



POWERLINK SET UP GUIDE

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Mini Motor S.P.A.

FBS-EPL-EN

Firmware Revision: >4.041 , Elker Cavina

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1. Powerlink

1.1. Overview



Note: available only for drivers equipped with CanOpen/Modbus RTU, CanOpen over EtherCAT or Ethernet PowerLink. (---/---/C; ---/---/ETH; ---/---/EPL).

The present document describes the adherence of the Minimotor stack to the following specification:

CanOPEN

- CiA DS301 v4.02 (CanOPEN DLL)
- CiA DS402 v3.0.1.15 (servodrive profile)

CanOPEN over EtherCAT:

- ETG1000-2 v1.0.1 (physical layer)
- ETG1000-3 v1.0.1 (DLL services)
- ETG1000-4 v1.0.1 (DLL protocols)
- ETG1000-5 v1.0.1 (AL services)
- ETG1000-6 v1.0.1 (AL protocols)
- CiA DS402 v3.0.1.15 (servodrive)
- ETG6010 v1.1.0 (CiA 402 impl. directives)

Ethernet PowerLink (EPL)

- EPSG DS 301 V1.2.0 (Powerlink DLL)

The purpose of the present document is to describe what optional features are implemented by the servomotor CanOPEN, CoE or EPL.

Applicable ---/---/--- software release: $\geq v4.036$

1.2. DS301 Communication Layer

This paragraph describes the details of the DS301 layer of the CanOpen interface. It applies only to the CanOPEN over can-bus implementation.

1.2.1. Physical Layer

Supported baudrate:

- 1Mbps tq=71ns SamplingPoint=11tq
- 500Kbps tq=142ns SamplingPoint=12tq

- 250Kbps $t_q=284\text{ns}$ SamplingPoint=12 t_q
- 125Kbps $t_q=571\text{ns}$ SamplingPoint=12 t_q
- 50Kbps $t_q=1.43\mu\text{s}$ SamplingPoint=12 t_q
- 20Kbps $t_q=3.57\mu\text{s}$ SamplingPoint=12 t_q

1.2.2. SDO protocol

- Maximum supported object size: 32bit
- Expedited transfer supported SUPPORTED
- Segmented transfer: NOT SUPPORTED
- Block transfer: NOT SUPPORTED

1.2.3. TIME protocol

The time protocol is NOT supported.

1.2.4. PDO protocol

The implementation supports up to 4 Pdo TX and 4 Pdo RX; each object can map up to 8 objects; mapping can be done only using the whole size of the object (i.e. is not possible to map 8 bit of a 32 bit object).

The following transmit type are implemented for PDO TX:

Transmission Type	Description
0	PDO is emitted when changes occur after SYNC is received
1..240	PDO emitted after SYNC, depending on SYNC message occurrence (e.g. 1 = every SYNC, 2 = every 2 SYNC, etc.)
241..251	Not supported
252	PDO emitted after RTR reception * Data sampled on SYNC * Emitted after RTR
253	PDO emitted after RTR reception * Data sampled and emitted after RTR
254	Not supported
255	PDO emitted asynchronously Two features supported for emission control: * Inhibit time (emission only when PDO content changes) * Event timer (periodical asynchronous emission)

Defaults:

- inhibit time: 100ms
- event time: 0 (periodic emission on TT=255 disabled by default)

See application profile for default PDO configuration. ==== EMCY protocol

Emergency protocol is implemented for reporting alarms from the servodrive; to control the emission of

EMCY messages, the inhibit time (object 1015h) can be modified. See the application profile for detailed list of alarms. (See paragraph 8.3)

1.2.5. NMT protocol

The NMT implementation includes standard commands for NMT state machine management. For node alive checking, the NODE GUARDING protocol is implemented; the behaviour of node guarding is set by objects 100Ch (guard time) and 100Dh (life factor).

1.2.6. HEARTBEATING

Heartbeating Protocol is supported. Register 1016h defines the time in multiples of 1ms for the Heartbeat protocol consumer. Register 1017h determines the time in multiples of 1ms for the producer of the protocol. Object 1029h determines the behaviour when the error is triggered.

1.3. Object Dictionary

Object dictionary is divided in the following sections:

Range Objects	Functions
1000h .. 1FFFh	Communication profile area
2000h .. 21FFh	Manufacturer parameter area
3000h .. 3FFFh	Manufacturer specific object area
6000h .. 67FFh	Profiled objects

Other areas are unused; the object list is common between CanOPEN, CoE and EPL implementation.

1.3.1. Communication area

The following table shows the list of communication area objects; since some objects are relevant only for CanOPEN or CoE implementation, the table shows in which fieldbus the object is relevant.

Index	Description	CANopen	CoE	EPL
1000	Device type	X	X	X
1001	Error register	X	X	X
1003	Predefined error	X	X	
1006	Cycle length			X
100C	Guard time	X		
100D	Life factor	X		
1010	Store parameters ^[1]	X	X	X
1014	EMCY cob-id	X		
1015	EMCY inhibit time	X	X	

Index	Description	CANopen	CoE	EPL
1016	Consumer Heartbeat Time	X		
1017	Producer Heartbeat Time	X		
1018	Identity object	X	X	X
1020	CFM Verify Configuration			X
1029	Error Behaviour	X		
1030	NMT Interface Group 0h			X
1300	SDO Sequ Layer Timeout			X
1400	PDO RX 1 – config ^[2]	X	X	X
1401	PDO RX 2 – config	X		
1402	PDO RX 3 – config	X		
1403	PDO RX 4 – config	X		
1600	PDO RX 1 – mapping ^[2]	X	X	X
1601	PDO RX 2 – mapping	X		
1602	PDO RX 3 – mapping	X		
1603	PDO RX 4 – mapping	X		
1800	PDO TX 1 – config ^[2]	X	X	X
1801	PDO TX 2 – config	X		
1802	PDO TX 3 – config	X		
1803	PDO TX 4 – config	X		
1A00	PDO TX 1 – mapping ^[2]	X	X	X
1A01	PDO TX 2 – mapping	X		
1A02	PDO TX 3 – mapping	X		
1A03	PDO TX 4 – mapping	X		
1C00	Sync manager types		X	
1C0A	DLL_CnCollision REC			X
1C0B	DLL_CnLoss REC			X
1C0C	DLL_CnLossSoC_REC			X
1C0D	DLL_CnLossSoA REC			X
1C0E	DLL_CnSpCJitter REC			X
1C0F	DLL_CnCRCError REC			X
1C10	Sync manager 0 config		X	
1C11	Sync manager 1 config		X	
1C12	Sync manager 2 config		X	

Index	Description	CANopen	CoE	EPL
1C13	Sync manager 3 config ^[2]		X	
	DLL_CnSocJitterRange ^[2]			X
1C14	DLL_CnLossOfSocTolerance			X
1C32	Output sync parameters		X	
1C33	Input sync parameters		X	
1E40	NWL_IpAddrTable_0h_REC			X
1E4A	NWL_IpGroup_REC			X
1F82	NMT_FeatureFlags_U32			X
1F83	NMT_EPLVersion_U8			X
1F8C	NMT_CurrNMTState_U8			X
1F93	NMT_EPLNodeID_REC			X
1F98	NMT_CycleTiming_REC			X
1F99	NMT_CNBasicEthernetTimeout_U32			X
1F9A	NMT_HostName_VSTR			X
1F9E	NMT_ResetCmd_U8			X

1.3.2. Manufacturer parameter area

The object range 2000h ... 21FFh allows to access servodrive parameters; the following table summarize the details of a parameter object:

Object details

Campo	Valore
Subidx	0
Object type	16bit, signed integer
Access	Read/Write
PDO mappable	NO

Object dictionary for manufacturer parameters

Index	Description
2000h	Parameter 0
2001h	Parameter 1
...	...
21FFh	Parameter 511

For details of the parameter meaning and encoding refer to the servodrive manual. **NOTE:** write objects in the

2000h ... 21FFh range will alter only RAM image of the parameter; to actually save parameter to non-volatile storage a write to object 1010h.0 needs to be performed (see 1010h).

1.3.3. Manufacturer Specific Area

This area contains several objects that allow to read/write manufacturer specific data.

Index	Access	Data type	PDO mappable	Description
3000h	RO	INT16	YES	Ain0 value (-32768 to 32768)
3001h	RO	UINT16	YES	Digital input bits 0–4
3002h	RW	UINT16	YES	Digital output bit0
3003h	RO	INT16	YES	Heatsink temperature (x0.1 °C)
3005h	RO	INT16	YES	Motor temperature (x0.1 °C)
3008h	RO	UINT16	YES	Actual alarm code (not EMCY)
3009h	RO	UINT	NO	Events (0–16, see section 6.1)
3010h	RO	UINT16	YES	Power stage tension (x0.1 V)
3011h	RO	INT16	YES	Motor IQ current (mA)
3012h	RW	UINT16	YES	Motor IQ limit (mA)
3014h	RO	INT16	YES	Output power (1W/lb)
3020h	RW	INT32	YES	Touchprobe positioning offset
3021h	RW	UINT32	YES	Touchprobe positioning modulo
3030h	RO	UINT16	YES	Acceleration RMS modulus (milli-G)
3031h	RO	UINT16	YES	Acceleration RMS x (milli-G)
3032h	RO	UINT16	YES	Acceleration RMS y (milli-G)
3033h	RO	UINT16	YES	Acceleration RMS z (milli-G)
3034h	RO	UINT16	YES	Acceleration DC x (milli-G)
3035h	RO	UINT16	YES	Acceleration DC y (milli-G)
3036h	RO	UINT16	YES	Acceleration DC z (milli-G)
3037h	RO	INT16	YES	Instantaneous Acceleration x (milli-G)
3038h	RO	INT16	YES	Instantaneous Acceleration y (milli-G)
3039h	RO	INT16	YES	Instantaneous Acceleration z (milli-G)

1.3.4. Profiled Objects

The range 6000h ... 67FFh of objects are defined as specified by CiA402; refer to the application area for further information.

Index	Access	Type	PDO mappable	Description
6040h	RW	U16	YES	Control word
6041h	RO	U16	YES	Status word
605Ah	RW	U16		Quickstop option code
605Bh	RW	U16		Shutdown option code
605Ch	RW	U16		Disable operation option code
605Dh	RW	U16		Halt option code
605Eh	RW	U16		Fault reaction option code
6060h	RW	S8	YES	Mode of operation
6061h	RO	S8	YES	Mode of operation display
6062h	RO	S32	YES	Position demand value
6064h	RO	S32	YES	Position actual value
6065h	RW	U32		Following error window
6066h	RW	U16		Following error time
6067h	RW	U32		Position window
6068h	RW	U16		Position window time
606Bh	RO	S32	YES	Velocity demand
606Ch	RO	S32	YES	Velocity actual value
606Dh	RW	U16		Velocity window
606Eh	RW	U16		Velocity window time
606Fh	RW	U16		Velocity threshold
6070h	RW	U16		Velocity threshold time
6071h	RW	S16	YES	Target torque
6072h	RW	U16	YES	Max torque
6073h	RW	U16	YES	Max current
6074h	RO	S16	YES	Torque demand value
6075h	RO	U32	YES	Motor rated current
6076h	RO	U32	YES	Motor rated torque
6077h	RO	S16	YES	Torque actual value
6078h	RO	S16	YES	Current actual value
6079h	RO	U32	YES	DC link voltage
607Ah	RW	S32	YES	Target position
607Bh.0	RO	U8	YES	Position Range Limit – number of subindex

Index	Access	Type	PDO mappable	Description
607Bh.1	RW	S32	YES	Negative limit
607Bh.2	RW	S32	YES	Positive limit
607Ch	RW	S32	YES	Home offset
607Dh.0	RO	U8	YES	Software position limit – number of subindex
607Dh.1	RW	S32	YES	Negative limit
607Dh.2	RW	S32	YES	Positive limit
607Eh	RW	U8		Polarity
607Fh	RO	U32	YES	Max speed
6080h	RO	U32	YES	Max speed (duplicate index)
6081h	RW	U32	YES	Profile velocity
6083h	RW	U32	YES	Profile acceleration
6084h	RW	U32	YES	Profile deceleration
6085h	RW	U32	YES	Quick stop deceleration
6087h	RW	U32	YES	Torque slope
6098h	RW	S8	YES	Homing method
6099h.0	RO	U8	YES	Homing speed – number of subindex
6099h.1	RW	U32	YES	Switch speed
6099h.2	RW	U32	YES	Index speed
609Ah	RW	U32	YES	Homing acceleration
60B0h	RW	S32	YES	Position offset
60B1h	RW	S32	YES	Velocity offset
60B2h	RW	S16	YES	Torque offset
60B8h	RW	U16	YES	Touch-probe function
60B9h	RW	U16	YES	Touch-probe status
60BAh	RW	S32	YES	Touch-probe positive edge latched position
60BBh	RW	S32	YES	Touch-probe negative edge latched position
60C0h	RO	S16	NO	IpData submode selection
60C1h.0	RO	U8	YES	IpDataRecord – number of subindex
60C1h.1	RW	S32	YES	IpData record
60C2h.0	RO	U8		Interpolation time period – number of subindex
60C2h.1	RW	S8		Ip time units
60C2h.2	RW	S8		Ip time index

Index	Access	Type	PDO mappable	Description
60F2h	RW	U16	YES	Position Option Code
60F4h	RO	U32	YES	Following Error
60FDh	RO	U32	YES	Digital inputs
60FEh.0	RO	U8	YES	Digital outputs – number of subindex
60FEh.1	RW	U32	YES	Physical outputs
60FEh.2	RW	U32	YES	Output mask
60FFh	RW	S32	YES	Target velocity
6502h	RO	U32	NO	Supported mode of operation

[1] To save 2000h parameters to non-volatile storage a 32bit write to object 1010h.1 needs to be performed; in particular the value to be written to save parameter is 65766173h ("SAVE").

[2] PDO config and mapping have different encoding for CoE/CanOPEN and EPL. Please check DLL manual for details.

2. Application Example

2.1. Tools

Powerlink Profile Example

Powerlink CSP Example

DBS/FC BSI Interface Software

2.2. Overview

This document shows the creation of a DBS/FC smart motor application using the Powerlink communication interface; a B&R controller is configured and an application is written into the Automation Studio development environment.

References:

- B&R PLC 4PPC50 for the Profile example and 4PPC70 for the CSP example
- DBS/FC Firmware version 4.041
- Automation Studio V 4.9.2.46



DBS and FC systems have the same electronics and firmware, so they follow the same procedure.



2.3. DBS Import

The first time using the DBS product, import the XDD descriptor into Automation Studio:

- Tools → Import Fieldbus device
- Search for MiniMot_DBS55_EPL.xdd in the DBS software distribution and press OK
- In the catalog, under Powerlink devices, the Minimotor DBS device should now be present

The next steps depend on how you want to control the motor: as a simple node using the CanOpen DS402 Profile Velocity, Torque, Position and Homing, or in interpolated mode, using — as in the example — the motor with the ACP10 subsystem.

2.4. Profile

2.4.1. Initial Steps

- Create a new project.
- Configure the Powerlink cycle time.

Name	Value	Unit
IF1		
Module type	Type 4	
Operating mode	POWERLINK V2	
MTU size	300	
Baud rate	100 MBit half duplex	
POWERLINK parameters		
Activate POWERLINK communication	on	
Device name	<InterfaceAddress>	
Cycle time	4000	µs
Multiplexing prescale	8	
Mode	managing node	

- Sync the CPU system timer with the Powerlink time.

Name	Value	Unit
System		
Reboot		
Communication		
Timing		
System timer	EPL/X2X Interface	
Interface	4PPC70_0573_20B.IF1	
Cycle time of interface	4000	µs
Multiply cycle time by	1	
System tick	4000	µs
Idle time		
Inter network cross link task		
Resources		
File devices		
Time synchronization		
Internet file system		
Ethernet parameters		
DNS parameters		

- Add the DBS using *Add Hardware Module* and configure the channels. Channel mappings depend on the specific requirement of the application. For this example, we map the following.

Channel Name	Process Variable	Data Type
+ ModuleOk	::M1_ok	BOOL
+ ActualAlarm_I3008		UINT
+ DC_LinkVoltage_0_1V_Isb_I3010	::M1_VDC	UINT
+ ControlWord_I6040Out	::M1_Cw	UINT
+ StatusWord_I6041	::M1_SW	UINT
+ ModesOfOperation_I6060Out	::M1_ModeofOp	SINT
+ ModesOfOperationDisplay_I6061	::M1_ModeofOpDisplay	SINT
+ PositionActualValue_I6064	::M1_ActualPos	DINT
+ VelocityActualValue_I606C	::M1_ActualVel	DINT
+ TargetTorque_I6071Out	::M1_TargetTorque	INT
+ MaxCurrent_I6073Out	::M1_TorqueLimit	UINT
+ TorqueActualValue_I6077	::M1_ActualTorque	INT
+ DC_LinkCircuitVoltage_I6079		UDINT
+ TargetPosition_I607AOut	::M1_TargetPos	DINT
+ HomeOffset_I607COut	::M1_HomingOffset	DINT
+ NegativeLimit_I607D_S01Out	::M1_NegLim	DINT
+ PositiveLimit_I607D_S02Out	::M1_PosLim	DINT
+ ProfileVelocity_I6081Out	::M1_ProfileVel	UDINT
+ ProfileAcceleration_I6083Out	::M1_ProfileAcc	UDINT
+ ProfileDeceleration_I6084Out	::M1_ProfileDec	UDINT
+ HomingMethod_I6098Out	::M1_HomMethod	USINT
+ TargetVelocity_I60FFOut	::M1_TargetVelocity	DINT

2.4.2. Sample Application

In the sample application we create a program that can run the motor in speed mode, in position mode towards a single position, and in position mode between two different positions.

To do so, in the Global.typ we build a Machine_State type.

```

TYPE
  Machine_State :
  (
    Idle,
    Velocity,
    Position,
    Auto_Enter,
    Auto_A,
    Auto_B,
    Auto_Moving,
    Auto_Wait,
    Home,
    Stop
  );
END_TYPE

```

In the Global variables we have two sets of variables. The GUI_ set is used in the user interface, while the M1_ set is linked to the motor channels.

```

VAR

```

```

Case_OP : Machine_State;
GUI_auto : BOOL;
GUI_Dir : BOOL;
GUI_en_hom : BOOL;
GUI_en_pos : BOOL;
GUI_en_vel : BOOL;
GUI_Home : BOOL;
GUI_hom_done : INT;
GUI_m1_ok : INT;
GUI_new_set : BOOL;
GUI_pos : DINT;
GUI_pos_reach : INT;
GUI_Run : BOOL;
GUI_Stop : BOOL;
GUI_tpos : DINT;
GUI_tposA : DINT;
GUI_tposB : DINT;
GUI_trq : REAL;
GUI_tvel : DINT;
GUI_vdc : REAL;
GUI_vel : DINT;
M1_ActualAlarm : UINT;
M1_ActualPos : DINT;
M1_ActualTorque : INT;
M1_Actualvel : DINT;
M1_Cw : UINT;
M1_HomingOffset : DINT;
M1_HomMethod : USINT;
M1_ModeofOp : SINT;
M1_ModeofOpDisplay : SINT;
M1_NegLim : DINT;
M1_ok : BOOL;
M1_PosLim : DINT;
M1_ProfileAcc : UDINT;
M1_ProfileDec : UDINT;
M1_ProfileVel : UDINT;
M1_SW : UINT;
M1_TargetPos : DINT;
M1_TargetTorque : INT;
M1_TargetVelocity : DINT;
M1_TorqueLimit : UINT;
M1_VDC : UINT;
END_VAR

```

Link the M1 variables to the channels as shown in the picture before. In the program part, under Variables.Var, write the following variables:

```

VAR
    Counter : USINT;
    Arrived_A : BOOL;
    SetAck : BOOL;
    Arrived_B : BOOL;
END_VAR

```

2.4.3. Code

In the _INIT code part, set the defaults:

```
PROGRAM _INIT
  (* Insert code here *)
  Case_OP := Idle;
  M1_PosLim := 2147483647;
  M1_NegLim := -2147483648;
  M1_TorqueLimit := 1000;
  Counter := 0;
END_PROGRAM
```

The _CYCLIC code implements the state machine that drives the motor through the control word / status word dialogue:

```
CASE Case_OP OF

  Idle:
    M1_Cw := 16#06;
    GUI_new_set := FALSE;
    GUI_hom_done := 0;
    Counter := 0;
    Arrived_A := 0;
    Arrived_B := 0;
    SetAck := 0;

    IF (NOT GUI_Run) THEN
      GUI_en_vel := FALSE;
      GUI_en_pos := FALSE;
      GUI_auto := FALSE;
    END_IF;

    (* Exit *)
    IF (GUI_en_hom) THEN
      Case_OP := Home;
    END_IF;
    IF (GUI_Run) THEN
      IF (GUI_en_vel) THEN
        Case_OP := Velocity;
      END_IF;
      IF (GUI_en_pos) THEN
        Case_OP := Position;
      END_IF;
      IF (GUI_auto) THEN
        Case_OP := Auto_Enter;
      END_IF;
    END_IF;

  Velocity:
    M1_ModeofOp := 3;
    IF (M1_ModeofOpDisplay = 3) THEN
      M1_Cw := 16#0F;
    ELSE
      M1_Cw := 16#06;
    END_IF;
    (* setpoint *)
    IF (GUI_Dir) THEN
      M1_TargetVelocity := -GUI_tvel;
    ELSE
      M1_TargetVelocity := GUI_tvel;
    END_IF;
    (* Exit *)
```



```

IF (NOT GUI_en_vel) THEN
    Case_OP := Idle;
END_IF;

Position:
    M1_ModeofOp := 1;
    IF (M1_ModeofOpDisplay = 1) THEN
        M1_Cw := 16#0F;
    ELSE
        M1_Cw := 16#06;
    END_IF;
    (* new set *)
    IF (GUI_pos < GUI_tpos-2 OR GUI_pos > GUI_tpos+2) THEN
        Counter := Counter + 1;
        IF (Counter > 3) THEN
            M1_Cw := 16#1F;
        ELSIF ((M1_SW AND 16#1000) = 16#1000) THEN
            M1_Cw := 16#0F;
            Counter := 0;
        END_IF;
    END_IF;
    M1_TargetPos := GUI_tpos;
    M1_ProfileVel := GUI_tvel;
    (* Exit *)
    IF (NOT GUI_en_pos) THEN
        Case_OP := Idle;
    END_IF;

Auto_Enter:
    M1_ModeofOp := 1;
    IF (M1_ModeofOpDisplay = 1) THEN
        M1_Cw := 16#0F;
    ELSE
        M1_Cw := 16#06;
    END_IF;
    Counter := Counter + 1;
    (* Exit *)
    IF (Counter > 3) THEN
        IF (Arrived_A) THEN
            Case_OP := Auto_B;
            Counter := 0;
        ELSIF (Arrived_B) THEN
            Case_OP := Auto_A;
            Counter := 0;
        ELSE
            Case_OP := Auto_A;
            Counter := 0;
        END_IF;
    END_IF;
    IF (NOT GUI_auto) THEN
        Case_OP := Idle;
    END_IF;

Auto_A:
    M1_TargetPos := GUI_tposA;
    M1_ProfileVel := GUI_tvel;
    M1_Cw := 16#1F;
    IF (M1_SW.12 AND M1_Cw = 16#1F) THEN
        SetAck := TRUE;
    END_IF;
    (* Exit *)

```

```

    IF (SetAck) THEN
        Case_OP := Auto_Moving;
        Arrived_B := FALSE;
    END_IF;
    IF (NOT GUI_auto) THEN
        Case_OP := Idle;
    END_IF;

Auto_B:
    M1_TargetPos := GUI_tposB;
    M1_ProfileVel := GUI_tvel;
    M1_Cw := 16#1F;
    IF (M1_SW.12 AND M1_Cw = 16#1F) THEN
        SetAck := TRUE;
    END_IF;
    (* Exit *)
    IF (SetAck) THEN
        Case_OP := Auto_Moving;
        Arrived_A := FALSE;
    END_IF;
    IF (NOT GUI_auto) THEN
        Case_OP := Idle;
    END_IF;

Auto_Moving:
    M1_Cw := 16#0F;
    Counter := Counter + 1;
    SetAck := FALSE;
    IF (Counter > 2) THEN
        IF (M1_SW.10 AND M1_Actualvel = 0) THEN
            IF (GUI_tposA-2 < M1_ActualPos AND M1_ActualPos < GUI_tposA+2) THEN
                Arrived_A := TRUE;
            ELSIF (GUI_tposB-2 < M1_ActualPos AND M1_ActualPos < GUI_tposB+2) THEN
                Arrived_B := TRUE;
            END_IF;
        END_IF;
    END_IF;
    (* Exit *)
    IF (Arrived_A OR Arrived_B) THEN
        Counter := 0;
        Case_OP := Auto_Wait;
    END_IF;
    IF (NOT GUI_auto) THEN
        Case_OP := Idle;
    END_IF;

Auto_Wait:
    Counter := Counter + 1;
    IF (Counter > 6) THEN
        Case_OP := Auto_Enter;
    END_IF;
    IF (NOT GUI_auto) THEN
        Case_OP := Idle;
    END_IF;

Home:
    M1_ModeofOp := 6;
    M1_HomMethod := 35;
    IF (M1_ModeofOpDisplay = 6) THEN
        M1_Cw := 16#1F;
    ELSE

```

```

M1_Cw := 16#06;
END_IF;
(* Status *)
IF ((M1_SW AND 16#400) = 16#400) THEN
    GUI_hom_done := 10; (* green - DONE *)
ELSIF ((M1_SW AND 16#2000) = 16#2000) THEN
    GUI_hom_done := 45; (* red - ERROR *)
ELSE
    GUI_hom_done := 41; (* orange - IN PROGRESS *)
END_IF;
(* Exit *)
IF (GUI_hom_done = 10) THEN
    GUI_en_hom := FALSE;
    Case_OP := Idle;
END_IF;

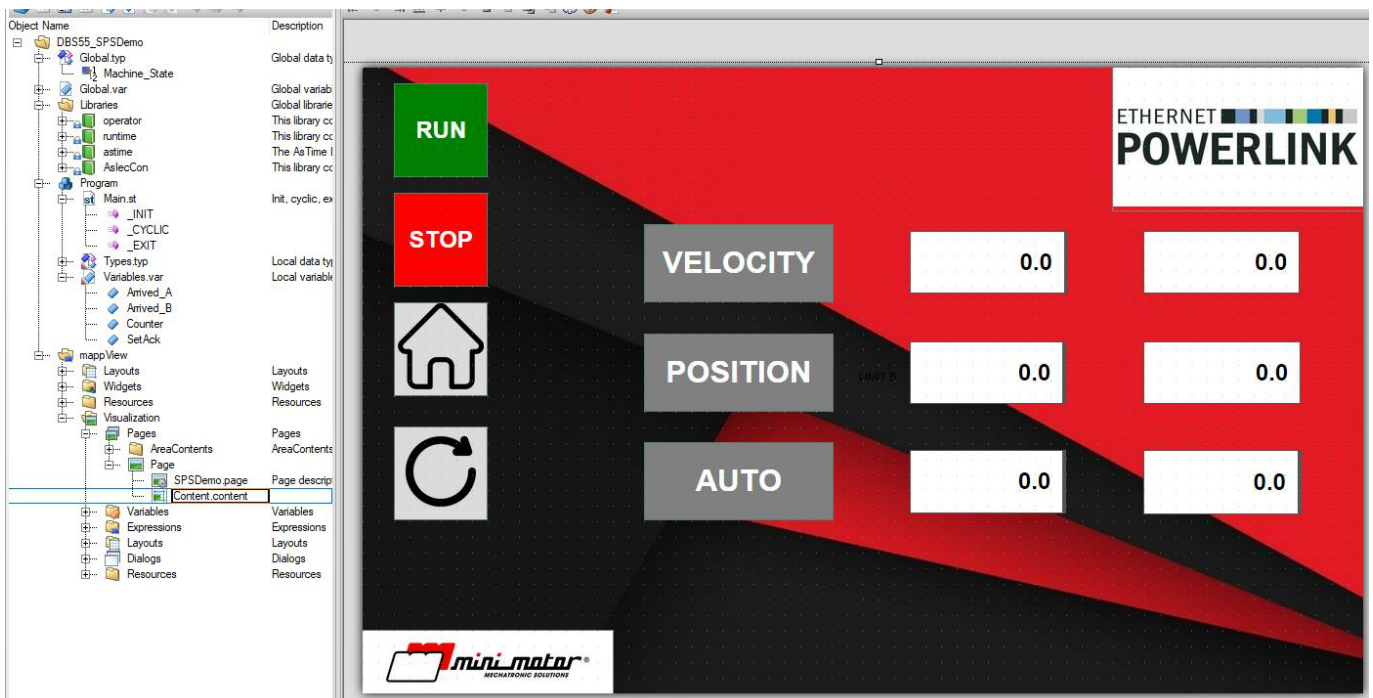
Stop:
M1_Cw := 16#06;
GUI_new_set := FALSE;
GUI_hom_done := 0;
GUI_en_pos := FALSE;
GUI_en_vel := FALSE;
GUI_en_hom := FALSE;
GUI_auto := FALSE;
GUI_Stop := FALSE;
Case_OP := Idle;

END_CASE;

IF (GUI_Stop) THEN
    GUI_Run := FALSE;
    Case_OP := Stop;
END_IF;

```

The program comes with a GUI suitable for a 4PPC50.

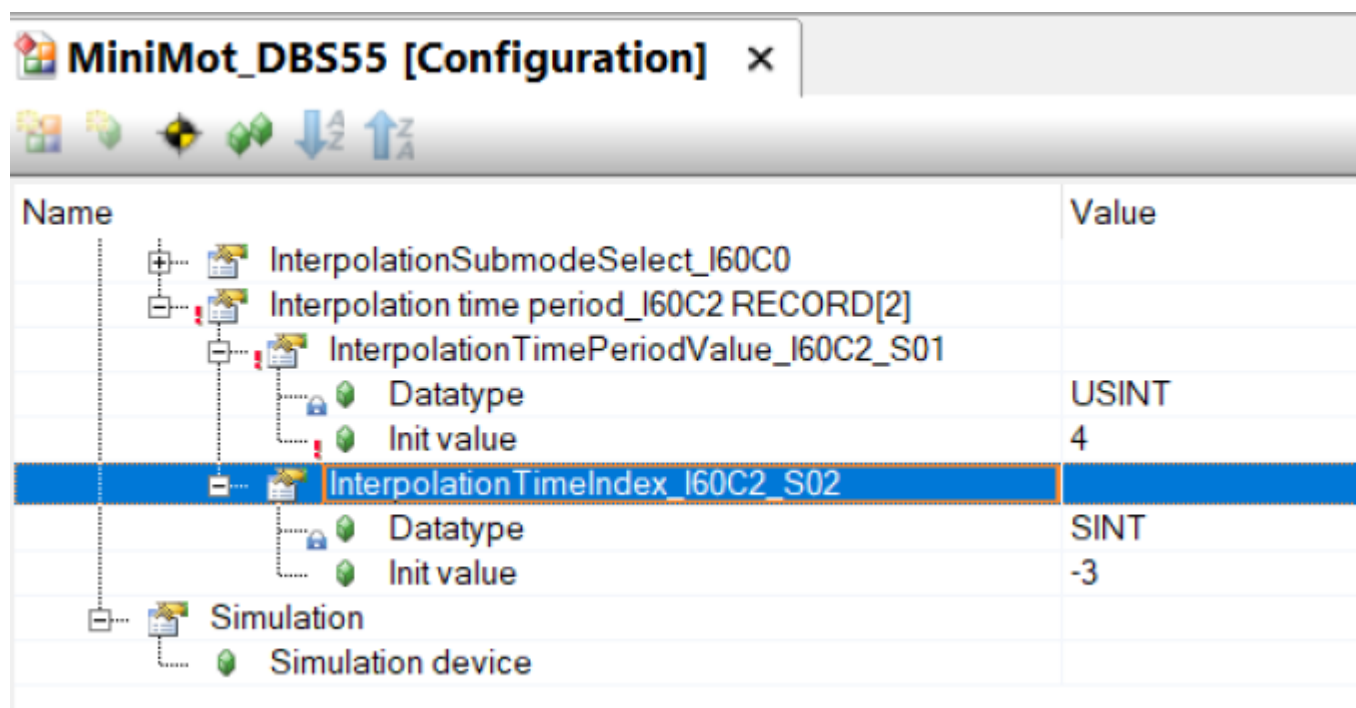


2.5. CSP

The example shows how to interface a DBS integrated motor, CSP enabled, with the B&R platform using the ACP10 library.

2.5.1. Initial Steps

- Create a new project.
- Configure the Powerlink cycle time.
- Sync the CPU system timer with the Powerlink time.
- Add the DBS using *Add Hardware Module* and configure the channels. The minimum required objects for the axis function are:
 - Write: ControlWord, Mode of Operation, Target Position
 - Read: Status Word, Mode of Operation Display, Position Actual Value
- Set up the interpolation time to match the Powerlink cycle rate. The setup in the picture is 4 ms.

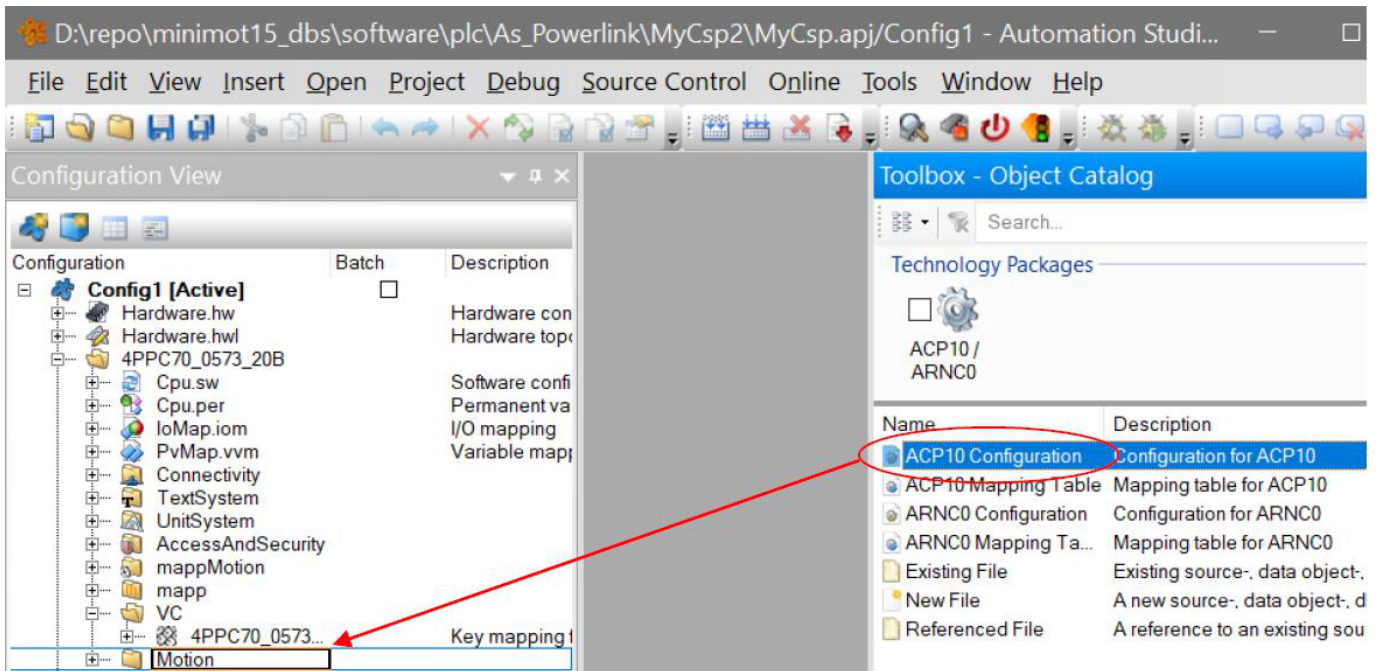


Name	Value
InterpolationSubmodeSelect_I60C0	
Interpolation time period_I60C2 RECORD[2]	
InterpolationTimePeriodValue_I60C2_S01	
Datatype	USINT
Init value	4
InterpolationTimeIndex_I60C2_S02	
Datatype	SINT
Init value	-3
Simulation	
Simulation device	

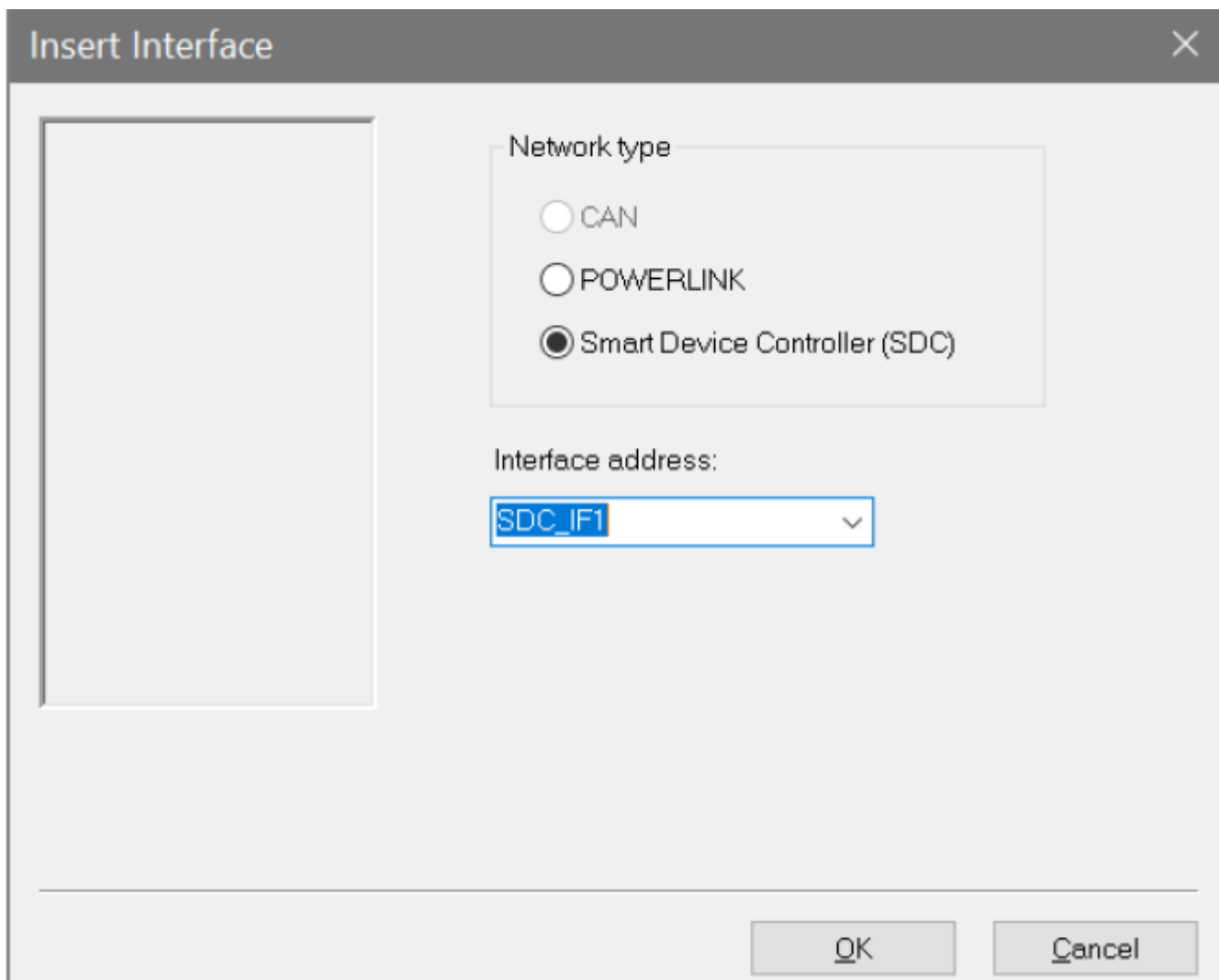
- Add the relevant variables in the Global.Var and link them to the DBS I/O mapping. In the provided example there are more variables linked, to better monitor the DBS system.

2.5.2. Add Axis to the NDC

- Add the motion folder in the configuration of the CPU, adding the ACP10 Configuration.

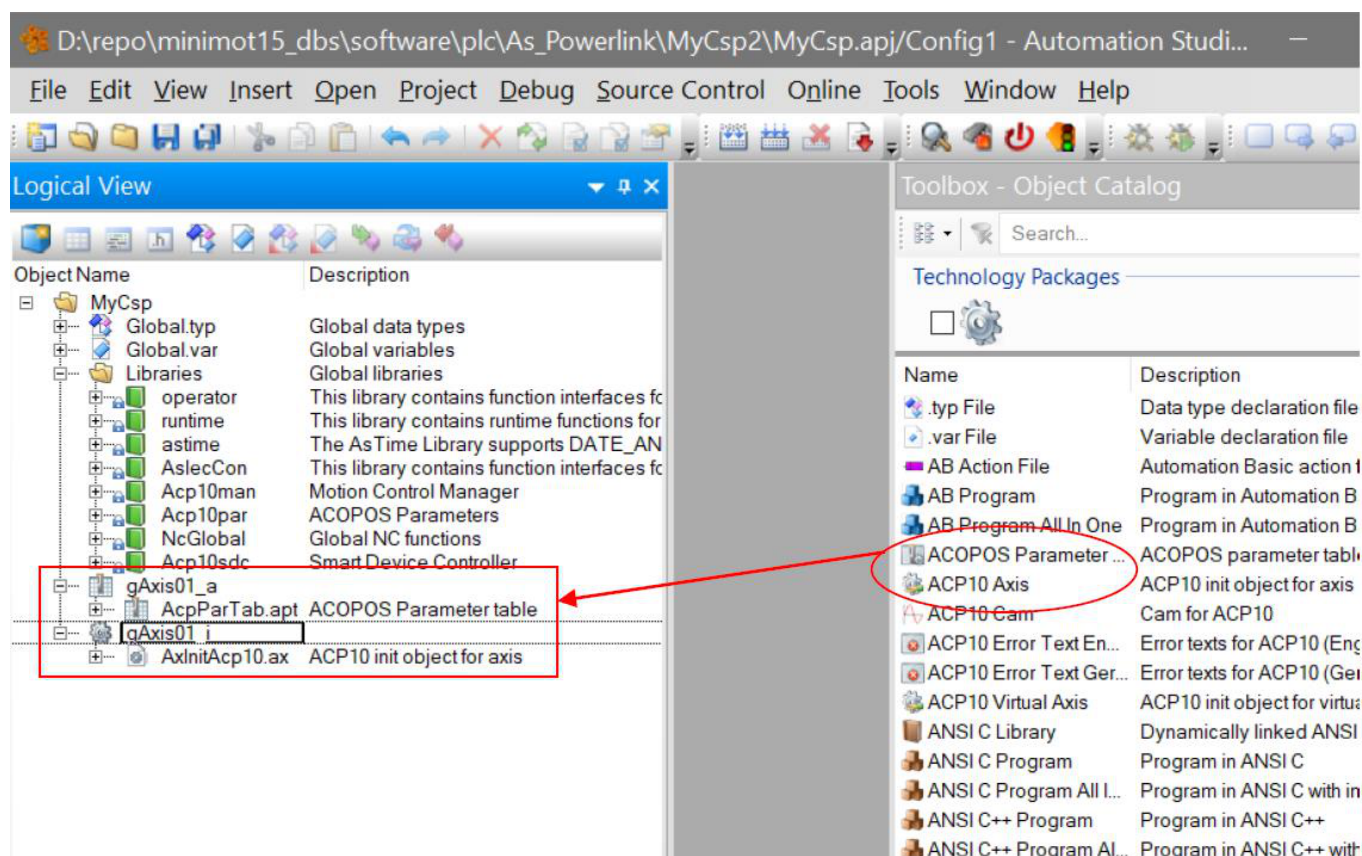


- Open Acp10cfg.ncc, right click in the blank space and select *Insert Interface...*, then select Smart Device Controller and confirm with OK.

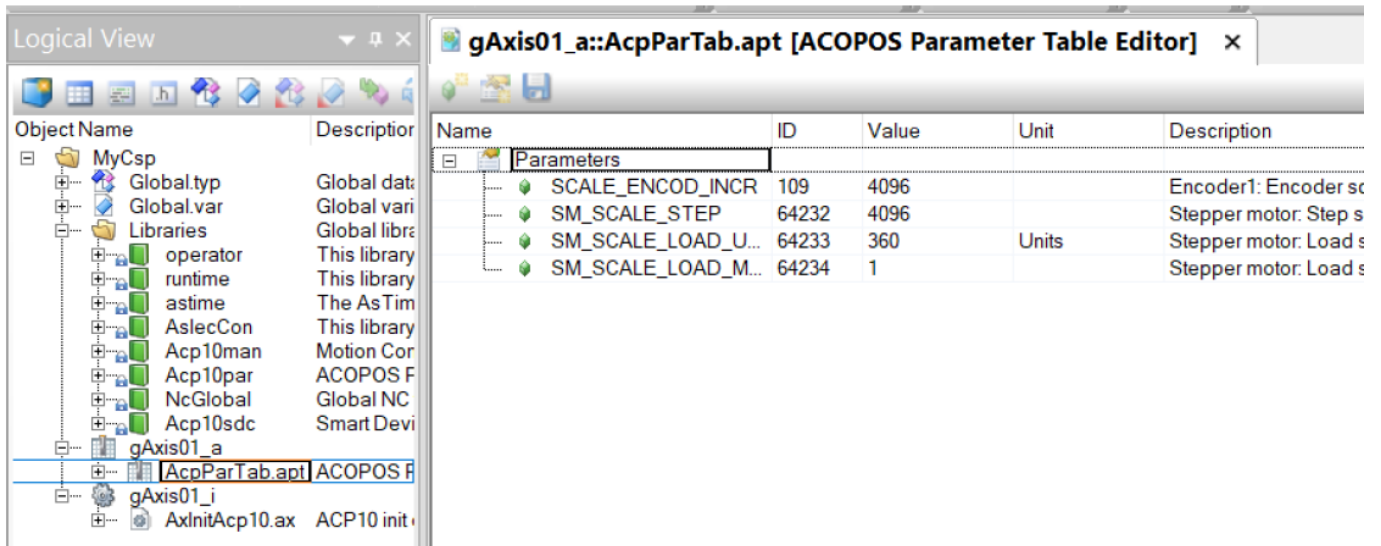


- In the Logical tab, select the root node and add an *ACOPos parameter table* and an *ACP10 Axis*; then

rename them as gAxis01_a and gAxis01_i.



- In the Configuration tab, open Acp10map1.ncm, right click and select *Add NC Object*, then compile it as:
 - Object name: gAxis01
 - PLC Address: SDC_IF1.ST1
 - Nc object: ncAxis
 - Channel: 1
 - Init parameter gAxis01_i
 - ACOPOS Parameter gAxis01_a
- Open gAxis01_a parameters and set up the following:
 - SCALE_ENCOD_INCR (ID=109) 4096 (pulses per revolution of DBS)
 - SM_SCALE_STEP (ID=64232) 4096 (pulses per revolution of DBS)
 - SM_SCALE_LOAD_UNITS (ID=64233) 360 (units per revolution, degrees)
 - SM_SCALE_LOAD_MOTREV (ID=64234) 1 (units referred to one revolution)



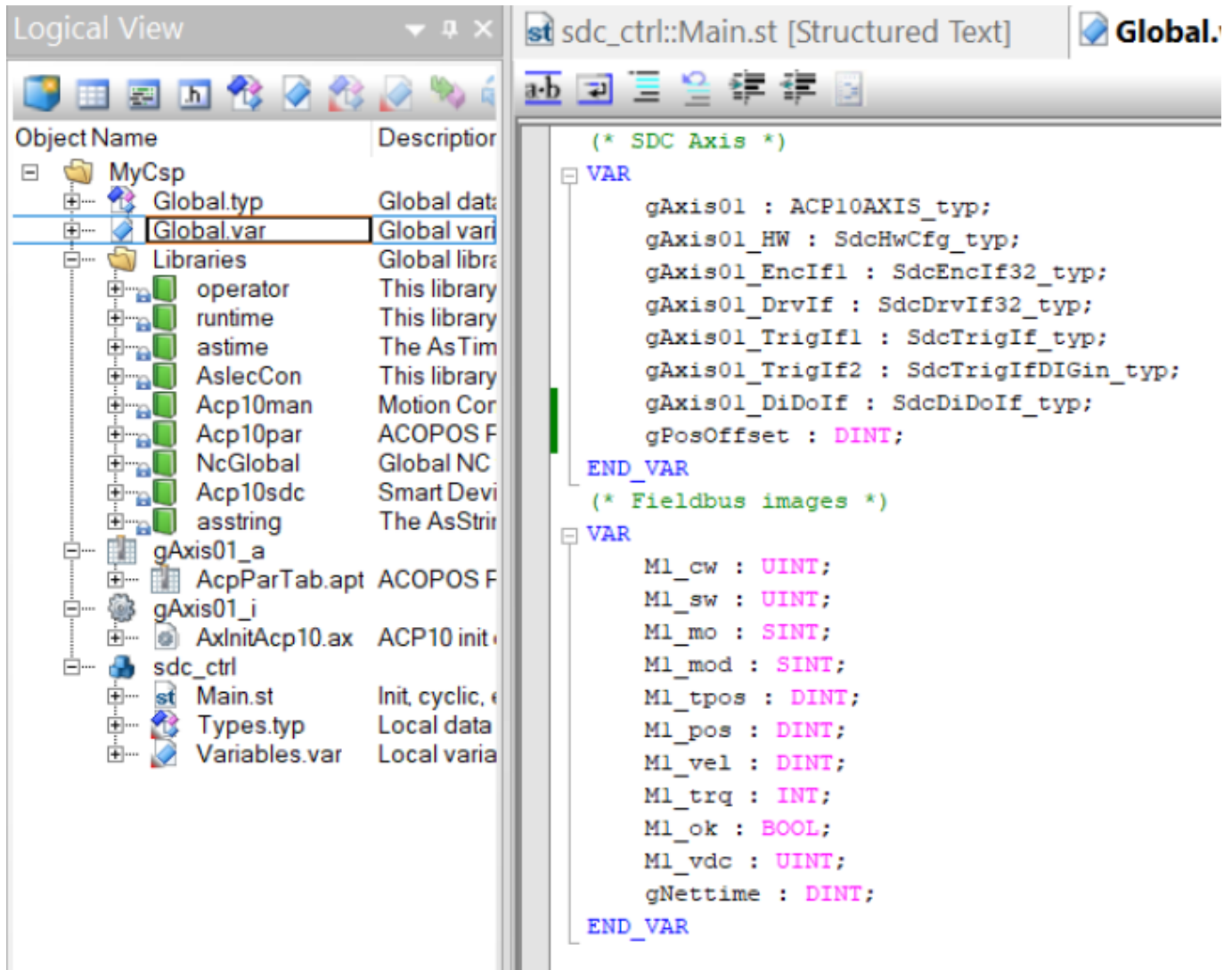
Name	ID	Value	Unit	Description
Parameters				
SCALE_ENCOD_INCR	109	4096		Encoder1: Encoder sc
SM_SCALE_STEP	64232	4096		Stepper motor: Step s
SM_SCALE_LOAD_U...	64233	360	Units	Stepper motor: Load s
SM_SCALE_LOAD_M...	64234	1		Stepper motor: Load s

- Open the gAxis01_i parameter tree and set the following parameters:
 - dig_in level: ncACTIVE_HI
 - encoder_if\parameter\scaling\load\units: 360 (degrees per rev)
 - limit\parameter\v_*: 18000 (degrees/sec, 3000 rpm)
 - limit\parameter\a*: 180000 (degrees/sec^2, 30000 rpm/s)
 - move\basis\parameter\v_*: 18000 (degrees/sec, 3000 rpm)
 - move\basis\parameter\a*: 180000 (degrees/sec^2, 30000 rpm/s)

Object Name	Description	Name	Value	Unit	Description
MyCsp		ACP10AXIS_type			
Global.typ	Global data	dig_in			Digital Inputs
Global.var	Global vari	level			Active Input Level
Libraries	Global libr	reference	ncACTIV_HI		Reference switch
operator	This library	pos_hw_end	ncACTIV_HI		Positive HW end switch
runtime	This library	neg_hw_end	ncACTIV_HI		Negative HW end switch
astime	The AsTim	trigger1	ncACTIV_HI		Trigger1
AslecCon	This library	trigger2	ncACTIV_HI		Trigger2
Acp10man	Motion Cor	encoder_if			Encoder Interface
Acp10par	ACOPOS F	parameter			Parameters
NcGlobal	Global NC	count_dir	ncSTANDARD		Count direction
Acp10sdc	Smart Devi	scaling			Scaling
gAxis01_a		load			Load
AcpParTab.apr	ACOPOS F	units	360	Units	Units at the load
gAxis01_i		rev_motor	1		Motor revolutions
AxInitAcp10.ax	ACP10 init	limit			Limit value
		parameter			Parameters
		v_pos	18000.0	Units/s	Speed in positive direction
		v_neg	18000.0	Units/s	Speed in positive direction
		a1_pos	180000.0	Units/s ²	Acceleration in positive direction
		a2_pos	180000.0	Units/s ²	Acceleration in positive direction
		a1_neg	180000.0	Units/s ²	Acceleration in positive direction
		a2_neg	180000.0	Units/s ²	Acceleration in positive direction
		t_jolt	0	s	Jolt time
		t_in_pos	0	s	Settling time before message 'In Posit
		pos_sw_end	2000000000	Units	Positive SW end
		neg_sw_end	-2000000000	Units	Negative SW end
		ds_warning	500	Units	Lag error limit for display of a warning
		ds_stop	1000	Units	Lag error limit for stop of a movement
		a_stop	1.0e30	Units/s ²	Acceleration limit for stop of a movem
		dv_stop	0	1/s	Speed error limit for stop of a moveme
		dv_stop_mode	ncOFF		Mode for speed error monitoring
		controller			Controller
		move			Movement
		stop			Stop Movement
		homing			Homing procedure
		basis			Basis movements
		parameter			Parameters
		v_pos	18000.0	Units/s	Speed in positive direction
		v_neg	18000.0	Units/s	Speed in positive direction
		a1_pos	180000.0	Units/s ²	Acceleration in positive direction
		a2_pos	180000.0	Units/s ²	Acceleration in positive direction
		a1_neg	180000.0	Units/s ²	Acceleration in positive direction
		a2_neg	180000.0	Units/s ²	Acceleration in positive direction
		message			Messages (errors, warnings)

2.5.3. SDC – DS402 Connection

- In the Global.var add the SDC axis variables.
- Add a new *ST Program all in one* and rename it sdc_ctrl.
- Add the B&R library asstring.
- Open Cpu.sw and ensure that sdc_ctrl runs in the *Cyclic 1* at 4 ms (it needs to run synchronously to the Powerlink data exchange).



Logical View

Object Name	Description
MyCsp	
Global.type	Global data
Global.var	Global vari
Libraries	Global libra
operator	This library
runtime	This library
astime	The AsTim
AslecCon	This library
Acp10man	Motion Cor
Acp10par	ACOPOS F
NcGlobal	Global NC
Acp10sdc	Smart Devi
asstring	The AsStri
gAxis01_a	
AcpParTab.ap	ACOPOS F
gAxis01_i	
AxInitAcp10.ax	ACP10 init
sd_crtl	
Main.st	Init, cyclic, e
Types.type	Local data
Variables.var	Local varia

sd_crtl::Main.st [Structured Text]

```

(* SDC Axis *)
VAR
    gAxis01 : ACP10AXIS_typ;
    gAxis01_HW : SdcHwCfg_typ;
    gAxis01_EncIf1 : SdcEncIf32_typ;
    gAxis01_DrvIf : SdcDrvIf32_typ;
    gAxis01_TrigIf1 : SdcTrigIf_typ;
    gAxis01_TrigIf2 : SdcTrigIfDIGin_typ;
    gAxis01_DiDoIf : SdcDiDoIf_typ;
    gPosOffset : DINT;
END_VAR

(* Fieldbus images *)
VAR
    Ml_cw : UINT;
    Ml_sw : UINT;
    Ml_mo : SINT;
    Ml_mod : SINT;
    Ml_tpos : DINT;
    Ml_pos : DINT;
    Ml_vel : DINT;
    Ml_trq : INT;
    Ml_ok : BOOL;
    Ml_vdc : UINT;
    gNettime : DINT;
END_VAR
    
```

2.5.4. Code

In the _INIT code part, add the configuration of the SDC axis; the code links all the sub-structures.

```

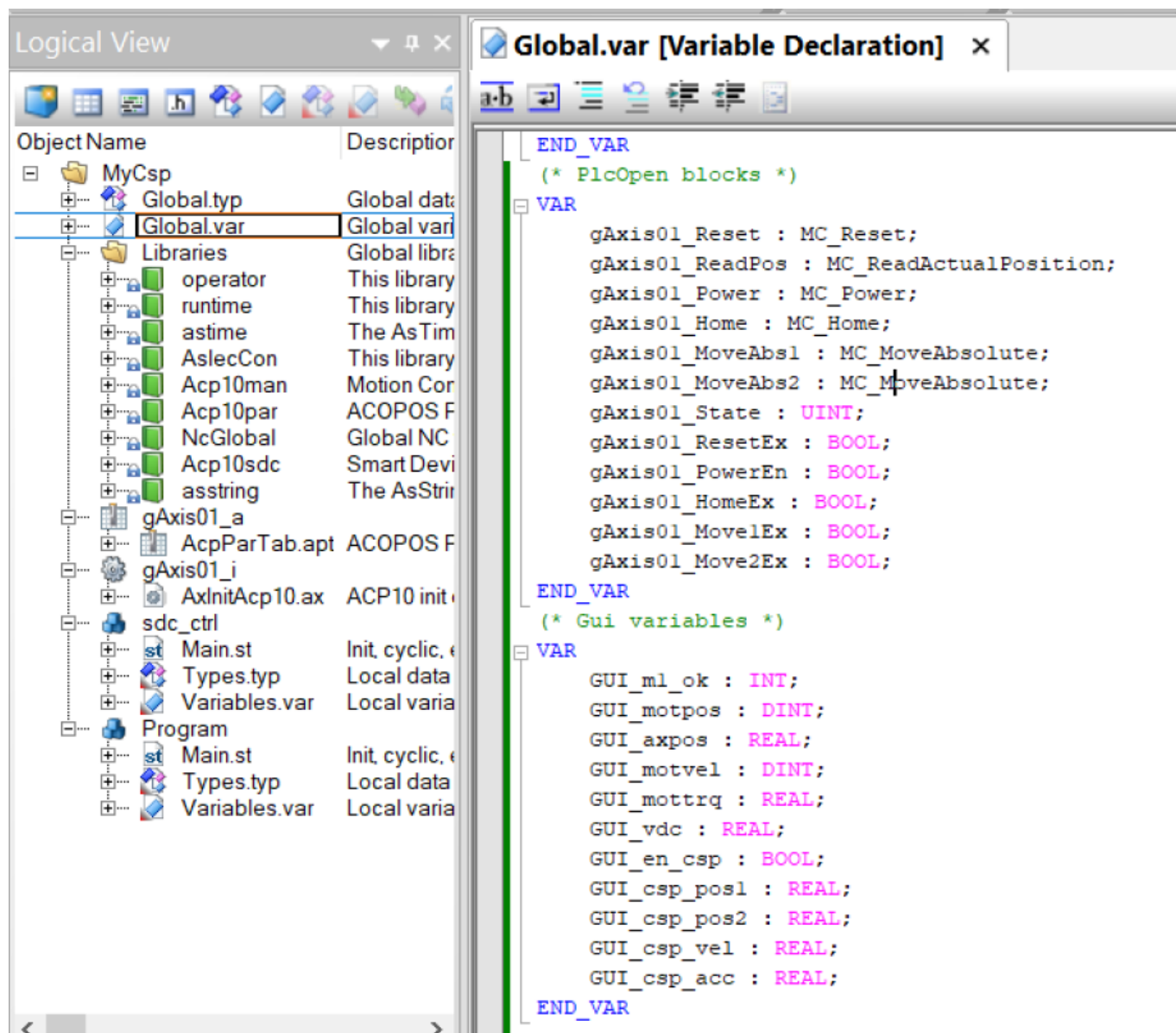
(* initialize EncIf1 *)
gAxis01_HW.EncIf1_Typ := ncSDC_ENC32;
strcpy( ADR(gAxis01_HW.EncIf1_Name[0]), ADR('gAxis01_EncIf1') );
(* initialize DrvIf *)
gAxis01_HW.DrvIf_Typ := ncSDC_DRVSM32;
strcpy( ADR(gAxis01_HW.DrvIf_Name[0]), ADR('gAxis01_DrvIf') );
(* initialize TrigIf1 *)
gAxis01_HW.TrigIf1_Typ := ncSDC_TRIG;
strcpy( ADR(gAxis01_HW.TrigIf1_Name[0]), ADR('gAxis01_TrigIf1') );
(* initialize TrigIf2 *)
gAxis01_HW.TrigIf2_Typ := ncSDC_TRIGDIGin;
strcpy( ADR(gAxis01_HW.TrigIf2_Name[0]), ADR('gAxis01_TrigIf2') );
(* initialize DiDoIf *)
gAxis01_HW.DiDoIf_Typ := ncSDC_DIDO;
strcpy( ADR(gAxis01_HW.DiDoIf_Name[0]), ADR('gAxis01_DiDoIf') );
    
```

The _CYCLIC code is composed of two blocks. The first simulates the life counters in order to comply with the liveness management from the numerical control; the OK flags are linked to the ModuleOK flag coming from Powerlink.

```
(* life counter simulation *)
gAxis01_DrvIf.iLifeCnt := gAxis01_DrvIf.iLifeCnt + 1;
gAxis01_EncIf1.iLifeCnt := gAxis01_EncIf1.iLifeCnt + 1;
gAxis01_EncIf1.iActTime := DINT_TO_INT(gNettime AND 16#FFFF);
gAxis01_DiDoIf.iLifeCntDriveEnable := gAxis01_DiDoIf.iLifeCntDriveEnable + 1;
gAxis01_DiDoIf.iLifeCntDriveReady := gAxis01_DiDoIf.iLifeCntDriveReady + 1;
gAxis01_DiDoIf.iLifeCntNegHwEnd := gAxis01_DiDoIf.iLifeCntNegHwEnd + 1;
gAxis01_DiDoIf.iLifeCntPosHwEnd := gAxis01_DiDoIf.iLifeCntPosHwEnd + 1;
gAxis01_DiDoIf.iLifeCntReference := gAxis01_DiDoIf.iLifeCntReference + 1;
gAxis01_TrigIf1.iLifeCnt := gAxis01_TrigIf1.iLifeCnt + 1;
gAxis01_TrigIf2.iLifeCnt := gAxis01_TrigIf2.iLifeCnt + 1;
(* drive ready emulation *)
gAxis01_EncIf1.iEncOK := M1_ok;
gAxis01_DiDoIf.iDriveReady := M1_ok;
gAxis01_DrvIf.iDrvOK := M1_ok;
```

The second part of the _CYCLIC code is the actual DS402 glue, where the control word is driven from the gAxis enable and the target is linked to the gAxis output reference.

```
(* ds402 linking *)
gAxis01_EncIf1.iActPos := M1_pos; (* position actual value to axis *)
gAxis01_DrvIf.iStatusEnable := gAxis01_DrvIf.iDrvOK;
M1_mo := 8; (* CSP *)
IF (M1_mod = 8) THEN
  IF ((M1_sw AND 16#4F) = 16#08) THEN
    M1_cw := 16#80; (* FAULT ACK *)
  ELSE
    IF gAxis01_DiDoIf.oDriveEnable THEN
      M1_cw := 16#0F; (* ENABLE *)
    ELSE
      M1_cw := 16#06; (* DISABLE *)
      gPosOffset := M1_pos - gAxis01_DrvIf.oSetPos;
    END_IF
  END_IF
ELSE
  M1_cw := 16#06; (* DISABLE *)
END_IF
(* motor target position *)
M1_tpos := gAxis01_DrvIf.oSetPos + gPosOffset; (* position target to drive *)
```



2.5.5. Sample Application

The provided example contains a sample application that enables the drive, does homing and continuously moves the motor between two position points.

- Add the B&R library Acp10_MC.
- In the Global.var add the PLCOpen block variables (MC_Reset, MC_Power, MC_Home, MC_MoveAbsolute, etc.).

In the _INIT code insert the parameter defaults:

```

GUI_csp_acc := 36000.0;
GUI_csp_vel := 3600.0;
GUI_csp_pos1 := 0.0;
GUI_csp_pos2 := 3600.0;
  
```

In the _CYCLIC the main part is the PLCOpen blocks for driving the motor and the state machine to drive them.

```

gAxis01_Reset(Axis := ADR(gAxis01), Execute := gAxis01_ResetEx);
  
```

```

gAxis01_Power(Axis := ADR(gAxis01), Enable := gAxis01_PowerEn);
gAxis01_ReadPos(Axis := ADR(gAxis01), Enable := TRUE);
gAxis01_Home(Axis := ADR(gAxis01), Execute := gAxis01_HomeEx);
gAxis01_MoveAbs1(Axis := ADR(gAxis01), Execute := gAxis01_Move1Ex, Position := GUI_csp_pos1,
    Velocity := GUI_csp_vel, Acceleration := GUI_csp_acc, Deceleration := GUI_csp_acc);
gAxis01_MoveAbs2(Axis := ADR(gAxis01), Execute := gAxis01_Move2Ex, Position := GUI_csp_pos2,
    Velocity := GUI_csp_vel, Acceleration := GUI_csp_acc, Deceleration := GUI_csp_acc);

(* Axis switch on *)
IF (GUI_en_csp) THEN
    CASE (gAxis01_State) OF
        1: (* Init reset *)
            gAxis01_ResetEx := FALSE;
            gAxis01_PowerEn := FALSE;
            gAxis01_HomeEx := FALSE;
            gAxis01_Move1Ex := FALSE;
            gAxis01_Move2Ex := FALSE;
            gAxis01_State := 2;
        2: (* Reset *)
            gAxis01_ResetEx := TRUE;
            IF (gAxis01_Reset.Done) THEN
                gAxis01_State := 3;
            END_IF
        3: (* Power *)
            gAxis01_ResetEx := FALSE;
            gAxis01_PowerEn := TRUE;
            IF (gAxis01_Power.Status) THEN
                gAxis01_State := 11;
            END_IF
        11: (* Home *)
            gAxis01_HomeEx := TRUE;
            IF (gAxis01_Home.Done) THEN
                gAxis01_State := 21;
            END_IF
        21: (* Move POS1 *)
            gAxis01_Move1Ex := TRUE;
            gAxis01_Move2Ex := FALSE;
            IF (gAxis01_MoveAbs1.Done) THEN
                gAxis01_State := 22;
            END_IF
        22: (* Move POS2 *)
            gAxis01_Move1Ex := FALSE;
            gAxis01_Move2Ex := TRUE;
            IF (gAxis01_MoveAbs2.Done) THEN
                gAxis01_State := 21;
            END_IF
    END_CASE
ELSE
    gAxis01_State := 1;
    gAxis01_ResetEx := FALSE;
    gAxis01_PowerEn := FALSE;
END_IF

```

Finally, the provided example adds a GUI suitable for a 4PPC70 that allows switching the drive on and off and setting up the targets and the parameters for the position trajectories.