



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO-E1500316-v2

*Advanced LIGO*

8/19/2015

---

**TwinCAT Library for GPS Receivers**

---

Daniel Sigg

Distribution of this document:  
LIGO Scientific Collaboration

This is an internal working note  
of the LIGO Laboratory.

**California Institute of Technology**  
**LIGO Project – MS 18-34**  
**1200 E. California Blvd.**  
**Pasadena, CA 91125**  
Phone (626) 395-2129  
Fax (626) 304-9834  
E-mail: [info@ligo.caltech.edu](mailto:info@ligo.caltech.edu)

**Massachusetts Institute of Technology**  
**LIGO Project – NW22-295**  
**185 Albany St**  
**Cambridge, MA 02139**  
Phone (617) 253-4824  
Fax (617) 253-7014  
E-mail: [info@ligo.mit.edu](mailto:info@ligo.mit.edu)

**LIGO Hanford Observatory**  
**P.O. Box 159**  
**Richland WA 99352**  
Phone 509-372-8106  
Fax 509-372-8137

**LIGO Livingston Observatory**  
**P.O. Box 940**  
**Livingston, LA 70754**  
Phone 225-686-3100  
Fax 225-686-7189

<http://www.ligo.caltech.edu/>

<b>Library</b>	
Title	GpsInterface
Version	1
TwinCAT version	V2.11.0
Name space	
Author	Daniel Sigg
Description	Monitors an M12 compatible Motorola GPS or the Trimble Thunderbolt GPS
Error Code	<p>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</p> <p>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</p>
Library Dependencies	Error, SaveRestore, COMlibV2

<b>User Interface Type</b>	
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)

<b>User Interface Type</b>	
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

**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

## LIGO-E1500316-v2

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)

## LIGO-E1500316-v2

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

## LIGO-E1500316-v2

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

LIGO-E1500316-v2

Ouput Tag	Name: Heading Type: LREAL Description: Heading 0 to 359.9°
-----------	--



<b>User Interface Type</b>	
<pre> TYPE GpsTrimbleReceiverModeEnum : (     GpsTrimbleReceiverModeInvalid,     GpsTrimbleReceiverModeAutomatic,     GpsTrimbleReceiverModeSingleSattelite,     GpsTrimbleReceiverModeHorizontal,     GpsTrimbleReceiverModeFullPosition,     GpsTrimbleReceiverModeOverDeterminedClock); END_TYPE </pre>	
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)

<b>User Interface Type</b>	
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

<b>User Interface Type</b>	
<pre> TYPE GpsTrimbleDecodingStatusEnum : (     GpsTrimbleDecodingStatusInvalid,     GpsTrimbleDecodingStatusDoingFixes,     GpsTrimbleDecodingStatusNoGpsTime,     GpsTrimbleDecodingStatusPDOPTooHigh,     GpsTrimbleDecodingStatusNoSattelites,     GpsTrimbleDecodingStatusOnly1Sattelite,     GpsTrimbleDecodingStatusOnly2Sattelites,     GpsTrimbleDecodingStatusOnly3Sattelites,     GpsTrimbleDecodingStatusSatteliteUnusable,     GpsTrimbleDecodingStatusTRAIMRejectFix); END_TYPE </pre>	
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

<b>User Interface Type</b>	
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

**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;

LIGO-E1500316-v2

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

## LIGO-E1500316-v2

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

## LIGO-E1500316-v2

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



## LIGO-E1500316-v2

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

<b>Function Block</b> 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

<b>Function Block</b> 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

**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 := SERIALINMODE_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
```