AMPEGON

Ampegon PPT GmbH
Feldstraße 56
DE-44141 Dortmund
Tel.: +49 231 476459 - 0

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GSI-SIS100-KI1

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Rev.	Date	Synopsis	Issued/Dept	Checked	Released
0.1	17.05.2016	First version	ThPf / RD	MiOs	MiOs
0.2	01.06.2016	Major changes	ThPf / RD	MiOs	MiOs
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0.4	02.08.2016	Minor changes	ThPf / RD	MiOs	MiOs
1.0	14.11.2016	Published	ThPf / RD	MiOs	MiOs
1.1	25.01.2017	Safety+Oil pumps	ThPf / RD	MiOs	MiOs

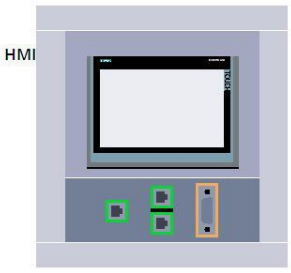
1 Control system and interfaces

The magnet supply consists of six independent working power supplies, controlled by one central Siemens S7-1500 PLC with one 15" touch panel. This PLC monitors the states from Danfysik's Termination Block inside the tunnel, controls the Danfysik's oil pumps and controls all six power supplies. It's not necessary to run all six power supplies together. In each power supply cabinet are three distributed Siemens S7 ET200SP knots. One on ground potential for the cabinet, two on high voltage potential to monitor the thyratrons. In the wall cabinet is an additional Siemens S7 ET200SP knot for controlling the Danfisik pumping station. Safety signals handled by a Phoenix SafetyBridge independent safety controller with ProfiNet interface to the PLC.

The PLC system consists of six parts.

1. The main PLC S7-1500 controls all six power supplies, the oil pumping station and handles the magnet interlocks from the tunnel. The HMI colour touch panel for local control operates all six power supplies and the oil pumping station.
2. Distributed I/O controller Siematic ET200SP on tunnel GND potential for controlling the oil pumps
3. Distributed I/O controller Siematic ET200SP on GND potential for controlling the cabinet
4. Distributed I/O controller Siematic ET200SP on high potential for controlling thyratron 1
5. Distributed I/O controller Siematic ET200SP on high potential for controlling thyratron 2
6. Safety I/Os with own safety hardware
7. SCU, optical and analogue interface to GSI control system, interlock system, timing system and machine protection system.

1.1 MAIN_CPU (S7-1500), GND-potential, isolated to tunnel GND



PM190W	24V / 8A	6EP1 333-4BA00
7x TBLC 25-124	TRACO 24 PS with isolated output	
CPU1515-2 PN	CPU mit 2x PROFINET IF	6ES7 515-2AM01-0AB0
TP 1500	HMI TP 1500 touch 15"	6AV2124-0QC02-0AX0
Planet IGS-801M	Industrial managed switch, 8 port	
EMO EN-70E	Network isolator for tunnel PLCs	

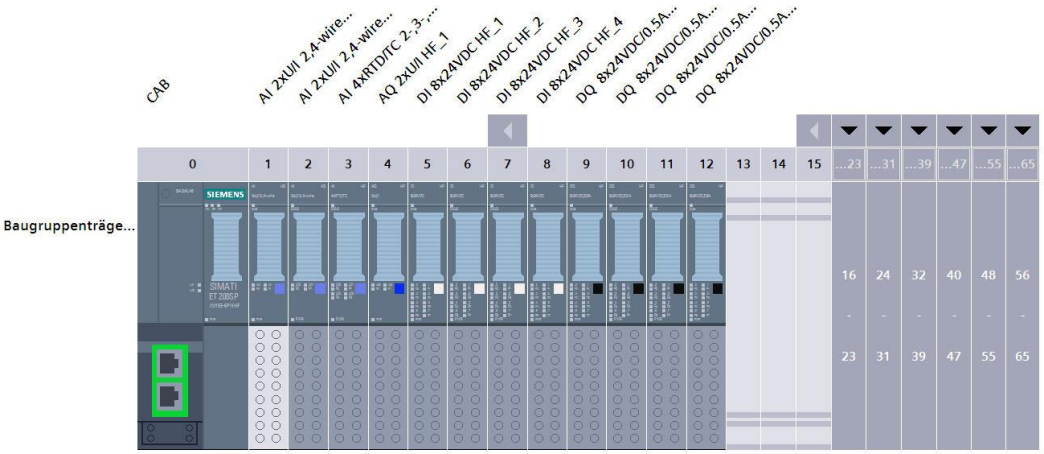
1.2 Oil Pumping Station (ET200SP), tunnel GND, isolated

SITOP PSU100L	24V / 5A	6EP1 333-1LB00
IM155-6 PN HS	Interface module high speed	6ES7 155-6AU00-0DN0
DI 8x24VDC HF	DI8 high feature	6ES7 131-6BF00-0CA0
DI 8x24VDC HF	DI8 high feature	6ES7 131-6BF00-0CA0
DO 8x24VDC HF	DO8 high feature	6ES7 132-6BF00-0CA0
AI 4xRTD/TC HF	AI4 / 4x PT100	6ES7 134-6JD00-0CA1

DI	magnet oil temperature warning
DI	magnet oil temperature alarm
DI	magnet oil pump A running
DI	magnet oil pump B running
DI	magnet oil flow switch 1
DI	magnet oil flow switch 2
DI	magnet oil flow switch 3
DI	magnet oil pump fuse okay

+ I/Os for oil pumping station

1.3 CAB (ET200SP), GND-potential (6x)

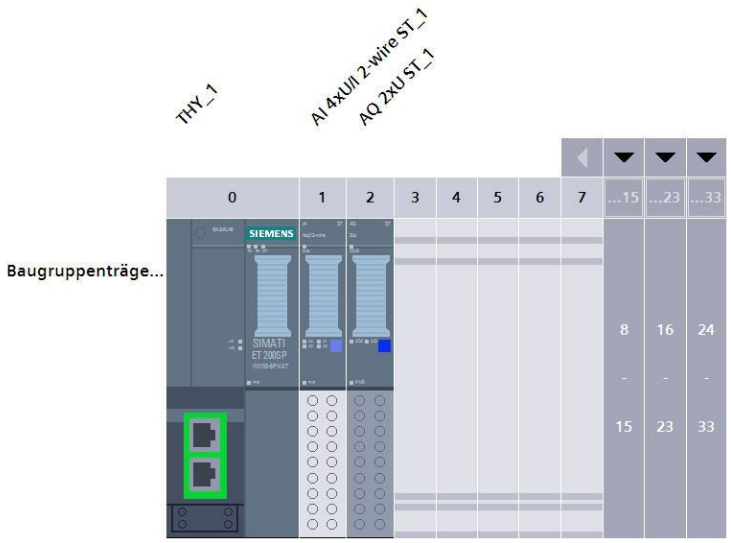


SITOP PSU100L	24V / 5A	6EP1 333-1LB00
IM155-6 PN HS	Interface module high speed	6ES7 155-6AU00-0DN0
AI 2xU/I HS	AI2 / 2x U high speed	6ES7 134-6HB00-0DA1
AI 2xU/I HS	AI2 / 2x U high speed	6ES7 134-6HB00-0DA1
AI 4xRTD/TC HF	AI4 / 4x PT100	6ES7 134-6JD00-0CA1
AO 2xU/I HF	AO2 / 2x U high feature	6ES7 135-6HB00-0CA1
DI 8x24VDC HF	DI8 high feature	6ES7 131-6BF00-0CA0
DI 8x24VDC HF	DI8 high feature	6ES7 131-6BF00-0CA0
DI 8x24VDC HF	DI8 high feature	6ES7 131-6BF00-0CA0
DI 8x24VDC HF	DI8 high feature	6ES7 131-6BF00-0CA0
DO 8x24VDC HF	DO8 high feature	6ES7 132-6BF00-0CA0
DO 8x24VDC HF	DO8 high feature	6ES7 132-6BF00-0CA0
DO 8x24VDC HF	DO8 high feature	6ES7 132-6BF00-0CA0
DO 8x24VDC HF	DO8 high feature	6ES7 132-6BF00-0CA0
Planet ISW-621TF	Industrial switch with 2x FO	ISW-621TF

AI	CABINET tank water inlet temperature
AI	HVPS I monitor
AI	HVPS U monitor
AI	HVPS Uset remote monitor
AO	ADC HVPS Uset local
DI	ADC input interface plug connected
DI	ADC output interface plug connected
DI	ADC SCU digital actual value interface plug 1 connected
DI	ADC SCU digital actual value interface plug 2 connected
DI	ADC SCU digital input interface plug connected
DI	ADC SCU digital output interface plug connected
DI	ADC SCU digital set point interface plug connected
DI	CABINET earthing rod position switch 1
DI	CABINET earthing rod position switch 2
DI	CABINET earthing rod position switch 3
DI	CABINET earthing rod position switch 4
DI	HVPS end of charge
DI	HVPS charge inhibit (monitor)
DI	HVPS interlock
DI	HVPS load fault
DI	HVPS main contactor
DI	HVPS overload
DI	HVPS power fault
DI	HVPS ready
DI	HVPS temperature
DI	HVPS high voltage on (monitor)
DI	SCU CONTROL READY (0= safe shutdown of the PS)
DI	SCU PS OFF (1= set system off, thyratron heater off)
DI	SCU PS ON (1= set system in standby, thyratron heating)
DI	SCU PS RESET (1= system reset after interlock)
DI	SCU Safety shutdown signal from SCU (interlock system)
DI	TANK oil flow okay
DO	ADC local remote

DO	CABINET fan on
DO	CABINET oil pump 1 on
DO	CABINET oil pump 2 on
DO	CABINET Signal lamp „heater on", orange
DO	CABINET Signal lamp „high voltage", red
DO	CABINET Signal lamp „off", green
DO	CABINET thyratron + THT 1 ON
DO	CABINET thyratron + THT 2 ON
DO	HVPS HV ON
DO	HVPS control on
DO	SCU Charge inhibit (1= HVPS inhibition of charging operation during pulse)
DO	SCU End of charge (1= HVPS end of charge, actual value = set value)
DO	SCU Group error (0= equipment summary interlock)
DO	SCU Line undervoltage (0= HVPS power fault)
DO	SCU Load fault (0= HVPS load fault, no load/open circuit)
DO	SCU Overload (0= HVPS overload, charging time too long)
DO	SCU Overtemperature (0= temperature summary interlock)
DO	SCU PS connected (1= all interface plugs connected)
DO	SCU PS local (1= local control)
DO	SCU PS operation (1= high voltage on / pulsing)
DO	SCU PS ready (1= ready for high voltage)
DO	SCU Safe state indicator (interlock system)
DO	SCU Setpoint limitation (0= HV set value out of allowed window)
DO	SCU summary interlock (interlock system)
DO	SCU tolerance band deviation (0= any actual value out of monitor window)
DO	SCU warning overtemperature (0= magnet temperature warning)

1.4 THY_1 (ET200SP), HV potential, ProfiNet via fibre optics

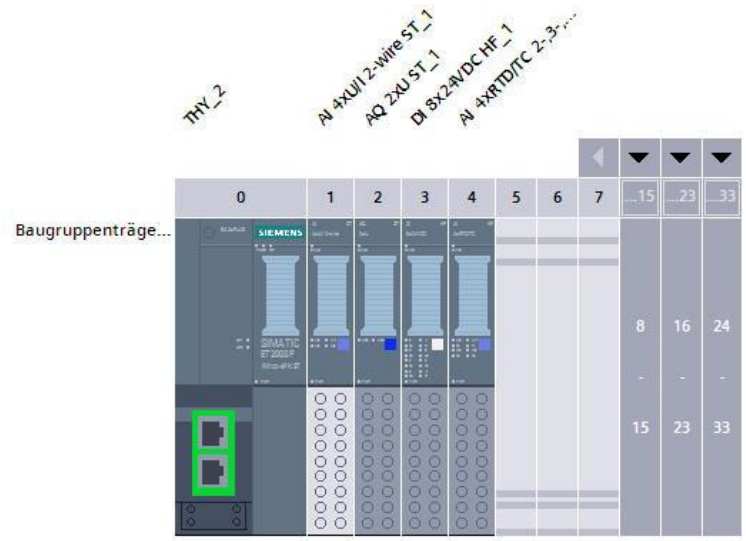


SITOP PSU100L	24V / 5A	6EP1 333-1LB00
IM155-6 PN ST	Interface module standard	6ES7 155-6AU00-0BN0

AI 4xU/I ST	AI4 / 4x U standard	6ES7 134-6HD00-0BA1
AQ 2xU/I ST	AO2 / 2x U standard	6ES7 135-6FB00-0BA1
Planet ISW-621TF	Industrial switch with 2x FO	ISW-621TF

AI	thyratron 1 reservoir U monitor
AI	thyratron 1 reservoir I monitor
AO	thyratron 1 reservoir U set
AI	thyratron 1 heater U monitor
AI	thyratron 1 heater I monitor
AO	thyratron 1 heater U set

1.5 THY_2 (ET200SP), HV potential, ProfiNet via fibre optics

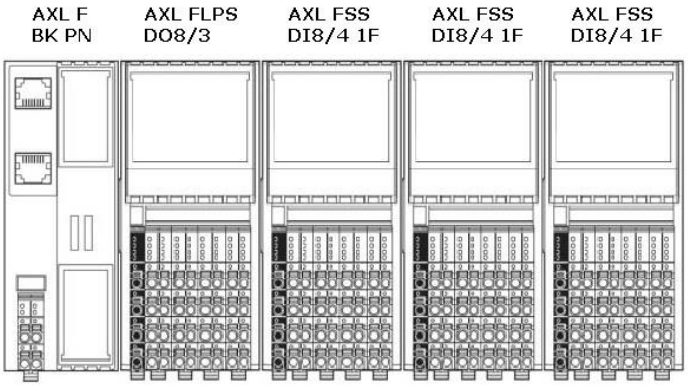


SITOP PSU100L	24V / 5A	6EP1 333-1LB00
IM155-6 PN ST	Interface module standard	6ES7 155-6AU00-0BN0
AI 4xU/I ST	AI4 / 4x U standard	6ES7 134-6HD00-0BA1
AQ 2xU/I ST	AO2 / 2x U standard	6ES7 135-6FB00-0BA1
DI 8x24VDC HF	DI8 high feature	6ES7 131-6BF00-0CA0
Planet ISW-621TF	Industrial switch with 2x FO	ISW-621TF

AI	thyratron 2 reservoir U monitor
AI	thyratron 2 reservoir I monitor
AO	thyratron 2 reservoir U set
AI	thyratron 2 heater U monitor
AI	thyratron 2 heater I monitor
AO	thyratron 2 heater U set
DI	CABINET tank 1 oil level switch
DI	CABINET tank 2 oil level switch
AI	CABINET tank 1 oil temperature
AI	CABINET tank 2 oil temperature

1.6 Safety Signals Wall Cabinet:

Safety I/O will be realized with Phoenix Contact Axioline SafetyBridge system. It's an independent safety hardware with ProfiNet interface to the S7-1500. The SafetyBridge system inside the wall cabinet is logically connected to all pulser units. To operate the safety system, all SafetyBridge isles in all six pulser cabinets has to be online all the time. Therefore the SafetyBridge isles in the pulser cabinets are supplied by 24V from the wall cabinet (GND isolated), even a pulser unit is switched off. So, the machine stop buttons at the switched off cabinet still work. The magnet vacuum interlock is routed via the SafetyBridge system to have the fastest response time.

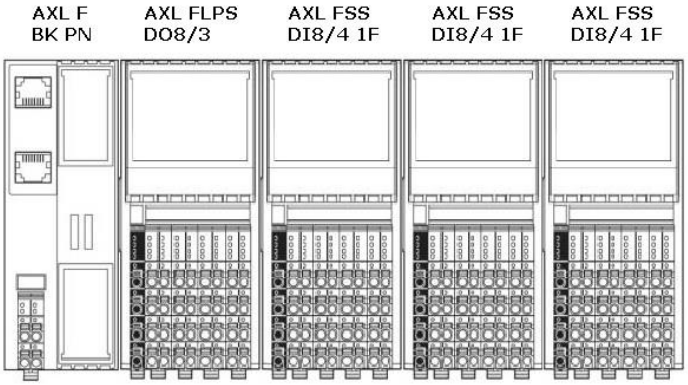


SITOP PSU100L	24V / 5A	6EP1 333-1LB00
AXL F BK PN	Bus coupler ProfiNet	2701815
AXL F LPSDO 8/3 1F	logic module 8x DO	2702171
AXL F SSDI 8/4 1F	safety input 8/4x DI	2702263
AXL F SSDI 8/4 1F	safety input 8/4x DI	2702263
AXL F SSDI 8/4 1F	safety input 8/4x DI	2702263

FDO	Oil pump 1 contactor
FDO	Oil pump 2 contactor
2FDI	Wall cabinet machine stop switch 1
2FDI	Pumping station machine stop switch 2
FDI	Oil pump contactor 1 state
FDI	Oil pump contactor 2 state
2FDI	Magnet resistor block1 position switch
2FDI	Magnet resistor block2 position switch
2FDI	Magnet resistor block3 position switch
2FDI	Magnet resistor block4 position switch
2FDI	Magnet resistor block5 position switch
2FDI	Magnet resistor block6 position switch
FDI	Vacuum interlock

1.7 Safety signals Pulser Cabinet (6x):

Safety I/O will be realized with Phoenix Contact Axioline SafetyBridge system. It's an independent safety hardware with ProfiNet interface to the S7-1500. For functionality of the machine stop buttons while a pulser unit is switched off, the SafetyBridge system is supplied by 24V from the wall cabinet (GND isolated).



SITOP PSU100L	24V / 5A	6EP1 333-1LB00
AXL F BK PN	Bus coupler ProfiNet	2701815
AXL F LPSDO 8/3 1F	logic module 8x DO	2702171
AXL F SSDI 8/4 1F	safety input 8/4x DI	2702263
AXL F SSDI 8/4 1F	safety input 8/4x DI	2702263
AXL F SSDI 8/4 1F	safety input 8/4x DI	2702263

FDO	main contactor release
FDO	HVPS + dump switches contactor
FDO	safe state indicator relay
FDO	Interlock indicator relay
FDO	HV ON
2FDI	cabinet door switch 1
2FDI	cabinet door switch 2
2FDI	cabinet door switch 3
2FDI	cabinet door switch 4
2FDI	cabinet door switch 5
2FDI	cabinet machine stop switch 1
2FDI	cabinet machine stop switch 2
FDI	Main switch state
FDI	HVPS contactor state
FDI	HV dump switch 1 state 1
FDI	HV dump switch 1 state 2
FDI	HV dump switch 2 state 1
FDI	HV dump switch 1 state 2
FDI	Safe state contactor state
FDI	Interlock contactor state
FDI	safety shutdown signal from GSI interlock system

1.8 Signals via GSI SCU drawer:

The SCU drawer is provided by GSI and contains the GSI SCU interface, the GSI timing/trigger system interface (optical), the GSI machine protection system interface (optical), the analogue interface and the GSI interlock system interface.

1.8.1 GSI SCU Interface:

D-SUB-25 SCU digital setpoint interface:

Pin	Signal	Function
1	Uint	DC+ from SCU control module
2	Out0	HVPS Uset-Bit0
3	Out1	HVPS Uset-Bit1
4	Out2	HVPS Uset-Bit2
5	Out3	HVPS Uset-Bit3
6	Out4	HVPS Uset-Bit4
7	Out5	HVPS Uset-Bit5
8	Out6	HVPS Uset-Bit6
9	Out7	HVPS Uset-Bit7
10	GND	GND from SCU control module
11	STROBE	Strobe output (signal valid)
12	GND	GND from SCU control module
13	GND	GND from SCU control module
14	Uint	DC+ from SCU control module
15	Out8	HVPS Uset-Bit8
16	Out9	HVPS Uset-Bit9
17	Out10	HVPS Uset-Bit10
18	Out11	HVPS Uset-Bit11
19	Out12	HVPS Uset-Bit12
20	Out13	HVPS Uset-Bit13
21	Out14	HVPS Uset-Bit14
22	Out15	HVPS Uset-Bit15
23	GND	GND from SCU control module
24	GND	GND from SCU control module
25	GND	GND from SCU control module

D-SUB-25 SCU digital actual value interface 1:

Pin	Signal	Function
1	Uext	DC+ from power supply A/D interface
2	In0	HVPS Umon-Bit0
3	In1	HVPS Umon-Bit1
4	In2	HVPS Umon-Bit2
5	In3	HVPS Umon-Bit3
6	In4	HVPS Umon-Bit4
7	In5	HVPS Umon-Bit5
8	In6	HVPS Umon-Bit6
9	In7	HVPS Umon-Bit7
10	EGND	GND from power supply A/D interface
11	STROBE	Strobe output (signal valid)
12	EGND	GND from power supply A/D interface
13	EGND	GND from power supply A/D interface

14	Uext	DC+ from power supply A/D interface
15	In8	HVPS Umon-Bit8
16	In9	HVPS Umon-Bit9
17	In10	HVPS Umon-Bit10
18	In11	HVPS Umon-Bit11
19	In12	HVPS Umon-Bit12
20	In13	HVPS Umon-Bit13
21	In14	HVPS Umon-Bit14
22	In15	HVPS Umon-Bit15
23	Uint	DC+ from SCU control module
24	REQUEST	Data request
25	GND	GND from SCU control module

D-SUB-25 SCU digital actual value interface 2:

Pin	Signal	Function
1	Uext	DC+ from power supply A/D interface
2	In0	HVPS Imon-Bit0
3	In1	HVPS Imon-Bit1
4	In2	HVPS Imon-Bit2
5	In3	HVPS Imon-Bit3
6	In4	HVPS Imon-Bit4
7	In5	HVPS Imon-Bit5
8	In6	HVPS Imon-Bit6
9	In7	HVPS Imon-Bit7
10	EGND	GND from power supply A/D interface
11	STROBE	Strobe input (signal valid)
12	EGND	GND from power supply A/D interface
13	EGND	GND from power supply A/D interface
14	Uext	DC+ from power supply A/D interface
15	In8	HVPS Imon-Bit8
16	In9	HVPS Imon-Bit9
17	In10	HVPS Imon-Bit10
18	In11	HVPS Imon-Bit11
19	In12	HVPS Imon-Bit12
20	In13	HVPS Imon-Bit13
21	In14	HVPS Imon-Bit14
22	In15	HVPS Imon-Bit15
23	Uint	DC+ from SCU control module
24	REQUEST	Data request
25	GND	GND from SCU control module

D-SUB-25 SCU digital input interface:

Pin	Signal	Function
1	Uext	DC+ from power supply A/D interface

2	IN1.0	PS connected (1= all interface plugs connected)
3	IN1.1	PS ready (1= ready for high voltage)
4	IN1.2	PS operation (1= high voltage on / pulsing)
5	IN1.3	PS local (1= remote control)
6	IN1.4	Group error (0= equipment summary interlock)
7	IN1.5	Line undervoltage (0= HVPS power fault)
8	IN1.6	Overload (0= HVPS overload, charging time too long)
9	IN1.7	Load fault (0= HVPS load fault, no load/open circuit)
10	EGND	GND from power supply A/D interface
11	IN1.16	Strobe input (signal valid)
12	EGND	GND from power supply A/D interface
13	EGND	GND from power supply A/D interface
14	Uext	DC+ from power supply A/D interface
15	IN1.8	End of charge (1= HVPS end of charge, actual value = set value)
16	IN1.9	Charging active (0= HVPS charge inhibit during pulse)
17	IN1.10	Warning overtemperature (0= magnet temperature warning)
18	IN1.11	Overtemperature (0= temperature summary interlock)
19	IN1.12	n.a.
20	IN1.13	Tolerance band deviation (0= any actual value out of monitor window)
21	IN1.14	Setpoint limitation (0= HV set value out of allowed window)
22	IN1.15	n.a.
23	Uint	DC+ from SCU control module
24	OUT1.0	n.a.
25	GND	GND from SCU control module

D-SUB-25 SCU digital output interface:

Pin	Signal	Function
1	Uint	DC+ from SCU control module
2	OUT2.0	CONTROL READY (0= safe shutdown of the PS)
3	OUT2.1	PS ON (1= set system in standby, thyratron heating)
4	OUT2.2	PS OFF (1= set system off, thyratron heater off)
5	OUT2.3	PS RESET (1= system reset after interlock)
6	OUT2.4	n.a.
7	OUT2.5	n.a.
8	OUT2.6	n.a.
9	OUT2.7	n.a.
10	GND	GND from SCU control module
11	OUT2.16	n.a.
12	GND	GND from SCU control module
13	GND	GND from SCU control module
14	Uint	DC+ from SCU control module
15	OUT2.8	n.a.
16	OUT2.9	n.a.
17	OUT2.10	n.a.
18	OUT2.11	n.a.
19	OUT2.12	n.a.

20	OUT2.13	n.a.
21	OUT2.14	n.a.
22	OUT2.15	n.a.
23	GND	GND from SCU control module
24	GND	GND from SCU control module
25	GND	GND from SCU control module

1.8.2 GSI Timing System:

Fibre optic 820nm, ST connector:

High voltage charge on (10µs light on pulse= HV on)

Trigger thyratron 1 (10µs light on pulse= trigger)

Trigger thyratron 2 (10µs light on pulse= trigger)

1.8.3 GSI Interlock System:

IEC 61076-2-101 M12 connector, 5 poles:

Pin	Signal	Function
1	X11	O1, Equipment summary interlock, dry contact (open= interlock)
1	X21	O2, Safe state indicator, dry contact (open= safe)
2	U+	DC+ 24V from GSI interlock system
3	X12	O1, Equipment summary interlock, dry contact (open= interlock)
4	Dig. In	I1, safety shutdown signal (0= shutdown)
5	X22	O2, Safe state indicator, dry contact (open= safe)

1.8.4 GSI Machine Protection System:

Fibre optic 820nm, ST connector:

Fast fault signal at any interlock (light off= interlock)

1.8.5 GSI analogue input card, isolated input:

Lemo connector 50 Ohm coaxial, type EPL.00.250.NTN:

Magnet current probe, +/-10V

1.9 Signals via PLC data block for GSI control system:

Remark:
MAG signals exist only one times in the system. PS1 signals are six times in the system (also for PS2 to PS6). For better overview of the table only PS1 signals are listed.

Signal	Data type	Unit / Logic
Analogue Signals		
PS1 thyratron 1 reservoir power supply U range monitor	REAL	V (Volt)
PS1 thyratron 1 reservoir U monitor	REAL	V (Volt)
PS1 thyratron 1 reservoir U upper limit monitor	REAL	V (Volt)
PS1 thyratron 1 reservoir U lower limit monitor	REAL	V (Volt)
PS1 thyratron 1 reservoir power supply I range monitor	REAL	A (Ampere)
PS1 thyratron 1 reservoir I monitor	REAL	A (Ampere)
PS1 thyratron 1 reservoir I upper limit monitor	REAL	A (Ampere)
PS1 thyratron 1 reservoir I lower limit monitor	REAL	A (Ampere)
PS1 thyratron 1 reservoir U set monitor	REAL	V (Volt)
PS1 thyratron 1 reservoir U set upper limit monitor	REAL	V (Volt)
PS1 thyratron 1 reservoir U set upper limit monitor	REAL	V (Volt)
PS1 thyratron 1 heater power supply U range monitor	REAL	V (Volt)
PS1 thyratron 1 heater U monitor	REAL	V (Volt)
PS1 thyratron 1 heater U upper limit monitor	REAL	V (Volt)
PS1 thyratron 1 heater U lower limit monitor	REAL	V (Volt)
PS1 thyratron 1 heater power supply I range monitor	REAL	A (Ampere)
PS1 thyratron 1 heater I monitor	REAL	A (Ampere)
PS1 thyratron 1 heater I upper limit monitor	REAL	A (Ampere)
PS1 thyratron 1 heater I lower limit monitor	REAL	A (Ampere)
PS1 thyratron 1 heater U set monitor	REAL	V (Volt)
PS1 thyratron 1 heater U set upper limit monitor	REAL	V (Volt)
PS1 thyratron 1 heater U set lower limit monitor	REAL	V (Volt)
PS1 thyratron 2 reservoir power supply U range monitor	REAL	V (Volt)
PS1 thyratron 2 reservoir U monitor	REAL	V (Volt)
PS1 thyratron 2 reservoir U upper limit monitor	REAL	V (Volt)
PS1 thyratron 2 reservoir U lower limit monitor	REAL	V (Volt)
PS1 thyratron 2 reservoir power supply I range monitor	REAL	A (Ampere)
PS1 thyratron 2 reservoir I monitor	REAL	A (Ampere)
PS1 thyratron 2 reservoir I upper limit monitor	REAL	A (Ampere)
PS1 thyratron 2 reservoir I lower limit monitor	REAL	A (Ampere)
PS1 thyratron 2 reservoir U set monitor	REAL	V (Volt)
PS1 thyratron 2 reservoir U set upper limit monitor	REAL	V (Volt)
PS1 thyratron 2 reservoir U set upper limit monitor	REAL	V (Volt)
PS1 thyratron 2 heater power supply U range monitor	REAL	V (Volt)
PS1 thyratron 2 heater U monitor	REAL	V (Volt)
PS1 thyratron 2 heater U upper limit monitor	REAL	V (Volt)
PS1 thyratron 2 heater U lower limit monitor	REAL	V (Volt)
PS1 thyratron 2 heater power supply I range monitor	REAL	A (Ampere)

PS1 thyratron 2 heater I monitor	REAL	A (Ampere)
PS1 thyratron 2 heater I upper limit monitor	REAL	A (Ampere)
PS1 thyratron 2 heater I lower limit monitor	REAL	A (Ampere)
PS1 thyratron 2 heater U set monitor	REAL	V (Volt)
PS1 thyratron 2 heater U set upper limit monitor	REAL	V (Volt)
PS1 thyratron 2 heater U set lower limit monitor	REAL	V (Volt)
PS1 HVPS U monitor	REAL	V (Volt)
PS1 HVPS I monitor	REAL	A (Ampere)
PS1 HVPS U set monitor	REAL	V (Volt)
PS1 tank 1 oil temperature measurement range monitor	REAL	°C (Centigrade)
PS1 tank 1 oil temperature warning level monitor	REAL	°C (Centigrade)
PS1 tank 1 oil temperature interlock level monitor	REAL	°C (Centigrade)
PS1 tank 1 oil temperature monitor	REAL	°C (Centigrade)
PS1 tank 2 oil temperature measurement range monitor	REAL	°C (Centigrade)
PS1 tank 2 oil temperature warning level monitor	REAL	°C (Centigrade)
PS1 tank 2 oil temperature interlock level monitor	REAL	°C (Centigrade)
PS1 tank 2 oil temperature monitor	REAL	°C (Centigrade)
INT state indicators		
PS1 thyratron 1 preheating time minute set value	INT	min (Minute)
PS1 thyratron 1 preheating remaining minutes	INT	min (Minute)
PS1 thyratron 1 preheating remaining seconds	INT	sec (Second)
PS1 thyratron 2 preheating time minute set value	INT	min (Minute)
PS1 thyratron 2 preheating remaining minutes	INT	min (Minute)
PS1 thyratron 2 preheating remaining seconds	INT	sec (Second)
PS1 system state	INT	0=OFF 1=HEATER RAMP UP 2=PREHEATING 3=HEATING READY 4=HVPS READY 5=HV ON
ALARM, STATE and SET signals, which inhibit operation		
MAG oil temperature under alarm level	BOOL	0=INTERLOCK
MAG oil pump A running	BOOL	1=RUNNING
MAG oil pump B running	BOOL	1=RUNNING
MAG oil flow okay	BOOL	0=INTERLOCK
MAG resistor block 1 in place	BOOL	0=INTERLOCK
MAG resistor block 2 in place	BOOL	0=INTERLOCK
MAG resistor block 3 in place	BOOL	0=INTERLOCK
MAG resistor block 4 in place	BOOL	0=INTERLOCK
MAG resistor block 5 in place	BOOL	0=INTERLOCK
MAG resistor block 6 in place	BOOL	0=INTERLOCK
MAG vacuum okay	BOOL	0=INTERLOCK
PS1 thyratron 1 reservoir voltage lower then upper limit	BOOL	0=INTERLOCK
PS1 thyratron 1 reservoir voltage higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 1 reservoir current lower then upper limit	BOOL	0=INTERLOCK
PS1 thyratron 1 reservoir current higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 1 heater voltage lower then upper limit	BOOL	0=INTERLOCK
PS1 thyratron 1 heater voltage higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 1 heater current lower then upper limit	BOOL	0=INTERLOCK

PS1 thyratron 1 heater current higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 1 PS + THT ON	BOOL	1=ON
PS1 thyratron 1 heater ready	BOOL	1=READY
PS1 thyratron 2 reservoir voltage lower then upper limit	BOOL	0=INTERLOCK
PS1 thyratron 2 reservoir voltage higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 2 reservoir current lower then upper limit	BOOL	0=INTERLOCK
PS1 thyratron 2 reservoir current higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 2 heater voltage lower then upper limit	BOOL	0=INTERLOCK
PS1 thyratron 2 heater voltage higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 2 heater current lower then upper limit	BOOL	0=INTERLOCK
PS1 thyratron 2 heater current higher then lower limit	BOOL	0=INTERLOCK
PS1 thyratron 2 PS + THT ON	BOOL	1=ON
PS1 thyratron 2 heater ready	BOOL	1=READY
PS1 HVPS control set on	BOOL	1=ON
PS1 HVPS set on	BOOL	1=ON
PS1 HVPS ready	BOOL	1=READY
PS1 HVPS HV on	BOOL	1=ON
PS1 HVPS temperature okay	BOOL	0=INTERLOCK
PS1 HVPS load without fault	BOOL	0=INTERLOCK
PS1 HVPS load under limit	BOOL	0=INTERLOCK
PS1 HVPS power okay	BOOL	0=INTERLOCK
PS1 HVPS contactor 1+2 closed	BOOL	1=CLOSED
PS1 HVPS contactor 1+2 set on	BOOL	1=ON
PS1 HVPS contactors okay	BOOL	0=INTERLOCK
PS1 cabinet door 1 closed	BOOL	0=INTERLOCK
PS1 cabinet door 2 closed	BOOL	0=INTERLOCK
PS1 cabinet door 3 closed	BOOL	0=INTERLOCK
PS1 cabinet door 4 closed	BOOL	0=INTERLOCK
PS1 cabinet door 5 closed	BOOL	0=INTERLOCK
PS1 cabinet earthing rod position switch 1 in park position	BOOL	0=INTERLOCK
PS1 cabinet earthing rod position switch 2 in park position	BOOL	0=INTERLOCK
PS1 cabinet earthing rod position switch 3 in park position	BOOL	0=INTERLOCK
PS1 cabinet earthing rod position switch 4 in park position	BOOL	0=INTERLOCK
PS1 cabinet HV dump switch 1 okay	BOOL	0=INTERLOCK
PS1 cabinet HV dump switch 2 okay	BOOL	0=INTERLOCK
PS1 cabinet HV dump switch 1 set on	BOOL	1=ON
PS1 cabinet HV dump switch 2 set on	BOOL	1=ON
PS1 cabinet HV dump switch 1 open	BOOL	1=OPEN
PS1 cabinet HV dump switch 2 open	BOOL	1=OPEN
PS1 cabinet machine stop switch 1 not pressed	BOOL	0=INTERLOCK
PS1 cabinet machine stop switch 2 nor pressed	BOOL	0=INTERLOCK
PS1 main power switch released	BOOL	0=INTERLOCK
PS1 oil pump on	BOOL	1=ON
PS1 oil level tank 1 okay	BOOL	0=INTERLOCK
PS1 oil level tank 2 okay	BOOL	0=INTERLOCK
PS1 tank 1 oil temperature okay	BOOL	0=INTERLOCK
PS1 tank 2 oil temperature okay	BOOL	0=INTERLOCK

PS1 no safety shutdown signal from GSI interlock system	BOOL	0=INTERLOCK
PS1 no summary interlock	BOOL	0=INTERLOCK
PS1 system ready	BOOL	1=READY
PS1 not in safe state	BOOL	0=SAFE STATE
PS1 safe state contactor okay	BOOL	0=INTERLOCK
PS1 control ready monitor	BOOL	1=READY
PS1 PS ON monitor	BOOL	1=ON
PS1 PS NOT OFF monitor	BOOL	1=NOT OFF
PS1 ADC input interface plug connected	BOOL	0=INTERLOCK
PS1 ADC output interface plug connected	BOOL	0=INTERLOCK
PS1 ADC SCU digital actual value interface plug 1 connected	BOOL	0=INTERLOCK
PS1 ADC SCU digital actual value interface plug 2 connected	BOOL	0=INTERLOCK
PS1 ADC SCU digital input interface plug connected	BOOL	0=INTERLOCK
PS1 ADC SCU digital output interface plug connected	BOOL	0=INTERLOCK
PS1 ADC SCU digital set point interface plug connected	BOOL	0=INTERLOCK
STATE and WARNINGS, without inhibit operation		
MAG oil temperature warning	BOOL	0=WARNING
PS1 thyratron 1 heater ramp up	BOOL	1=RAMP FINISHED
PS1 thyratron 1 heater preheating	BOOL	1=HEATING READY
PS1 thyratron 2 heater ramp up	BOOL	1=RAMP FINISHED
PS1 thyratron 2 heater preheating	BOOL	1=HEATING READY
PS1 HVPS end of charge	BOOL	1=EOC
PS1 HVPS charge inhibit	BOOL	0=INHIBIT
PS1 cabinet fans on	BOOL	1=ON
PS1 tank 1 oil temperature warning	BOOL	0=WARNING
PS1 tank 2 oil temperature warning	BOOL	0=WARNING
PS1 reset (positive edge controlled, 1s high signal)	BOOL	1=RESET
PS1 local	BOOL	1=REMOTE
PS1 cabinet signal lamp „heater on“, orange	BOOL	1=HEATER ON
PS1 cabinet signal lamp „high voltage“, red	BOOL	1=HIGH VOLTAGE
PS1 cabinet signal lamp „off“, green	BOOL	1=OFF

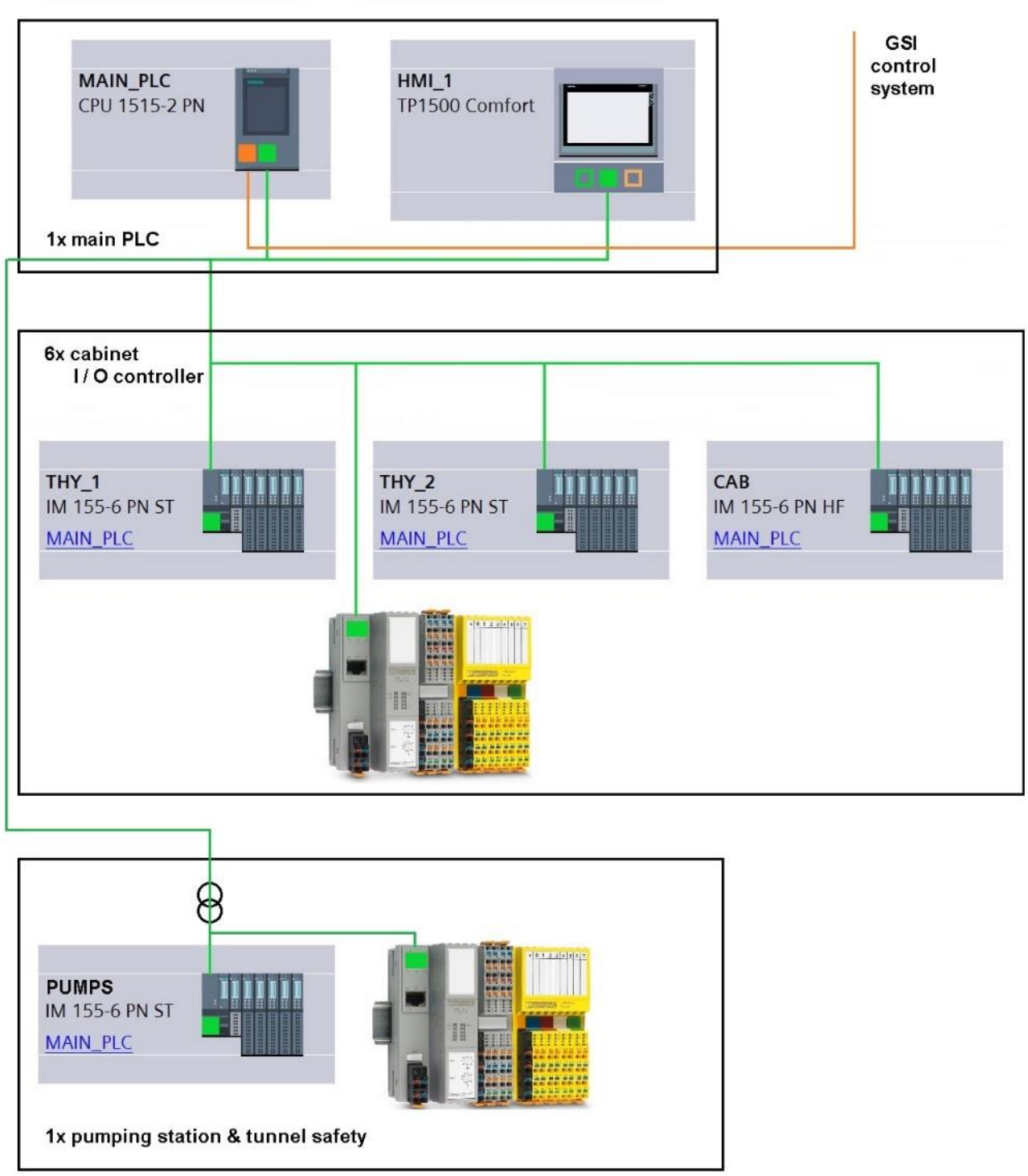
2 HMI

The HMI display program is based on the General Ampegon GUI description [1]. The display controls all six power supplies and is located in the main CPU cabinet.

3 Network

The main CPU has two separated network ports. One is for the connection to the GSI control net to access the data block described in 1.9. From this port is no access to the second network possible.

The second network port is the ProfiNet to the I/O interfaces and safety controls in each cabinet and the HMI display.
The network has a star topology with main CPU as base. Each cabinet is connected via fibre optic ProfiNet connections. So it's possible to run the cabinets independent and single cabinets can be switched off.



A more detail control block diagram is mapped in [2].

4 Grounding Concept

To reduce interferences resulting of ground loops, the ground of tunnel and cabinet is separated. Shield of shielded cables is connected only in the cabinets. In the tunnel, it ends without connection to avoid transport of interferences from tunnel to cabinets.

The digital signals from the magnet are two wire signals without ground connection. They are connected via a shielded multicore cable to the main CPU cabinet. The shield is only connected to the cabinet. In the tunnel, it's open and not connected.

The safety knot for the magnet interlocks and the I/O knot for the pumping station is in the main wall cabinet, but its ground is separated and the network connection is isolated.

The current transformers at the magnets are connected by triaxial cables (e.g. Belden 9222) directly to the isolated input of the analogue card in the SCU unit in the power supply cabinets. The transformer output is isolated, too. The inner conductor and the inner shield of the triaxial cable used as coaxial connection between current probe and analogue card. The outer shield is connected to the power supply cabinet. Inside the tunnel, it's open and not connected.

5 References

[1] R. Burek, *130023-0028-v1.0 General Ampegon GUI description,* Ampegon PPT GmbH, 2014.

[2] T. Pfeiffer, *130023-0027v0.1 Control Block Diagram,* Ampegon PPT GmbH, 2016.