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4X35 PROFIBUS-DP SYSTEM

Status and weight transfer using Profibus-DP

Applies for:

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1) CONTENTS

2) INTRODUCTION

2.1 Introduction

This document describes the use of a 4X35 Profibus-DP system unit from Eilersen Electric. The 4X35 system unit consists internally of a 4035 Profibus-DP module (with the program listed on the front page) and a 4040 communication module.

The 4X35 system unit is connected to X loadcells (1-4). With the program specified on the front page, the 4X35 Profibus-DP unit is capable of transmitting weight and status for up to 4 loadcells in a single telegram.

It is possible to connect the 4X35 Profibus-DP unit to a Profibus-DP network, where it will act as a slave. It will then be possible from the Profibus-DP master to read status and weight for each of the connected loadcells. Functions as zeroing, calibration and calculation of system weight(s) **must** be implemented on the Profibus-DP master.

By use of DIP-switches it is possible to:

- select measurement time.
- select scaling.
- include one of 3 different FIR filters.

Exchange of data between master and slave takes place as described in the following.

2.2 Profibus-DP specification

The Profibus-DP unit confirms to the following Profibus-DP specifications:

Protocol:	Profibus-DP
Communications form:	RS485
Module type:	Slave
Baud rates [kbit/sec]:	9.6, 19.2, 93.75, 187.5, 500, 1500, 3000, 6000, 12000
Profibus address:	0-127
Profibus connection:	9-pin sub-D (female) connector

IMPORTANT: Load cell modules and instrumentation <u>must be placed outside the hazardous zone</u> if the load cells are used in hazardous ATEX (Ex) area. Furthermore, only ATEX certified load cells and instrumentation can be used in ATEX applications.

3) DATA EXCHANGE

3.1 Profibus-DP communication using PPO

Profibus-DP communication with the 4X35 Profibus-DP unit uses a so called 'parameter-process data object' (PPO) consisting of 26 bytes. This telegram (object) is only used when transferring data from the slave to the master, since **no** data are transmitted from the master to the slave. The structure for this telegram is as follows:

Lc Register		**Lc Status(0)**		**Lc Signal(0)**					**Lc Status(3)**		**Lc Signal(3)**			
0	1	2	3	4	5	6	7		20	21	22	23	24	25

The byte order (MSB/LSB first?) for the individual parts of the telegram is determined by a jumper. Normally this jumper is set from the factory so that MSB comes first. In the following bit 0 will represent the least significant bit in a register.

LcRegister is a word (two bytes) that constitute a bit register for indication of connected loadcells detected during power on. Hence bit 0-3 will be ON, if the corresponding loadcell address (LC1-LC4) was detected during power on. **LcRegister** is always transferred in **16 bit unsigned integer** format.

LcStatus(X) is a word (two bytes) that constitute a register containing the actual status for loadcell **X**. **LcStatus(X)** is always transferred in **16 bit unsigned integer** format. During normal operation this register will be 0, but if an error occurs some bits in the register will be set resulting in an error code. A description of the different error codes can be found in the chapter *STATUS CODES*.

LcSignal(X) is a double word (four bytes) constituting a register containing the actual weight signal from loadcell **X**. Depending on a jumper **LcSignal(X)** will be in either **32 bit signed integer** format or in **IEEE754 floating point** format. This jumper is default set so transfer of **LcSignal(X)** is done in **32 bit signed integer** format. Note that the value is only valid if the corresponding **LcStatus(X)** register is 0 indicating no error present. The scaling of the loadcell signal is determined by a DIP-switch as described later.

Since only status and weight for the loadcells are transmitted in the telegram, functions such as status handling, calculation of system weight(s), zeroing and calibration **must** be implemented on the Profibus-DP master. Please refer to the chapter *DATA PROCESSING* for an explanation on how this typically can be done.

3.2 Data formats

The Profibus-DP communication can transfer data in the following three data formats. If necessary please refer to other literature for further information on these formats.

3.2.1 Unsigned integer format (16 bit)

The following are examples of decimal numbers represented on 16 bit unsigned integer format:

Decimal	Hexadecimal	Binary (MSB first)
0	0x0000	00000000 00000000
1	0x0001	00000000 00000001
2	0x0002	00000000 00000010
200	0x00C8	00000000 11001000
2000	0x07D0	00000111 11010000
20000	0x4E20	01001110 00100000

3.2.2 Signed integer format (32 bit)

The following are examples of decimal numbers represented on 32 bit signed integer format:

Decimal	Hexadecimal	Binary (MSB first)
-20000000	0xFECED300	11111110 11001110 11010011 00000000
-2000000	0xFFE17B80	11111111 11100001 01111011 10000000
-200000	0xFFFCF2C0	11111111 11111100 11110010 11000000
-20000	0xFFFFB1E0	11111111 11111111 10110001 11100000
-2000	0xFFFFF830	11111111 11111111 11111000 00110000
-200	0xFFFFFF38	11111111 11111111 11111111 00111000
-2	0xFFFFFFFE	11111111 11111111 11111111 11111110
-1	0xFFFFFFFF	11111111 11111111 11111111 11111111
0	0x00000000	00000000 00000000 00000000 00000000
1	0x00000001	00000000 00000000 00000000 00000001
2	0x00000002	00000000 00000000 00000000 00000010
200	0x000000C8	00000000 00000000 00000000 11001000
2000	0x000007D0	00000000 00000000 00000111 11010000
20000	0x00004E20	00000000 00000000 01001110 00100000
200000	0x00030D40	00000000 00000011 00001101 01000000
2000000	0x001E8480	00000000 00011110 10000100 10000000
20000000	0x01312D00	00000001 00110001 00101101 00000000

3.2.3 IEEE754 floating point format (32 bit)

Representation of data on IEEE754 floating point format is done as follows:

Byte1		Byte2		Byte3	Byte4
bit7	bit6 bit0	bit7	bit6 bit0	bit7 bit0	bit7 bit0
S	2^{7} …..…. 2^{1}	2^{0}	2^{-1} …….... 2^{-7}	2^{-8} …………..... 2^{-15}	2^{-16} ………..…. 2^{-23}
Sign	Exponent		Mantissa	Mantissa	Mantissa

Formula:

$$\text{Value} = (-1)^{S} * 2^{(\text{exponent}-127)} * (\text{I}+\text{Mantissa})$$

Example:

Byte1	Byte2	Byte3	Byte4
0100 0000	1111 0000	0000 0000	0000 0000

$$\text{Value} = (-1)^{0} * 2^{(129-127)} * (1 + 2^{-1} + 2^{-2} + 2^{-3}) = 7.5$$

Please note that if transfer of MSB first has been selected (default setting), the byte with the “sign” will come first in the weight indications, and if LSB first has been selected the byte with the “sign” will come last in the weight indications.

3.3 Measurement time

By use of DIP-switches located internally in the 4X35 Profibus-DP system unit it is possible to choose between 4 different measurement times. All loadcells are sampled/averaged over a measurement period determined by Sw3.1 and Sw3.2 as follows:

SW3.1	SW3.2	Measurement time
OFF	OFF	20 ms
OFF	ON	100 ms
ON	OFF	400 ms
ON	ON	2000 ms

NOTE: Upon default delivery SW3.1 is OFF and SW3.2 is ON, so that 100ms measuring time is achieved.

The hereby found loadcell signals (possibly filtered) are used in the Profibus-DP communication until new signals are achieved when the next sample period expires.

3.4 Filtering

By use of DIP-switches located internally in the 4X35 Profibus-DP system unit it is possible to include one of 3 different FIR filters, that will be used to filter the loadcell signals. Thus it is possible, to send the unfiltered loadcell signals achieved over the selected measurement period through one of the following FIR filters, before the results are transmitted on the Profibus:

SW3.4	SW3.3	No.	Taps	Frequency				Damping
				Tavg 20ms	Tavg 100ms	Tavg 400ms	Tavg 2000ms	
OFF	OFF	0	-	-	-	-	-	-
ON	OFF	1	9	12.0 Hz	2.4 Hz	0.6 Hz	0.12 Hz	-80dB
OFF	ON	2	21	6.0 Hz	1.2 Hz	0.3 Hz	0.06 Hz	-80dB
ON	ON	3	85	1.5 Hz	0.3 Hz	0.075Hz	0.015Hz	-80dB

NOTE: With both switches OFF, which is default setting upon delivery, no filtering is performed.

3.5 Scaling

By use of a DIP-switch it is possible to select the desired scaling of the weight signals. The scaling of the weight signals on the Profibus is determined by SWP.1 as follows, where the table shows how a given weight is represented on the Profibus depending on switch and jumper settings:

Weight [gram]	JU7 = OFF (32 bit signed integer) (normal default delivery)		JU7 = ON (IEEE754 floating point)	
	SWP.1 = OFF (1 gram)	SWP.1 = ON (1/10 gram)	SWP.1 = OFF (1 gram)	SWP.1 = ON (1/10 gram)
1,0	1	10	1,000	10,000
123,4	123	1234	123,000	1234,000

4) DATA PROCESSING

4.1 Zeroing, calibration and weight calculation

Calculation of system weight(s) is done by addition of the weight registers for the loadcells belonging to the system. This is explained below. **Note** that the result is only valid if all status registers for the loadcells in question indicate no errors. It should also be noted that it is up to the master to ensure the usage of consistent loadcell data when calculating the system weight (the used data should come from the same telegram).

4.1.1 Zeroing of weighing system

Zeroing of a weighing system (all loadcells in the specific system) should be performed as follows, taking into account that no loadcell errors may be present during the zeroing procedure:

1) The weighing arrangement should be empty and clean.
2) The Profibus-DP master verifies that no loadcell errors are present, after which it reads and stores the actual weight signals for the loadcells of the actual system in corresponding zeroing registers.

```
LcZero[x]=LcSignal[x]
```

3) After this the uncalibrated gross weight for loadcell **X** can be calculated as:

```
LcGross[X] = LcSignal[X] – LcZero[X]
```

4.1.2 Corner calibration of weighing system

In systems where the load is not always placed symmetrically the same place (for example a platform weight where the load can be placed randomly on the platform when a weighing is to take place), a fine calibration of a systems corners can be made, so that the weight indicates the same independent of the position of the load. This is done as follows:

1) Check that the weighing arrangement is empty. Zero the weighing system.
2) Place a known load (`CalLoad`) directly above the loadcell that is to be corner calibrated.
3) Calculate the corner calibrationfactor that should be multiplied on the uncalibrated gross weight of the loadcell in order to achieve correct showing as:

```
CornerCalFactor[x] = (CalLoad)/(LcGross[x])
```

After this the determined corner calibration factor is used to calculate the calibrated gross weight of the loadcell as follows:

```
LcGrossCal[x] = CornerCalFactor[x] * LcGross[x]
```

4.1.3 Calculation of uncalibrated system weight

Based on the loadcell gross values (`LcGross[x]` or `LcGrossCal[x]`), whether they are corner calibrated or not, a uncalibrated system weight can be calculated as either:

```
Gross = LcGross[X1] + LcGross[X2] + …
```

or:

```
Gross = LcGrossCal[X1] + LcGrossCal[X2] + …
```

4.1.4 System calibration of weighing system

Based on the uncalibrated system weight a system calibration can be made as follows:

1) Check that the weighing arrangement is empty. Zero the weighing system.
2) Place a known load (`CalLoad`) on the weighing arrangement. **NOTE:** In order to achieve a correct calibration of the system it is recommended, that the used calibration load is at least 50% of the system capacity.
3) Calculate the calibrationfactor that should be multiplied on the uncalibrated system weight in order to achieve correct showing as:

```
CalFactor = (CalLoad)/(Actual Gross)
```

After this the determined calibration factor is used to calculate the calibrated system weight as follows:

```
GrossCal = CalFactor * Gross
```

If the determined calibrationfactor falls outside the interval 0.9 to 1.1 it is very likely that there is something wrong with the mechanical part of the system. This does not however apply to systems that do not have a loadcell under each supporting point. For example on a three legged tank with only one loadcell, you should get a calibration factor of approximately 3 because of the two “dummy” legs.

5) INSTALATION OF SYSTEM

5.1 Checklist during installation

During installation of the system the following should be checked:

1) The Profibus-DP master should be configured to communicate with the 4X35 Profibus-DP system unit using the supplied GSD file.

2) Using DIP-switches the desired measurement time, filter and scaling is selected.

3) The loadcells are mounted mechanically and connected to BNC connectors in the front panel of the 4X35 system unit.

4) The 4X35 Profibus-DP system unit is connected to the Profibus-DP network using the Profibus-DP connector in the front panel of the 4X35 system unit. If necessary a possible termination of the Profibus-DP network is made at this Profibus-DP slave.

5) Use SW1 in the front panel of the 4X35 system unit to select any features associated with SW1 on the 4040 communication module.

6) Use SWP.2-SWP.8 in the front panel of the 4X35 system unit to select the communication address of the 4X35 Profibus-DP system unit.

7) Power (24VDC) is applied at the 2 pole power connectors in the front panel of the 4X35 system unit as described in the hardware section, and the Profibus-DP communication is started.

8) Verify that the **PBE** lamp (red) is NOT lit, and that the **DES** lamp (yellow) and **RTS** lamp (yellow) are lit/flashing.

9) Verify that the **TxLC** lamp (yellow) is lit (turns on after approx. 5 seconds).

10) Verify that the two **TxBB** lamps (green) are lit.

11) Verify that NONE of the **1**, **2**, **3** or **4** lamps (red) are lit.

12) Verify that the 4X35 Profibus-DP system unit has found the correct loadcells (**LcRegister**), and that no loadcell errors are indicated (**LcStatus(x)**).

13) Verify that every loadcell gives a signal (**LcSignal(x)**) by placing a load directly above each load-cell one after the other (possibly with a known load).

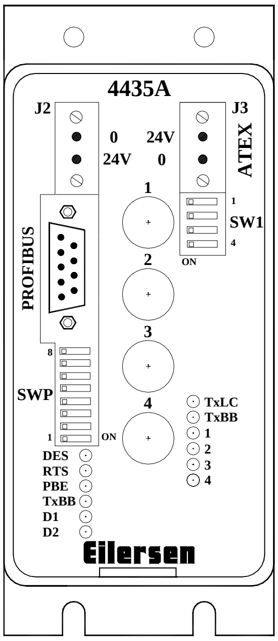
The system is now installed and a zero and fine calibration is made as described earlier. Finally verify that the weighing system(s) returns a value corresponding to a known actual load.

Note that in the above checklist no consideration has been made on which functions are implemented on the Profibus-DP master.

6) HARDWARE DESCRIPTION

6.1 4X35 overview

The following figure is an overview of a 4X35 system unit with 4 loadcell connections (i.e. a 4435 system unit):



6.2 4X35 front panel description

This chapter describes the connections, DIP-switch settings and lamp indications that are available on the front panel of the 4X35 system unit.

6.2.1 Connection of power

The 4X35 system unit is powered by applying +24VDC on the green two pole connectors (J2 and J3) as specified on the front panel of the 4X35 system unit. This powers the entire 4X35 system unit including the loadcells.

IMPORTANT: The used power supply must be stable and free of transients. It may therefore be necessary to use a separate power supply dedicated to the weighing system, and not connected to any other equipment.

NOTE: If the loadcells are to be placed inside an EX area, then the 4X35 system unit itself **MUST** be placed outside the EX area, and the 4X35 system unit **MUST** be supplied as follows:

1) The 2 pole connector (J3), located to the right above the 4 pole DIP-switch block, **MUST** be powered by a 4051A power supply (+24VDC ATEX approved) from Eilersen Electric.
2) The 2 pole connector (J2), located to the left above the 9 pole Sub-D connector (PROFIBUS), **MUST** be powered by a separate +24VDC, that has **NO** connection to the ATEX approved +24VDC from the above mentioned 4051A power supply.

6.2.2 Connection of loadcells

The loadcells must be connected to the available BNC connectors in the front panel of the 4X35 system unit. The loadcells are connected starting with the connector marked 1 and continuing onwards in rising order. Thus if three loadcells are to be connected, they should be connected to the BNC connectors marked 1, 2 and 3.

6.2.3 Profibus-DP connector

The front panel of the 4X35 system unit is equipped with a nine pole female sub-D connector with a standard Profibus-DP interface. This allows for direct connection to a Profibus-DP network using standard Profibus-DP connectors. Termination of the Profibus should take place in the sub-D connector (male) of the cable. The specific terminals in the connector have the following function:

TERMINALS	FUNCTION
1	Not used
2	Not used
3	RS485-A (**positive** line) (Siemens designation: B line)
4	Request to Send (RTS)
5	0 VDC (Gnd)
6	+5VDC (Vout)
7	Not used
8	RS485-B (**negative** line) (Siemens designation: A line)
9	Not used

Note that some companies use different designations for the RS485-A and the RS485-B lines. Therefore the polarity of the lines has been listed.

6.2.4 SW1 settings

The front panel of the 4X35 system unit is equipped with a 4 pole DIP switch block named SW1. These switches are mounted on the 4040 communication module, and they are **ONLY** read during power-on. When the 4040 communication module is equipped with standard program, their functionality is as follows:

Sw1.1	FIR Filter
OFF	No filter
ON	30 taps

SWITCH	FUNCTION
Sw1.2-Sw1.4	*Reserved for future use*

6.2.5 SWP settings

The front panel of the 4X35 system unit is equipped with a 8 pole DIP switch block named SWP. These switches allow setting of the Profibus-DP communication address of the 4X35 Profibus-DP system unit. This DIP switch block has the following function:

SWITCH	FUNCTION
SWP.1	**Scaling** Used to select the desired scaling as described in an earlier chapter. Note that these switches are only read during power on.
SWP.2-SWP.8	**Selection of Profibus-DP communication address** The address is selected as the DIP-switches are binary coded, so SWP.2 is MSB and SWP.8 is LSB. Note that these switches are only read during power on.

6.2.6 Light Emitting Diodes (LEDs)

The front panel of the 4X35 system unit is equipped with a number of status lamps (light emitting diodes). These have the following functionality:

LED	**FUNCTION**
DES (Yellow)	**Data Exchange State** Exchange of data between 4X35 Profibus-DP slave and master.
RTS (Yellow)	**RtS signal (SPC3)** The 4X35 Profibus-DP system unit sends to the master.
PBE (Red)	**Profibus Error (when initializing the SPC3)** The 4X35 Profibus-DP system unit was not initialized correctly.
TxBB (Left) (Green)	**4035 communication with 4040 module (internal)** 4035 Profibus-DP module is transmitting to 4040 communication module.
D1 *(Green)*	*Reserved for future use*
D2 *(Green)*	*Reserved for future use*
TxLC (Yellow)	**4040 communication with loadcells** 4040 communication module is communicating with loadcells.
TxBB (Right) (Green)	**4040 communication with 4035 Profibus-DP module (internal)** 4040 communication module is transmitting to 4035 Profibus-DP module.
1 (Red)	**Status for loadcell 1** Bad connection, loadcell not ready or other error detected.
2 (Red)	**Status for loadcell 2** Bad connection, loadcell not ready or other error detected.
3 (Red)	**Status for loadcell 3** Bad connection, loadcell not ready or other error detected.
4 (Red)	**Status for loadcell 4** Bad connection, loadcell not ready or other error detected.

6.3 Hardware Selftest

During power-on the 4X35 Profibus-DP system unit will perform a hardware selftest. The test will cause the light emitting diodes D1, D2 and PBE to turn on and off shortly, one at a time.

6.4 Update times

Please note that update times across the Profibus-DP communication depends on the specific Profibus-DP configuration (selected baudrate, number of slaves, scan times etc.).

7) APPENDIX – INTERNAL FEATURES

7.1 4035 Profibus-DP module

This chapter describes possible connections, DIP-switch settings and jumper settings that are available internally on the 4035 Profibus-DP module. These will normally be set from Eilersen Electric and should only be changed in special situations.

7.1.1 SW3 settings

The 4035 Profibus-DP module is internally equipped with a 4 pole DIP switch block named SW3. This DIP switch block has the following function:

SWITCH	**FUNCTION**
Sw3.1-Sw3.2	**Measurement time** Used to select the desired measurement time as described in an earlier chapter. Note that these switches are only read during power on.
Sw3.3-Sw3.4	**Filtering** Used to select the desired filter as described in an earlier chapter. Note that these switches are only read during power on.

7.1.2 Jumper settings

The 4035 Profibus-DP module is internally equipped with 7 jumpers. These jumpers have these functions:

JUMPER	**FUNCTION**
JU1	*Reserved for future use* *(normal default factory setting is OFF)*
JU2-JU4	*Reserved for future use (termination)* *(normal default factory setting is OFF)*
JU6	*Reserved for future use* *(normal default factory setting is OFF)*
JU7	**Selection of (32 Bit Signed Integer) / (IEEE754) data format** The jumper determines if the weight indications in the telegram are in *32 bit signed integer* or in *IEEE754 floating point* format. OFF: *32 bit signed integer* format (normal setting from factory) ON: *IEEE754 floating point* format
JU8	**Selection of LSB/MSB data format** The jumper determines the byte order in which data are transmitted/received. OFF: LSB first ON: MSB first (normal setting from factory)

7.2 4040 communication module

This chapter describes possible connections, DIP-switch settings, jumper settings and LED status lamps that are available internally on the 4040 communication module. These will normally be set from Eilersen Electric and should only be changed in special situations.

7.2.1 SW2 settings

The 4040 communication module is internally equipped with a 8 pole DIP switch block named SW2. Please note that these switches are **ONLY** read during power-on. This DIP switch block has the following function when the 4040 communication module is equipped with standard program:

Sw2.1	**Sw2.2**	**Sw2.3**	**Number of loadcells**
OFF	OFF	OFF	1
ON	OFF	OFF	1
OFF	ON	OFF	2
ON	ON	OFF	3
OFF	OFF	ON	4
ON	OFF	ON	5
OFF	ON	ON	6
ON	ON	ON	6

SWITCH	**FUNCTION**
Sw2.4-Sw2.8	*Reserved for future use*

7.2.2 Jumper settings

The 4040 communication module is internally equipped with 4 jumpers named P2, P3, P4 and P5. In this system these jumpers must be set as follows:

JUMPER	**POSITION**
P2	OFF (Loadcell connected to 4040 **NOT** accessible using SEL1)
P3	OFF (Loadcell connected to 4040 **NOT** accessible using SEL6)
P4	OFF (Loadcell connected to 4040 **NOT** accessible using SEL1)
P5	OFF (Loadcell connected to 4040 **NOT** accessible using SEL6)

7.2.3 Light Emitting Diodes (LEDs)

The 4040 communication module is internally equipped with a number of status lamps (light emitting diodes). The lamps have the following functionality when the 4040 communication module is equipped with standard program:

LED	**FUNCTION**
D11 *(Red)*	*Reserved for future use*
D12 *(Red)*	*Reserved for future use*
D13 *(Red)*	*Reserved for future use*
D14 *(Red)*	*Reserved for future use*

8) APPENDIX - STATUS CODES

Status codes are shown as a 4 digit hex number. If more than one error condition is present the error codes are OR'ed together.

CODE (Hex)	CAUSE
0001	*Reserved for future use*
0002	*Reserved for future use*
0004	*Reserved for future use*
0008	*Reserved for future use*
0010	**Power failure** Supply voltage to loadcells is to low.
0020	**New loadcell detected or loadcells swapped** Power the system off and back on. Then verify that all parameters are acceptable.
0040	**No answer from loadcell** Bad connection between loadcell and loadcell module? Bad connection between loadcell module and communication module?
0080	**No answer from loadcell** Bad connection between communication module and master module?
0100	*Reserved for future use*
0200	*Reserved for future use*
0400	*Reserved for future use*
0800	**No loadcell answer** Bad connection between loadcell and loadcell module? Bad connection between loadcell module and communication module? Bad connection between communication module and master module? Bad setting of DIP switches on loadcell or communication module?
1000	*Reserved for future use*
2000	*Reserved for future use*
4000	*Reserved for future use*
8000	*Reserved for future use*

Please note that the above listed status codes are valid when the 4040 communication module is equipped with standard program.