mode or noop |
| In/out Argument | Name: Gps  Type: GpsTrimbleStruct  Description: User interface structure |
| In/out Argument | Name: GpsInit  Type: GpsTrimbleStruct  Description: Save/restore variable in persistent memory |
| In/out Argument | Name: ComPortData  Type: GpsSerialPortBufferStruct  Description: Serial port buffers |

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| **Function Block**  FUNCTION\_BLOCK GpsSerialPortControlFB  VAR\_INPUT  Mode: ComSerialLineMode\_t;  pComIn: POINTER TO ARRAY[0..65] OF BYTE;  pComOut: POINTER TO ARRAY[0..65] OF BYTE;  SizeComIn: UINT;  END\_VAR  VAR\_OUTPUT  END\_VAR  VAR\_IN\_OUT  Com: GpsSerialPortBufferStruct;  END\_VAR | |
| Type Name | GpsSerialPortControlFB |
| Description | Function block used to read the serial interface for a GPS device |
| Definition | Function Block |
| Input Argument | Name: Mode  Type: ComSerialLineMode\_t  Description: Serial port decription (check COMlibV2 doc) |
| Input Argument | Name: pComIn:  Type: POINTER TO ARRY [0..65] OF BYTE  Description: pointer to input buffer of serial terminal |
| Input Argument | Name: pComOut:  Type: POINTER TO ARRY [0..65] OF BYTE  Description: pointer to output buffer of serial terminal |
| Input Argument | Name: SizeComIn:  Type: UNIT  Description: Size of buffers |
| In/out Argument | Name: Com  Type: GpsSerialPortBufferStruct  Description: Serial port buffers |

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| **Program Example:**  (\* Global variables \*)  VAR\_GLOBAL  SysTimingComPortDataM2: GpsSerialPortBufferStruct;  SysTimingCOMinM2 AT %I\*: EL6inData22B;  SysTimingCOMoutM2 AT %Q\*: EL6outData22B;  SysTimingComPortM2FB: GpsSerialPortControlFB;  SysTimingCGPS\_AFB: GpsTrimbleFB;  END\_VAR  VAR\_GLOBAL PERSISTENT  SysTimingCGPS\_AInit: GpsTrimbleStruct;  END\_VAR  (\* Call from fast task with 1 ms update rate \*)  PROGRAM TimingFast  SysTimingComPortM2 (  Mode := SERIALLINEMODE\_EL6\_22B,  pComIn := ADR (SysTimingCOMinM2),  pComOut := ADR (SysTimingCOMoutM2),  SizeComIn := SIZEOF (SysTimingCOMinM2),  Com := SysTimingComPortDataM2);  END\_PROGRAM  (\* Call from standard task with 10 ms update rate \*)  PROGRAM Timing  VAR  SaveRestore: SaveRestoreFB;  GotoSafe: BOOL;  Request: SaveRestoreEnum;  END\_VAR  SaveRestore( SaveInterval := T#1m,  GotoSafe := GotoSafe,  Request => Request );  SysTimingCGPS\_AFB (  ComPortData := SysTimingComPortDataM2,  Gps := H1.Sys.Timing.C.GPS\_A,  Request := Request,  GpsInit := SysTimingCGPS\_AInit);  END\_PROGRAM |