Step-by-Step Guide to Setting up the Measurement Installation

MANUAL

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Introduction

This manual contains information on how the measurement data acquisition system was installed in November 2021. This measurement concept intended to replace some existing devices with newer, more suitable alternatives to increase system robustness; however, it did not introduce new functionalities. Once the concept was established, and the prototype was made, the associated hardware and software ran in parallel (for two days) with the system that had existed prior. This was done to ensure that the new installation has recorded measurements that align with the old ones.

Contents

1 Step 1: Acquire Hardware

1.1 Campbell's CR1000 Datalogger

The installation uses Campbell's CR1000 datalogger (see figure 1). CR1000 supports Modbus, which is the communication protocol that will be used.

A USB to serial RS232 converter can connect the logger to the pc (see figure 2). An extension cable might also be needed for the converter.

The manual for Campbell's CR1000 datalogger can be accessed at:

file://bfh.ch/data/TI/eit/50_Labore/T025a-LZPV/Lzpv/Anlagen/Tiergarten_SoLab60/12_DatenLogger/Hannah's_Data_Logger_Project/Datalogger/cr1000_manual.pdf

Figure 1: Campbell's CR1000 Datalogger

Figure 2: USB to serial RS232 converter

1.2 FS1701 Analogue to Digital Converter

The analogue to digital signal converters can connect standard analogue signals (voltage or current) to the Modbus system (see figure 3). The device can simultaneously process up to 8 inputs (4-20mA or 0-10 V) and make them available via the Modbus RTU protocol.

The operating manual for FS1701 can be accessed at: file://bfh.ch/data/TI/eit/50_Labore/T025a-LZPV/Lzpv/Anlagen/Tiergarten_SoLab60/12_DatenLogger/Hannah's_Data_Logger_Project/FS1701/bedienungsanleitung_operating_manual_fs1701.pdf

Figure 3: FS1701 Analogue to Digital Converter

1.3 Power Supplies

The following TRACO POWER power supply components are needed:

- TSP 090–124 Din Rail 24 VDC Power Supply (see figure 4) used to supply power to the Modbus.

> Information on this Power Supply can be accessed on the TSP Series datasheet: file://bfh.ch/data/TI/eit/50_Labore/T025a-LZPV/Lzpv/Anlagen/Tiergarten_SoLab60/12_DatenLogger/Hannah's_Data_Logger_Project/Power%20Supply/tracopower-tsp-090-124.pdf

- TSP–BCM24 Battery Controller Module (see figure 5) manages the connected battery that will be charged and held in charged mode by the power supply. In case of a mains power failure, the battery will supply the output power until the battery is discharged. As a consequence, the output voltage of the system is equivalent to the battery voltage.

> Information on the Battery Controller Module can be accessed on page 8 of the TSP Series datasheet: file://bfh.ch/data/TI/eit/50_Labore/T025a-LZPV/Lzpv/Anlagen/Tiergarten_SoLab60/12_DatenLogger/Hannah's_Data_Logger_Project/Power%20Supply/tracopower-tsp-090-124.pdf

- TCL 024-112 DC TRACO POWER 12V DC/DC converter (see figure 6) used to supply power to the datalogger and the Moxa.

> Information on this Power Supply can be accessed on this datasheet: file://bfh.ch/data/TI/eit/50_Labore/T025a-LZPV/Lzpv/Anlagen/Tiergarten_SoLab60/12_DatenLogger/Hannah's_Data_Logger_Project/Power%20Supply/12V%20DC%20to%20DC%20converter.pdf

Figure 4: TSP 090–124 Din Rail 24 VDC Power Supply

Figure 5: SP–BCM24 Battery Controller Module

Figure 6: DC TRACOPOWER 12V DC/DC converter

1.4 SINEAX DM5F

SINEAX DM5F is a programmable heavy current transducer (see figure 7). Like the FS1701, DM5F is essentially an analogue to the digital signal converter. It can connect standard analogue signals (voltage or current) to the Modbus system. The device can process up to 6 inputs simultaneously and make them available via the Modbus RTU protocol. For example, it can also calculate the system's Reactive power and make it available via Modbus.

The device also comes with a USB cable (see figure 8) used to connect to the PC for programming.

Figure 7: SINEAX DM5F

Figure 8: SINEAX DM5 USB

The SINEAX DM5 manual along with other useful documentation can be accessed in this folder: \\bfh.ch\data\TI\eit\50_Labore\T025a-LZPV\Lzpv\Anlagen\Tiergarten_SoLab60\12_Daten Logger\Hannah's_Data_Logger_Project\camillebauer\Documentation

1.5 Moxa-tcc-80

The Moxa TCC-80/80I Series (see figure 9) provides Port-powered RS-232 to RS-422/485 converters.

A serial port terminal connector connects to the DB9 female socket (see figure 10).

Additionally, a connector cable had to be manually assembled to plug into the power socket of the Moxa (see figure 11). Pre-made USB power cords exist that fit the Moxa, but it is not possible to connect them to the power supply we are using. However, it is possible to dismantle the USB power cord by cutting the USB connector to expose two wires that can then be stripped and connected to the power supply.

The datasheet for the Moxa TCC-80/80I Series can be accessed at: file://bfh.ch/data/TI/eit/50_Labore/T025a-LZPV/Lzpv/Anlagen/Tiergarten_SoLab60/12_DatenLogger/Hannah's_Data_Logger_Project/Moxa/moxa-tcc-80.pdf

Figure 9: Moxa TCC-80/80I Series

Figure 10: Serial port terminal connector

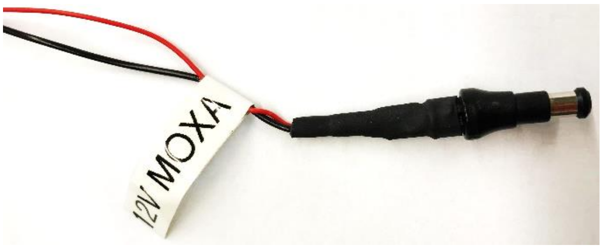

Figure 11: Serial port terminal connector

2 Step 2: Download Software

2.1 LoggerNet

LoggerNet is Campbell's data logger support software package. It supports programming, communication, and data retrieval between data loggers and a PC.

When first opened, LoggerNet displays a full view of the Toolbar (see figure 12). 'Device Config Utility' is selected to access the DevConfig window (see figure 13). After choosing the device CR1000, on the left panel, you will have a list of the serial ports (COM1, COM2, etc.) installed on your PC. Select the highest baud rate option (115200) and assuming you have the data logger connected to the PC, you can establish a connection by pressing *Direct* then *connect*.

Figure 12: LoggerNet Toolbar

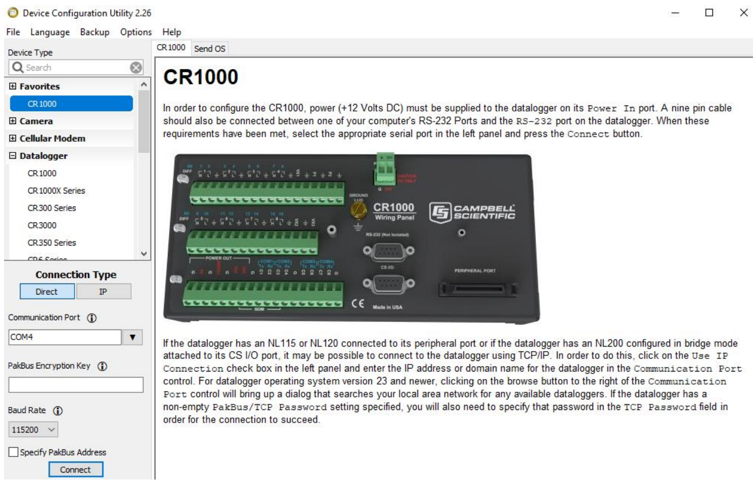

Figure 13: Device configure utility

The required software to download LoggerNet is found in this folder:

[\\bfh.ch\data\TI\eit\50_Labore\T016-Photovoltaik_1\03_Informatik\02_Software\07_MessenLoggenErfassen\Campbell\Campbell\CD_Loggernet-V4\upgradeLoggerNet4.7]()

Registration information:

Username: PV-Lab
Company: BFH
CD Key: LGRNET-A4FC-JWABR4BHPKKYGAEZ

The LoggerNet manual can be found here: [file://bfh.ch/data/TI/eit/50_Labore/T016-Photovoltaik_1/03_Informatik/02_Software/07_MessenLoggenErfassen/Campbell/CD_Loggernet-V4/Manual/loggernet.pdf]()

2.2 CB-Manager

The CB-Manager is a configuration and commissioning software for various devices of the Camille Bauer portfolio. The user can select during installation which product series needs to be supported. The homepage of the CB-Manager application is shown in figure 14.

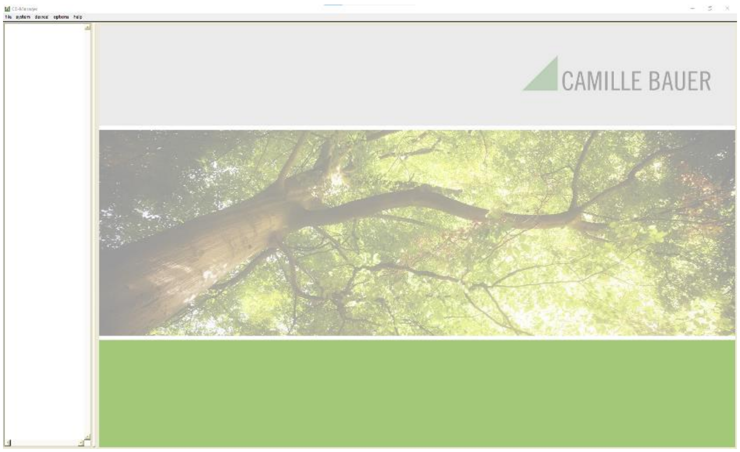

Figure 14: CB-Manager Application

The software can be downloaded from this folder:

\\bfh.ch\data\TI\eit\50_Labore\T025a-LZPV\Lzpv\Anlagen\Tiergarten_SoLab60\12_DatenLogger\Hannah's_Data_Logger_Project\camillebauer\CB-Manager\cb-manager software

The manual is also available in the same folder, in English and German.

3 Step 3: Connect Devices

3.1 Overall system block diagram

The block diagram shows the data paths and the functions that manipulate the signals in the system (see figure 15). Each block is labelled in its function without specifying individual electrical components that make up the block. This diagram is useful for understanding device relationships, but the detailed connection will be discussed in the next two sections.

The CR1000 datalogger is the master. DM5F and FS1701 are the logger's slaves; consequently, they are each given a unique address (DM5F's address is 1 and FS1701's address is 2). Six analogue signals are inputted to the DM5, and eight are inputted to the FS1701. These analogue signals are the signals we want to measure from our PV installation. DM5F and FS1701 both take the analogue signals and, upon the master's request, output them using RS485 two wire standard, following the Modbus communication protocol. The CR1000 datalogger sends and receives using the RS232 standard; therefore, the Moxa is used to convert RS232 to RS485 (and vice versa), so the CR1000 can communicate with the DM5F and FS1701.

Six analogue signals are directly inputted to the datalogger's analogue input terminals.

The DM5F and FS1701 are powered by 24 volts DC, the datalogger and the Moxa are powered by 12 volts DC. An additional 24 volts (two 12-volt batteries in series) is fed into the battery management system to prevent any interruptions to the measurements in the event of a power cut.

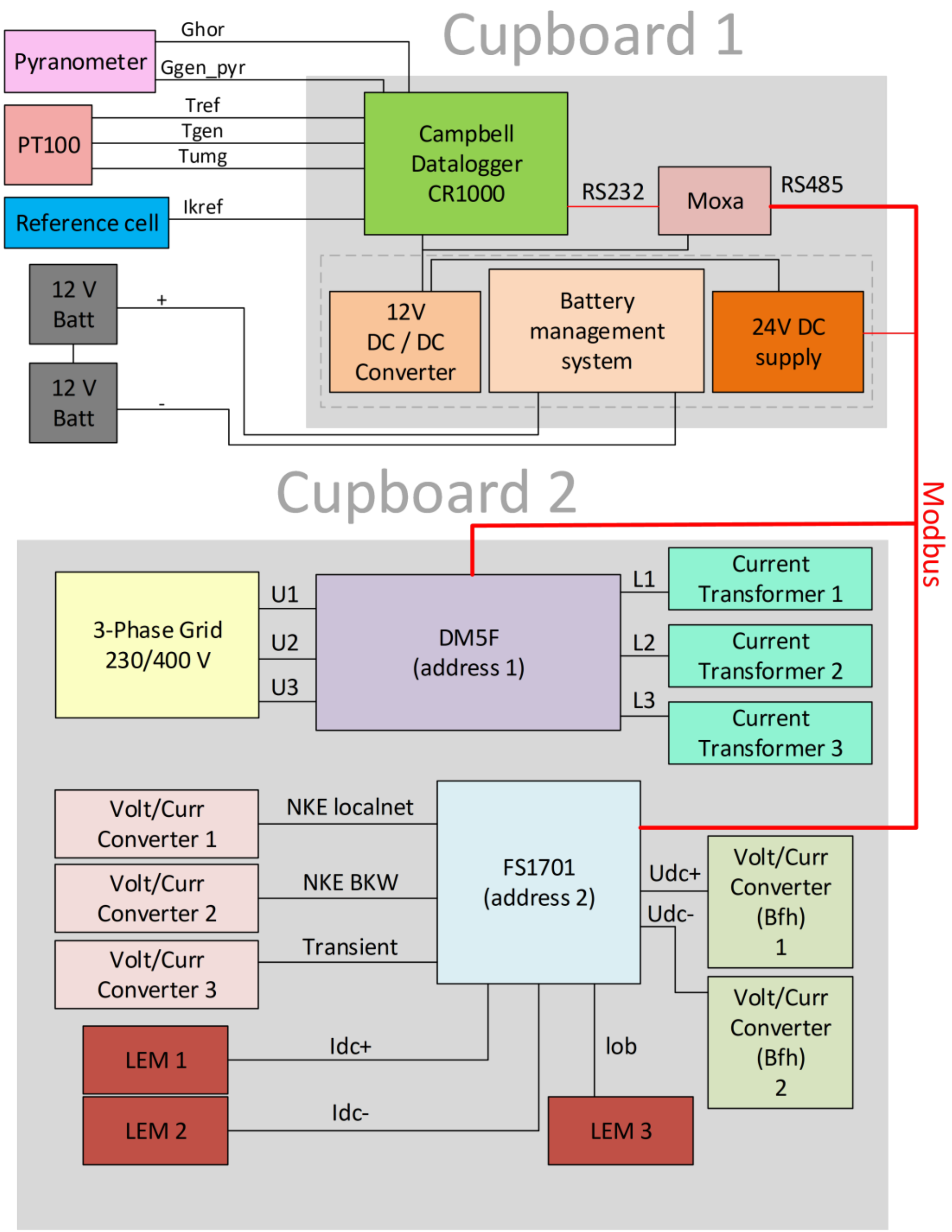

Figure 15: Overall system block diagram

3.2 Full System Schematic

The overall system schematic is shown in figure 16. The schematic exhibits the significant devices used in the system, i.e., the CR1000 datalogger, DM5 and the FS1701. The schematic also shows which pins (on each device) are used to connect each input.

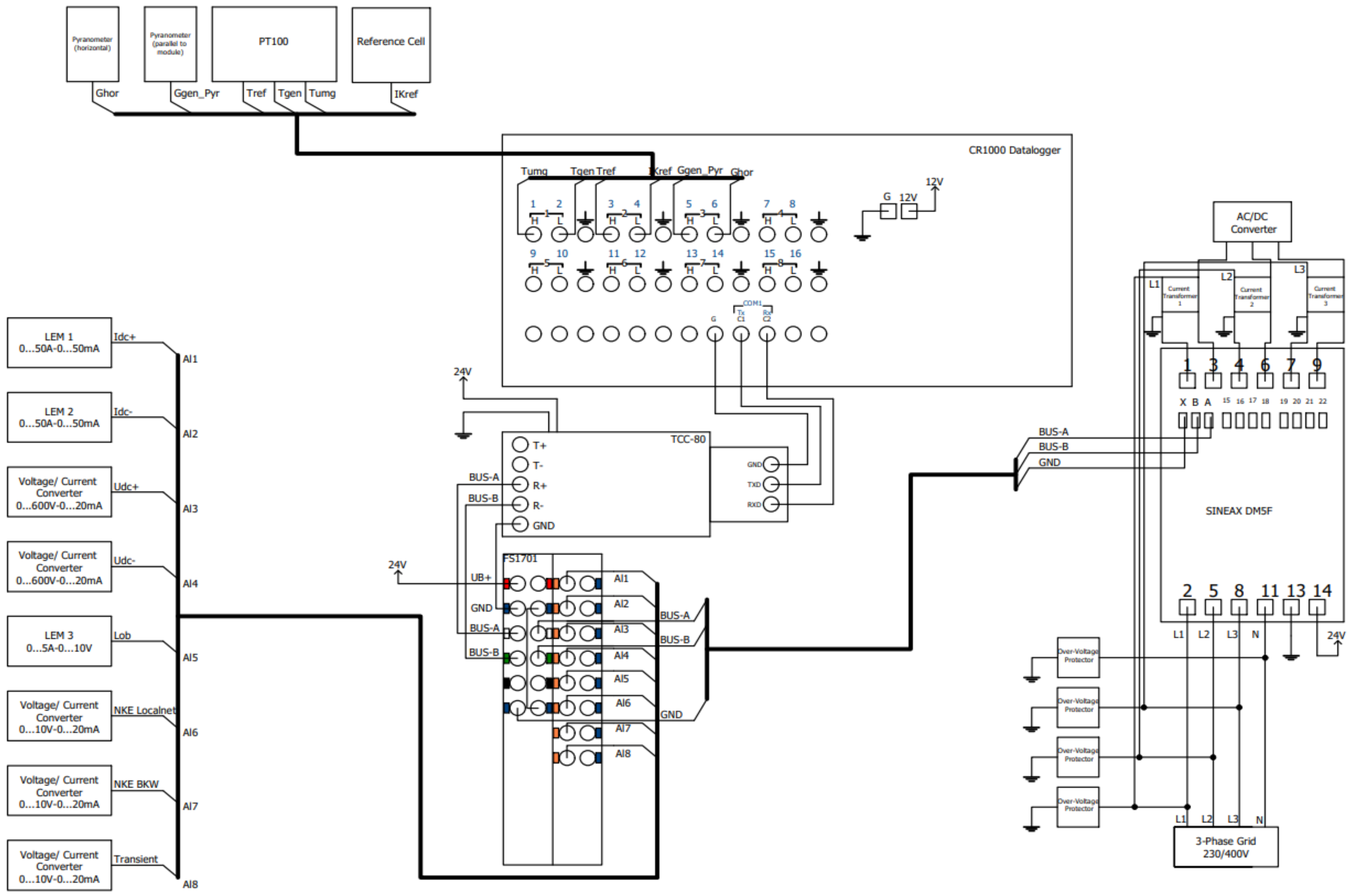

Figure 16: Overall system schematic

3.3 Connect CR1000 to the FS1701 via Moxa

Figure 17 shows the connection diagram for the CR1000, FS1701 and the Moxa. The FS1701 is powered by 12V, where the positive end is connected to the pin UB+. The two ground pins can be linked to ease access. FS1701 connects to the Moxa by three wires: a wire connects BUS-A (on the FS1701) to R+ (on the Moxa), the second wire connects BUS-B to R- and the third wire connects the ground pin of the FS1701 to that of Moxa. Note that the same ground pin of the Moxa should be connected to the 0V terminal. The Moxa Tx's output side is connected to the Tx pin of com1 on the datalogger, Rx is connected to the Rx terminal of com1 on the datalogger, and the GND is connected to the ground on the logger. Note, it doesn't make a difference which communication port is used so long as it is consistent with the programming, which will be discussed later. The data logger is connected to the PC via a USB to serial RS232 converter cable. 12V DC is used to power the logger.

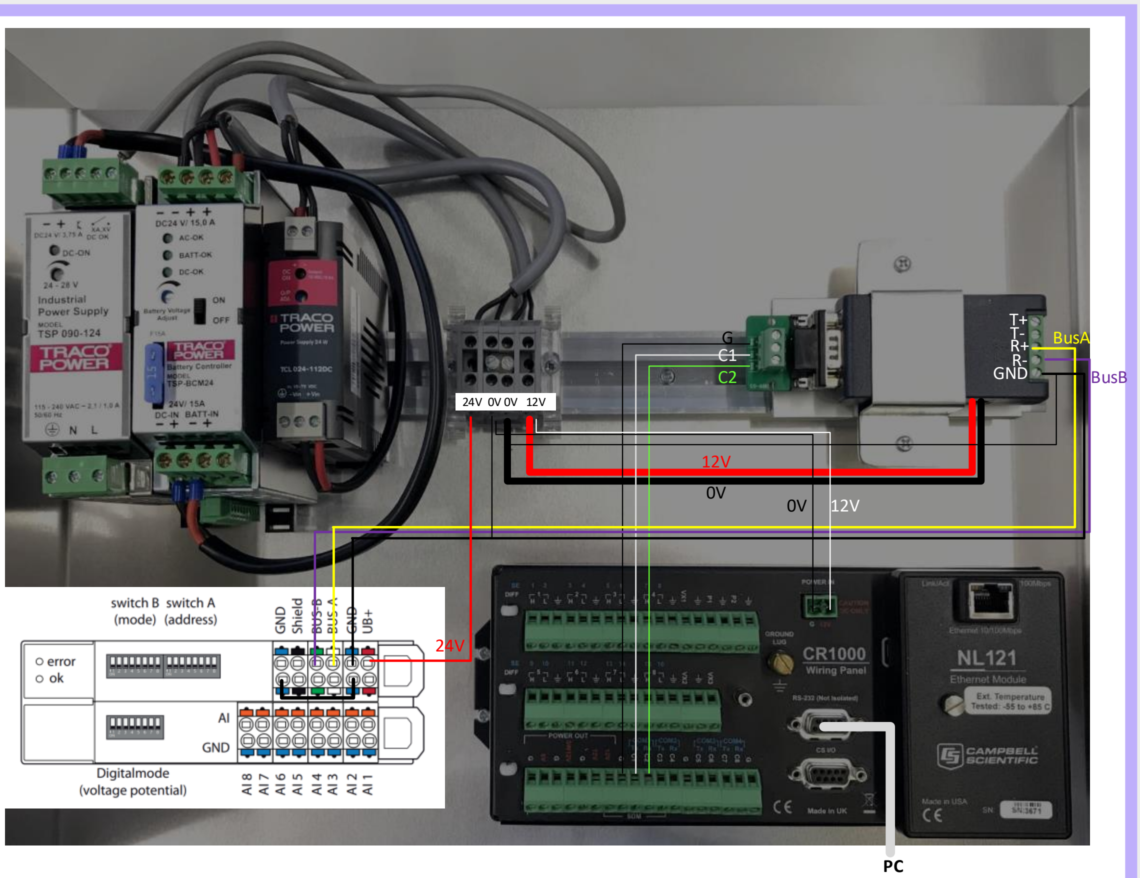

Figure 17: Connection diagram of datalogger, FS1701 and the Moxa

Note, on the physical installation, the DM5 and FS1701 are placed in a different cupboard to the datalogger, unlike what is shown in the diagrams.

3.4 Connect inputs to DM5

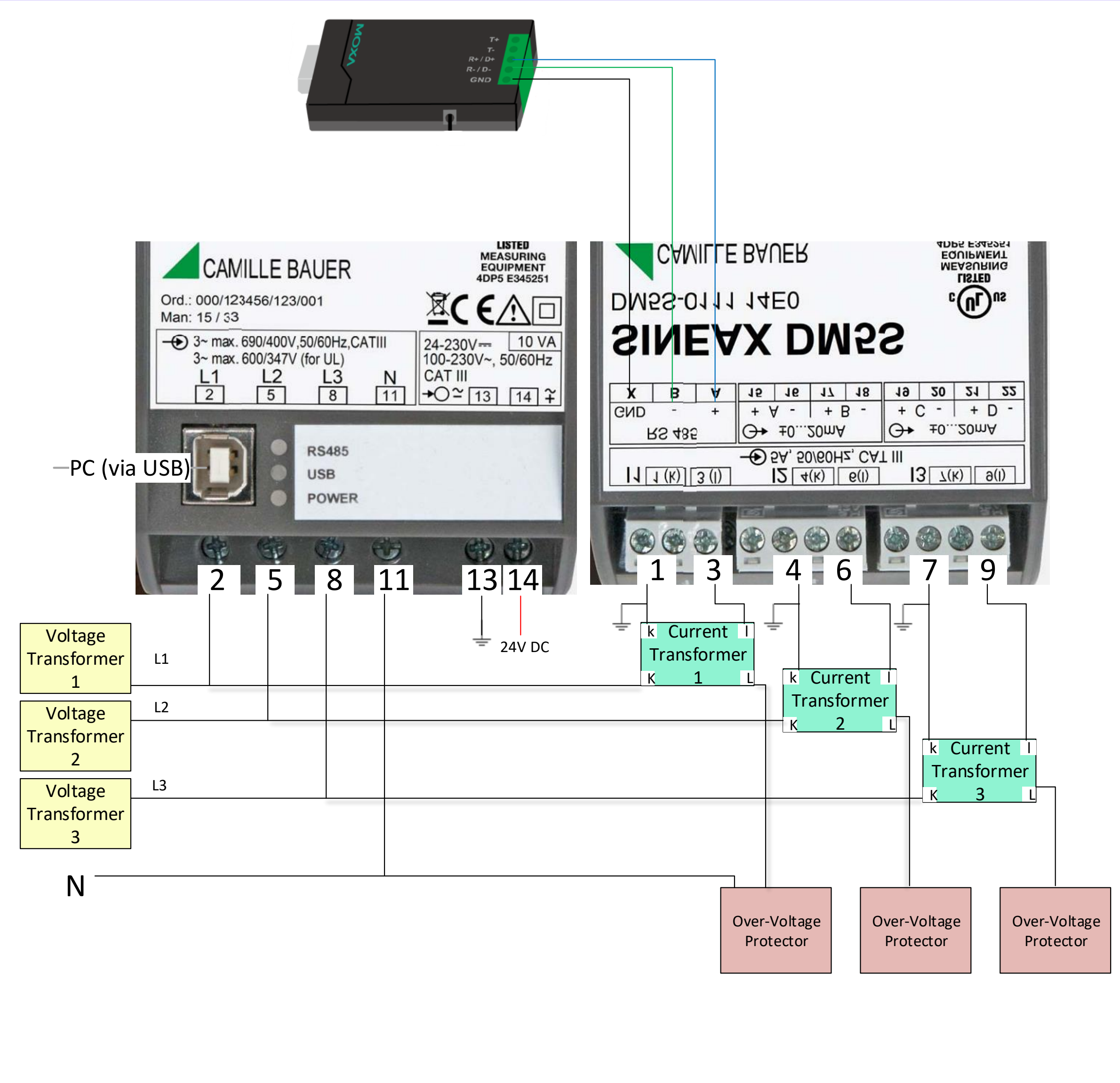

Figure 18: Connection Diagram for inputs to the DM5F

The inputs to the DM5 are connected via a four-wire system, unbalanced load with a current transformer (see figure 18). The configuration is also shown on page 21 of SINEAX's Device handbook.

The SINEAX device handbook can be found here:

file://bfh.ch/data/TI/eit/50_Labore/T025a-LZPV/Lzpv/Anlagen/Tiergarten_SoLab60/12_DatenLogger/Hannah's_Data_Logger_Project/camillebauer/Documentation/Operating%20Instructions.pdf

4 Step 4: Program Devices

The DM5, FS1701 and the CR1000 must be programmed separately. The programming of the CR1000 will not be discussed in this report as it is written on the CRbasic editor. However, the code is commented and can be found here:

\\bfh.ch\data\TI\eit\50_Labore\T025a-LZPV\Lzpv\Anlagen\Tiergarten_SoLab60\12_DatenLogger\Hannah's_Data_Logger_Project\Datalogger\CRbasic_Programs\Logging_DM5+FS1701_ver8a_Gvolt+DClong

4.1 Programming the DM5

The DM5 is programmed on the CB-Manager. After the software has been started for the first time, some important settings must be made. The settings are automatically stored as the program is terminated and are available when the program is started the next time.

Plug the DM5 into the PC using a USB interface; consequently, select 'USB (DM5S)' as an interface in the *options menu* (see figure 19).

The next step is the recognition of the devices connected to the interface. Select "Search devices" in the *system* menu (see figure 20). The PC software now searches all attached devices.

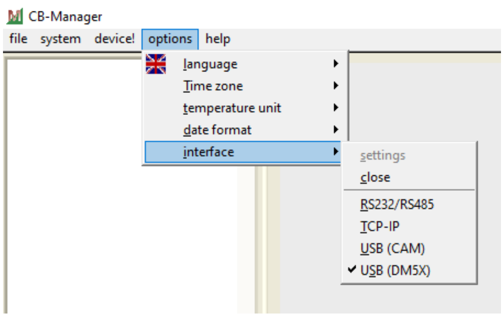

Figure 19: Selecting USB (DM5X) as an interface

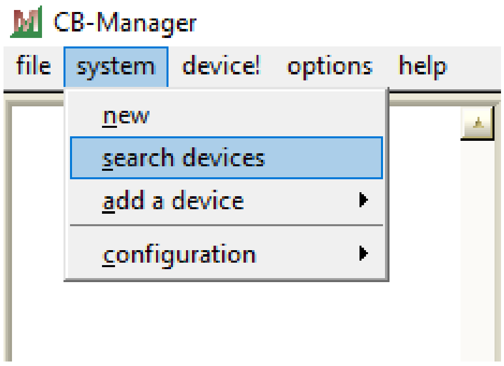

Figure 20: Search for devices conncted to the PC

Double-click with the left mouse button and the PC software will read and display the device's configuration on the screen (see figure 21). The first parameter display shows the device settings concerning Modbus communication and the hardware device information. Note, the address of the DM5 is set 1, and the baud rate is 9600.

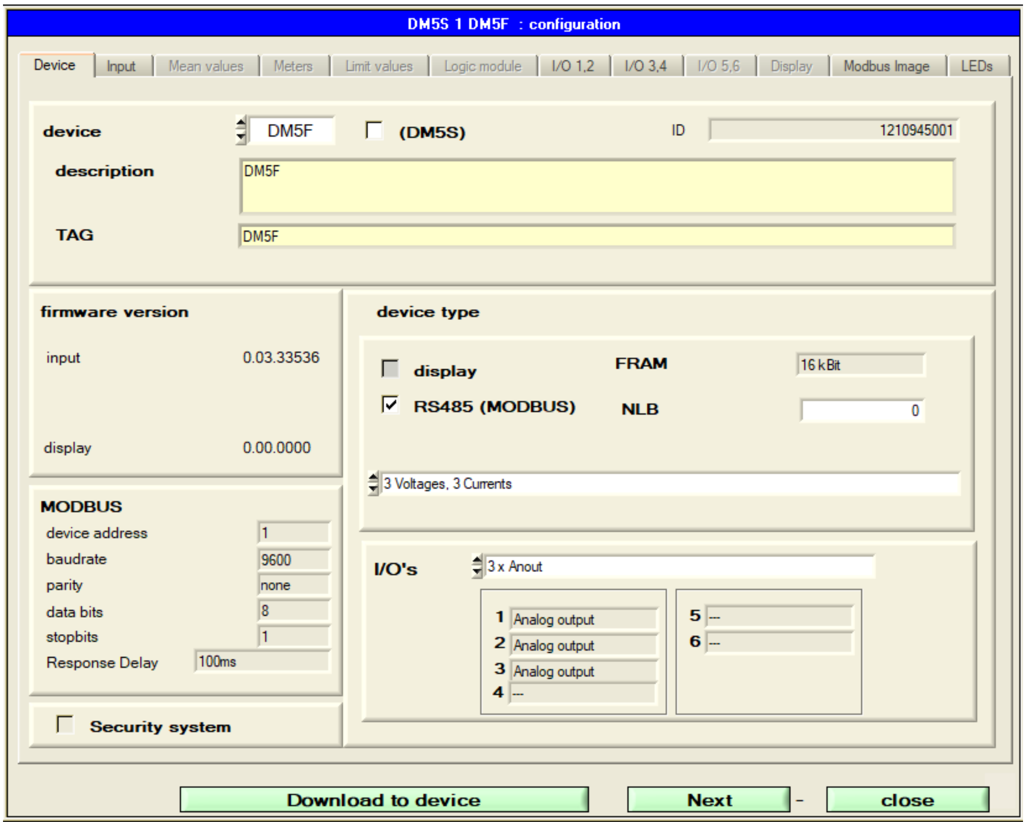

Figure 21: Device Configuration

Secondary and primary values for the voltage and current inputs have been selected (see figure 22).

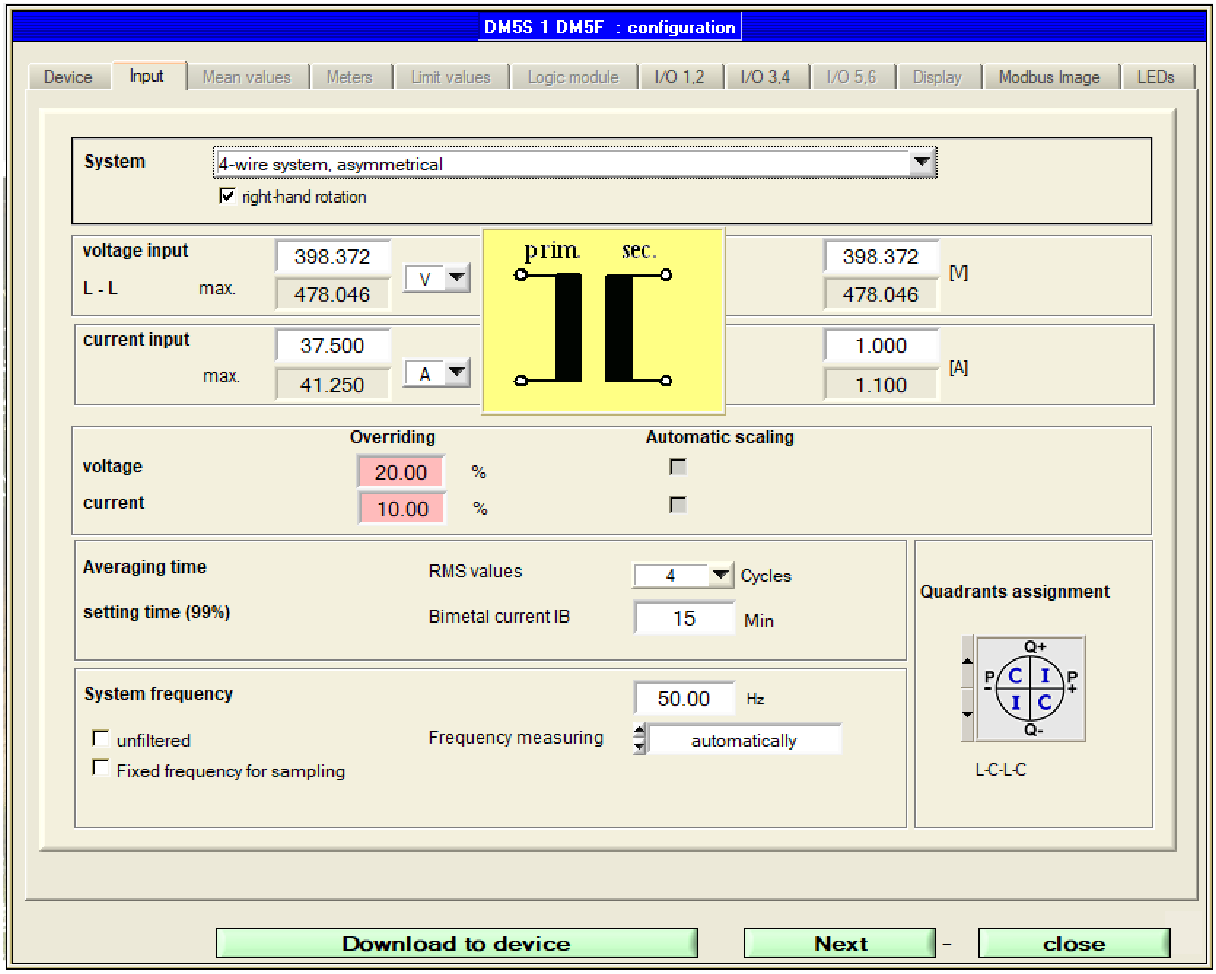

Figure 22: Measurement input

Figure 23 shows the Modbus image that has been set for the Dm5F. Theoretically, up to 60 values may be arranged in a free sequence on the register addresses 40700-40819. All of these values are floating-point values, which allocate 2 registers per value.

Table 1 shows all the measured quantities used in the DM5—figure 23 shows all the quantities needed for this installation.

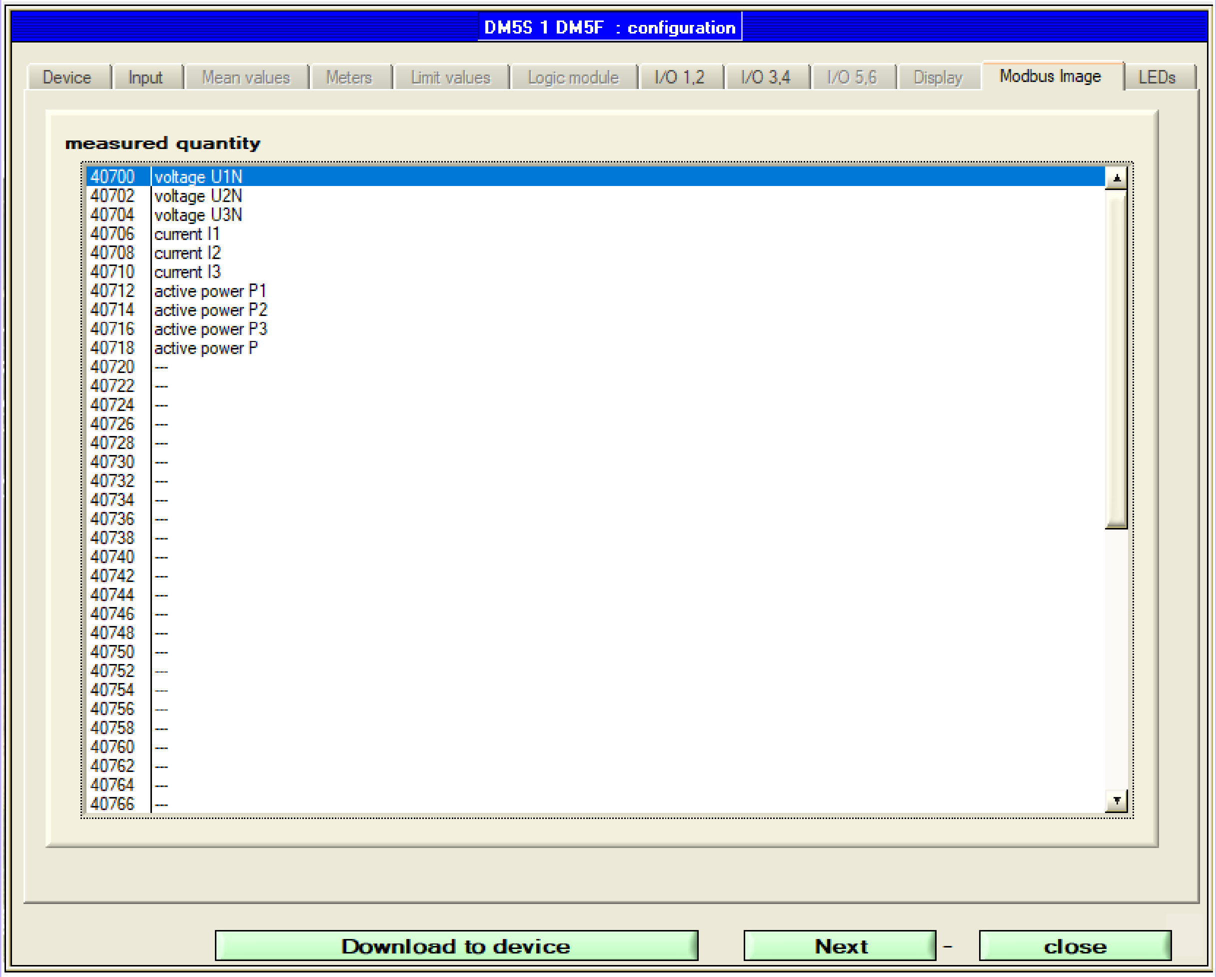

Figure 23: Modbus image

Name	Description
U	Voltage system in single, 3- or 4-wire systems
U1N	Voltage between phase L1 and neutral
U2N	Voltage between phase L2 and neutral
U3N	Voltage between phase L3 and neutral
U12	Voltage between phases L1 and L2
U23	Voltage between phases L2 and L3
U31	Voltage between phases L3 and L1
UNE	Zero displacement voltage 4-wire systems
I	Current system in single, 3- or 4-wire systems
I1	Current phase L1
I2	Current phase L2
I3	Current phase L3
IN	Neutral current
P	Active power system (P=P1+P2+P3)
P1	Active power phase L1
P2	Active power phase L2
P3	Active power phase L3
Q	Reactive power system (Q=Q1+Q2+Q3)
Q1	Reactive power phase L1
Q2	Reactive power phase L2
Q3	Reactive power phase L3
S	Apparent power system
S1	Apparent power phase L1
S2	Apparent power phase L2
S3	Apparent power phase L3
F	System frequency
PF	Active power factor P/S, system
PF1	Active power factor P1/S1, phase 1
PF2	Active power factor P2/S2, phase 2
PF3	Active power factor P3/S3, phase 3
QF	Reactive power factor P/S, system
QF1	Reactive power factor P1/S1, phase 1
QF2	Reactive power factor P2/S2, phase 2
QF3	Reactive power factor P3/S3, phase 3
LF	Load factor system, sign(Q)×(1 – abs(PF)
LF1	Load factor phase L1
LF2	Load factor phase L2
LF3	Load factor phase L3
UM	Average voltage (U1N+U2N+U3N)/3
IM	Average current (I1+I2+I3)/3
IMS	Average current with sign of P
IB	Current damped, balanced system (bimetal)
IB1	Current damped phase L1 (bimetal)
IB2	Current damped phase L2 (bimetal)
IB3	Current damped phase L3 (bimetal)
BS	Slave pointer IB
BS1	Slave pointer IB1
BS2	Slave pointer IB2
BS3	Slave pointer IB3

Table 1: All measured quantities that can be used in the DM5

4.2 Programming the FS1701

The FS1701 can simultaneously process up to 8 inputs (4-20mA or 0-10 V) and connect them to the Modbus system. The programming of the FS1701 can only be carried out using the three sets of DIP switches on the device itself. The three sets of switches are Switch A, Switch B and Digital mode (voltage potential) Switch.

Switch A is used to specify an address for the device that the datalogger (master) can use to call it. The device can have any address from 0 to 255 as long as it differs from other slaves in the communication system. In this installation, 2 is given as the address for the FS1701. Address of 2 can be defined by turning on the second DIP switch on Switch A. The DIP switch combination for any given address is illustrated in figure 24.

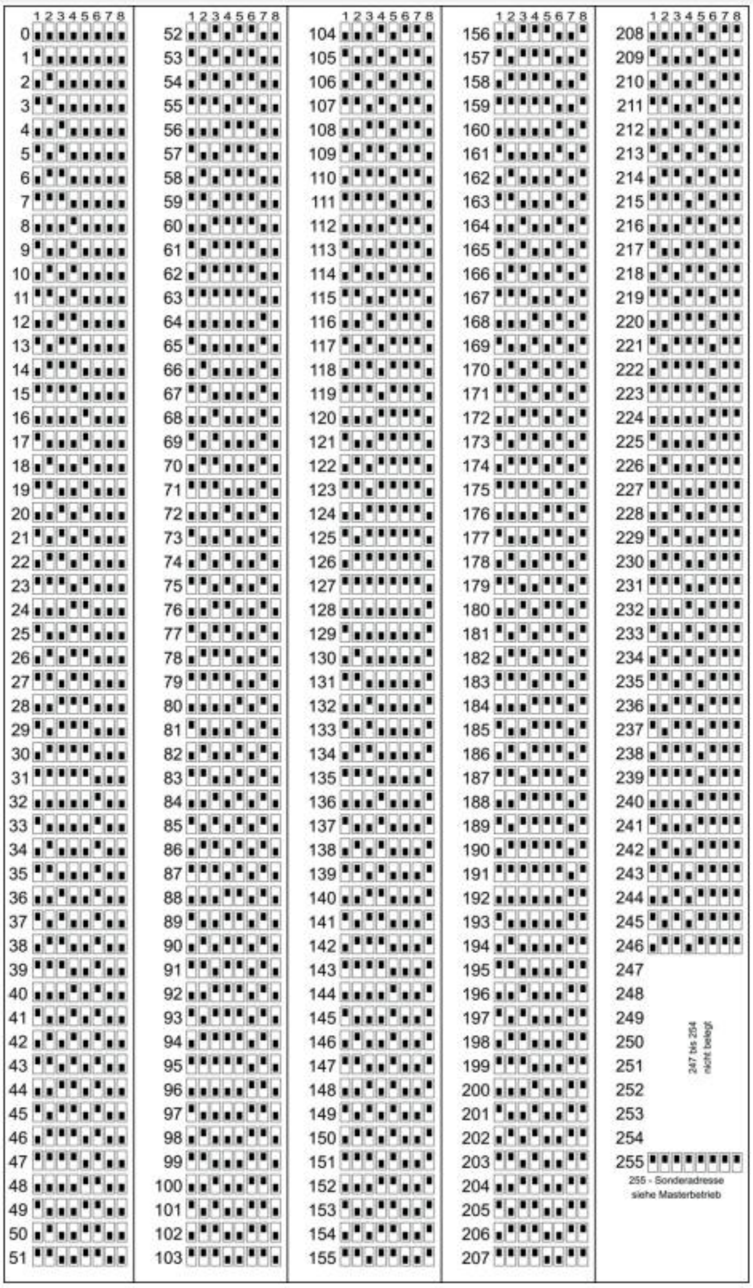

Figure 24: DIP switch combination for all possible addresses

Switch B is used to set interface parameters. We use 8 data bits for this installation, 1 stop bit, no parity; therefore, DIP 1 is switched on, DIP 2 can be either off or on, and DIP 3 is off. Baud rate 9600 is selected; therefore, DIP 4 is on, and DIP 5 is off. And terminating resistor is chosen, so DIP 8 is on. The DIP switch combination for any data transfer is shown in figure 25.

Switch B			
DIP 1	**DIP 2**	**DIP 3**	**Datenübertragung** ***Data Transfer***
ON	-	OFF	8N1 (8 Datenbit, 1 Stoppbit, keine Parität)
OFF	OFF	OFF	8E1 (8 Datenbit, 1 Stoppbit, gerade Parität)
OFF	ON	OFF	8O1 (8 Datenbit, 1 Stoppbit, ungerade Parität)
ON	-	ON	8N2 (8 Datenbit, 2 Stoppbit, keine Parität)
OFF	OFF	ON	8E2 (8 Datenbit, 2 Stoppbit, gerade Parität)
OFF	ON	ON	8O2 (8 Datenbit, 2 Stoppbit, ungerade Parität)

D **Baudrate**
EN Baud rate

Switch B		
DIP 4	**DIP 5**	**Baudrate** ***baud rate***
OFF	OFF	2400
ON	OFF	9600
OFF	ON	19200
ON	ON	38400

D **Widerstände**
EN Transistors

Switch B	
DIP (ON = Aktiv/*Active*)	**Widerstand** ***resistor***
6	Pullupwiderstand *Pullup transistor*
7	Pulldownwiderstand *Pulldown transistor*
8	Abschlusswiderstand */ terminating resistor*

Figure 25: Data Transfer settings for Switch B. The settings used for the installation are highlighted.

The full switch configuration of the FS1701 is shown in figure 26. The Digital mode (voltage potential) switch is not used.

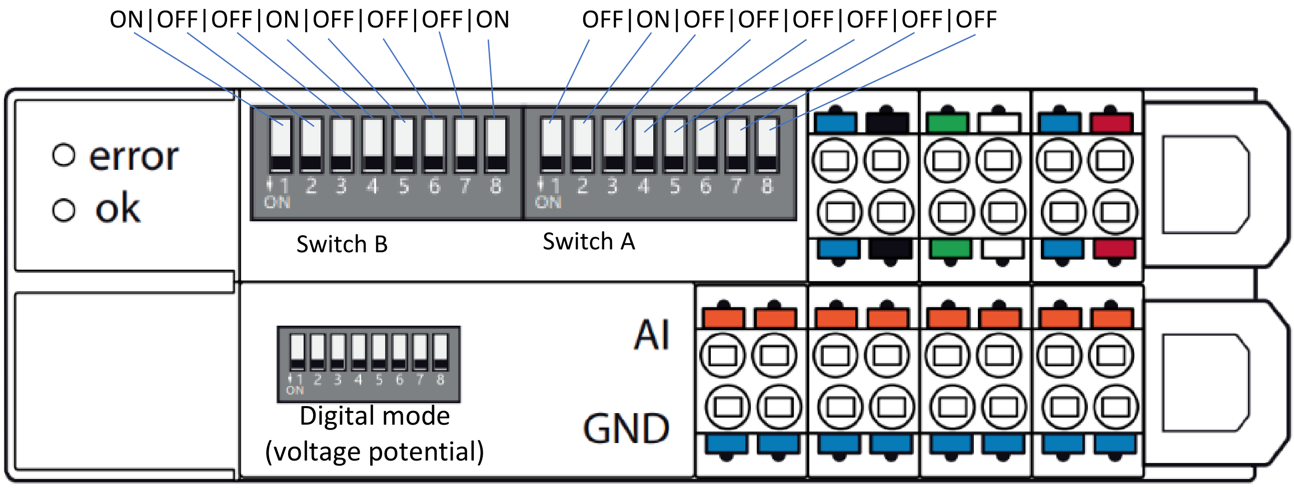

Figure 26: Switch configuration of the FS1701 used for the installation

5 Step 5: Inputs and Addresses

The DM5 inputs are shown in table 2.

Input name	Unit	Description	Real Signal	Register Address on DM5	Measurement
Iac1	Amps	Alternating current 1	0..37.5A - 0..20mA	118	Current in phase L1
Uac1	Volts	Alternating voltage 1	0..250V - 0..20mA	102	Voltage phase L1 to N
Pac1	Watts	Alternating power 1	0..9kW - 0..20mA	128	Active power phase 1 (L1 – N)
Iac2	Amps	Alternating current 2	0..37.5A - 0..20mA	120	Current in phase L2
Uac2	Volts	Alternating voltage 2	0..250V - 0..20mA	104	Voltage phase L2 to N
Pac2	Watts	Alternating power 2	0..9kW - 0..20mA	130	Active power phase 2 (L2 – N)
Iac3	Amps	Alternating current 3	0..37.5A - 0..20mA	122	Current in phase L3
Uac3	Volts	Alternating voltage 3	0..250V - 0..20mA	106	Voltage phase L3 to N
Pac3	Watts	Alternating power 3	0..9kW - 0..20mA	132	Active power phase 3 (L3 – N)
Plum	Watts	The sum of active powers	NA	126	Active power system (P = P1 + P2 + P3)
Fr	Hertz	Frequency	NA	150	System frequency

Table 2: Inputs to DM5

The inputs of the FS1701 are shown in table 3

Input name	Unit	Description	Real Signal	Register Address on FS1701	Name of the pin on the device
Idc_plus	Amps	Direct current +	0..50A - 0..50mA	2	AI1
Idc_minus	Amps	Direct current -	0..50A - 0..50mA	3	AI2
Udc_plus	Volts	Direct voltage +	0..600V - 0..20mA	4	AI3
Udc_minus	Volts	Direct voltage -	0..600V - 0..20mA	5	AI4
Iob	Amps	Harmonics	0..5A - 0..10V	6	AI5
NKE_Localnet	NA	Net command detection	0..10V - 0..20mA	7	AI6
NKE_BKW	NA	Net command detection	0..10V - 0..20mA	8	AI7
Transient	NA	Period of disturbance	0..10V - 0..20mA	9	AI8

Table 3: Inputs to FS1701

For west installation, table 4 shows which connection pin is associated with which signal. Figures 27 and 28 show the FS1701 and the connection pins for the west installation.

West Installation:

Connection pin	**Signal**
+13/-13	Udc+
+14/-14	Udc-
+15/-15	Idc+
+16/-16	Idc-
+19/-19	NKE_Localnet
+20/-20	NKE_BKW
+21/-21	Transient

Table 4: West Installation, connection pins and signals

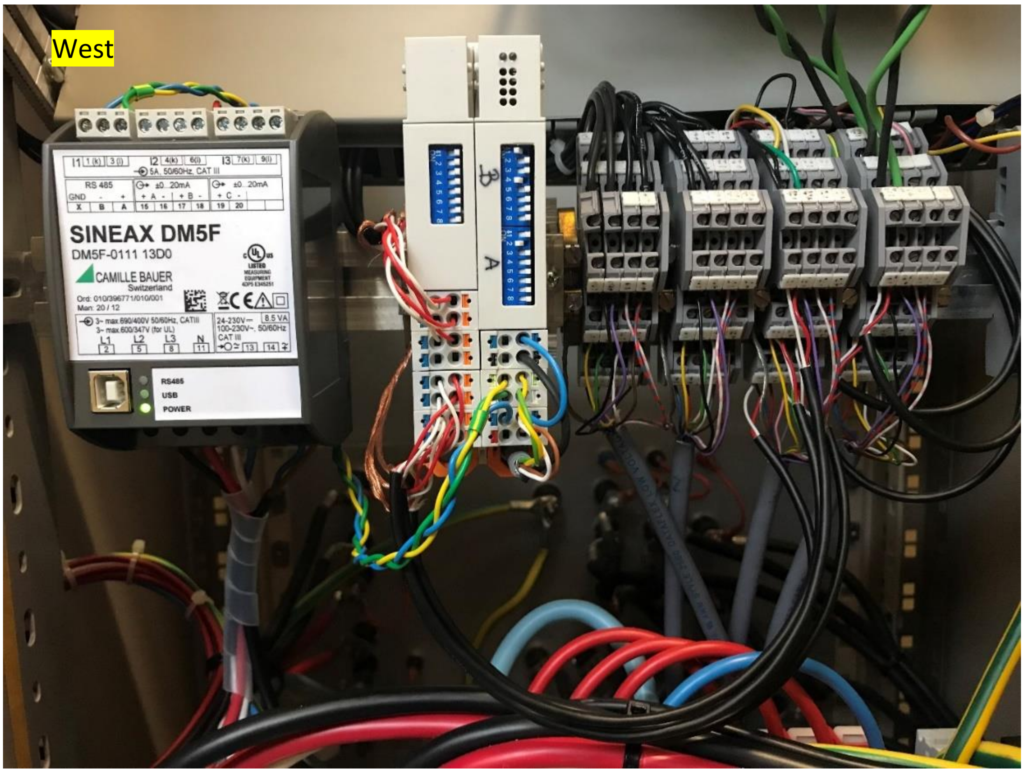

Figure 27: DM5F and FS1701 and the connection pins for the west Installation

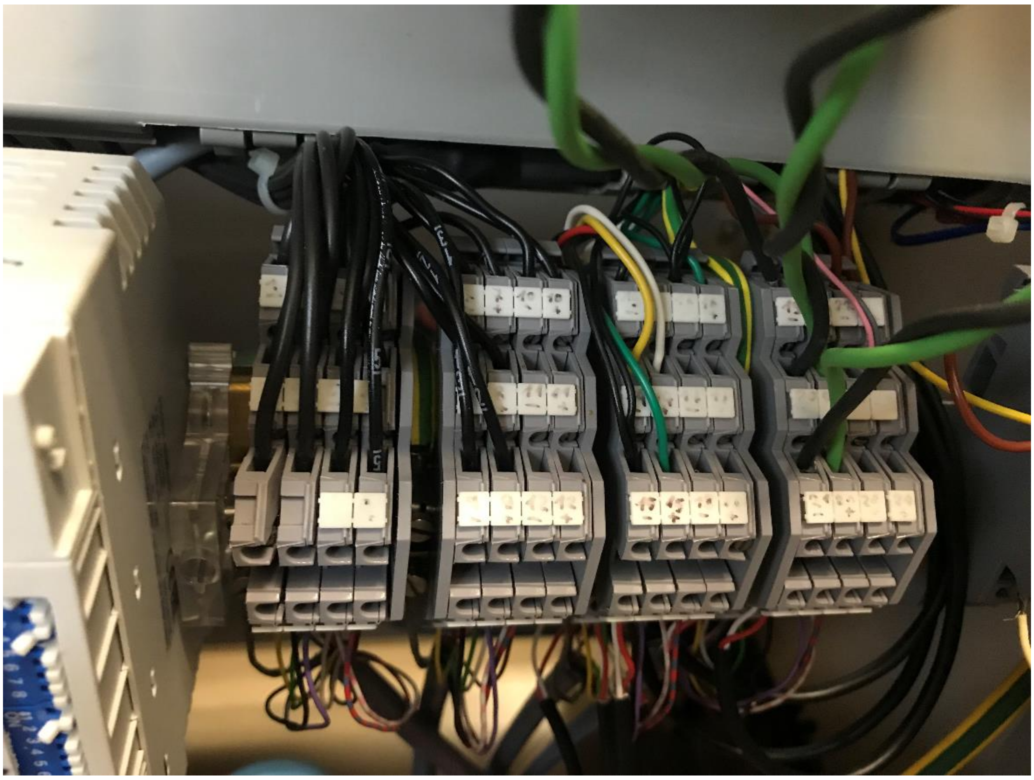

Figure 28: Close up of the connection pins for the west Installation

For the east installation, table 5 shows which connection pin is associated with which signal. Figures 29 and 30 show the FS1701 and the connection pins for the east installation.

Connection pin	Signal
+13/-13	Udc+
+14/-14	Udc-
+16/-16	Idc+
+15/-15	Idc-

Table 5: East Installation, connection pins and signals

Note, for the west and east installations, Iob is connected directly to FS1701; therefore, not shown in the tables.

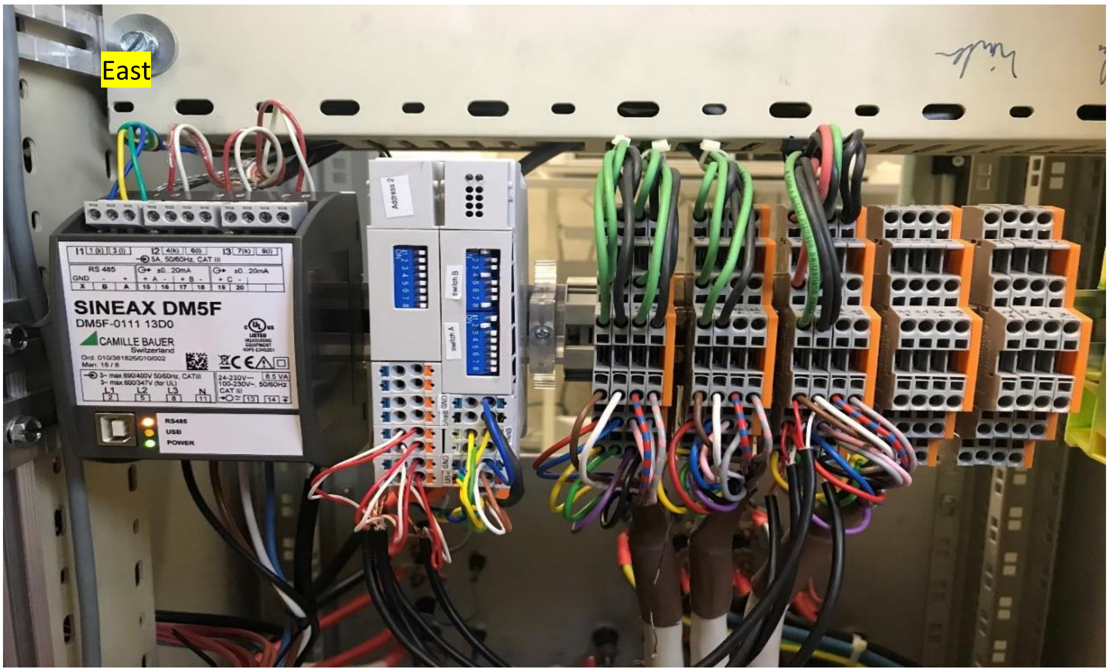

Figure 29: Close up of the connection pins for the west Installation

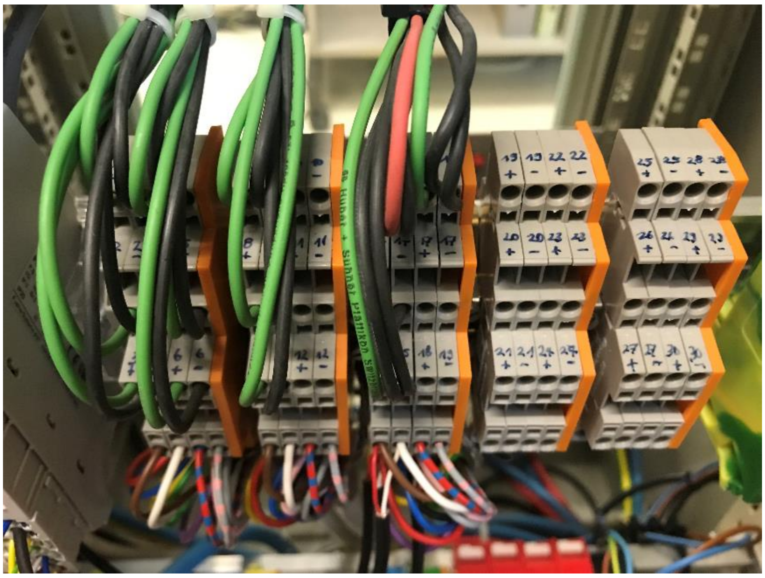

Figure 30: Close up of the connection pins for the west Installation