# 4x60 User’s guide EtherCAT

**4x60 EtherCAT Module**

**Status and weight transfer using EtherCAT**


| | |
|---|---|
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# Contents

# Introduction

This document describes the use of a 4X60 EtherCAT system unit from Eilersen Electric, when the software version listed on the front page is installed. The 4X60 system unit consists internally of a 4060 EtherCAT module 4040 communication module and a 4015 loadcell connection module.

With this software, the 4X60 EtherCAT unit can transmit weight and status for up to 4 loadcells in a single data area.

It is possible to connect the 4X60 unit to a EtherCAT network, where it will act as a slave. It will then be possible from the EtherCAT 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 **outside** the 4X60, in the EtherCAT master.

By use of DIP-switches it is possible to select measurement time and include one of 15 different FIR filters, which will be used to filter the loadcell signals, as well as selecting the desired scaling of the loadcell signals.

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

# ATEX (Ex) specification

**IMPORTANT: Instrumentation (the 4X60A) must be placed outside the hazardous zone if the load cells are used in hazardous ATEX (Ex) area. Furthermore, only ATEX certified load cells, instrumentation and power supply type 4051A can be used in ATEX applications.**

# Installation

Before the 4x60 module is connected to the EtherCAT the following steps must be perform:

- Install the loadcells
- Connect loadcells to the loadcell inputs (from input 1 an upwards)
- Select the desired sample time, scaling and filtering with SWE
- Connect 24VDC, min. 2A, both at the J2 and the J3 (ATEX) terminals
- Connect EtherCAT master to the IN port (directly or through other EtherCAT modules)
- Optionally connect remaining EtherCAT modules to the OUT port

  **PLEASE NOTICE** that when connecting multiple 4x60A modules in series **cross-over** cables may be needed between the 4x60A modules
- Setup the EtherCAT master for communication with the module

# How to

## – Connect the loadcells

Loadcells must be connected from input 1 and upwards, no inputs must be skipped, unused loadcell input(s) must be the last input(s) on the module (e.g. a 4460 with 4 loadcell inputs used with 3 loadcells, inputs 1-3 must be used and input 4 left unconnected).

The number of loadcells should match the number of loadcells indicated on the internal switch 4040.SW2.

## – Set the scaling, sample time and filtering

The scaling of the weight signals is set with the SWE switch (SWE.1-2):

| SWE.1 | OFF | ON | OFF | ON | Example weight in gram |
|---|---|---|---|---|---|
| SWE.2 | OFF | OFF | ON | ON | |
| Scaling/Resolution (gram) | 1 | 1/10 0.1 | 1/100 0.01 | 10 | |
| Weight signal | 1 | 10 | 100 | 0 | 1,0 |
| | 123 | 1234 | 12340 | 12 | 123.4 |
| | 12341 | 123410 | 1234100 | 1234 | 12341 |

All loadcells are sampled/averaged over the selected sample time. The found loadcell signals (possibly filtered) are used on the EtherCAT until new signals are found when the next sample period expires.

The sample time is set with the SWE switch (SWE.3-4).

| SWE.3 | SWE.4 | Sample time |
|---|---|---|
| OFF | OFF | 20 ms |
| ON | OFF | 100 ms |
| OFF | ON | 200 ms |
| ON | ON | 400 ms |

It is possible to include one of 15 different FIR filters, which will be used to filter the loadcell signals. The unfiltered loadcell signals are averaged over the selected sample time and sent through one of the following FIR filters, before the results are transmitted on the EtherCAT:

NOTE: With all switches OFF no filtering is performed.

The filter is selected with the SWE switch (SWE.5-8).

| SWE.5 | SWE.6 | SWE.7 | SWE.8 | No. | Taps | Frequency examples | | Damping |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Tavg = 20ms | Tavg = 200ms | |
| OFF | OFF | OFF | OFF | 0 | - | - | - | - |
| ON | OFF | OFF | OFF | 1 | 7 | 12.0 Hz | 1.2 Hz | -60dB |
| OFF | ON | OFF | OFF | 2 | 9 | 10.0 Hz | 1.0 Hz | -60dB |
| ON | ON | OFF | OFF | 3 | 9 | 12.0 Hz | 1.2 Hz | -80dB |
| OFF | OFF | ON | OFF | 4 | 12 | 8.0 Hz | 0.8 Hz | -60dB |
| ON | OFF | ON | OFF | 5 | 12 | 10.0 Hz | 1.0 Hz | -80dB |
| OFF | ON | ON | OFF | 6 | 15 | 8.0 Hz | 0.8 Hz | -80dB |
| ON | ON | ON | OFF | 7 | 17 | 6.0 Hz | 0.6 Hz | -60dB |
| OFF | OFF | OFF | ON | 8 | 21 | 6.0 Hz | 0.6 Hz | -80dB |
| ON | OFF | OFF | ON | 9 | 25 | 4.0 Hz | 0.4 Hz | -60dB |
| OFF | ON | OFF | ON | 10 | 32 | 4.0 Hz | 0.4 Hz | -80dB |
| ON | ON | OFF | ON | 11 | 50 | 2.0 Hz | 0.2 Hz | -60dB |
| OFF | OFF | ON | ON | 12 | 64 | 2.0 Hz | 0.2 Hz | -80dB |
| ON | OFF | ON | ON | 13 | 67 | 1.5 Hz | 0.15 Hz | -60dB |
| OFF | ON | ON | ON | 14 | 85 | 1.5 Hz | 0.15 Hz | -80dB |
| ON | ON | ON | ON | 15 | 100 | 1.0 Hz | 0.10 Hz | -60dB |

## – Connect the power

The 4X60 system unit is powered by applying +24VDC on **both** green two pole connectors (**J2** and **J3**) as specified on the front panel of the 4X60 system unit. This powers the entire 4X60 system unit including the loadcells.

The 24VDC supply must be minimum 2A.

**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.

**IMPORTANT: Instrumentation (the 4X60A) must be placed outside the hazardous zone if the load cells are used in hazardous ATEX (Ex) area. Furthermore, only ATEX certified load cells, instrumentation and power supply type 4051A can be used in ATEX applications.**

**NOTE:** If the loadcells are to be placed inside an EX area, then the 4X60 system unit itself **MUST** be placed outside the EX area, and the 4X60 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 RJ45 Ethernet connector, **MUST** be powered by a separate +24VDC, that has **NO** connection to the ATEX approved +24VDC from the above mentioned 4051A power supply.

**NOTE:** In ***Appendix A – Connection of power*** figures are showing how power supply is connected to Non-ATEX and ATEX applications respectively.

## – Read the loadcell data on EtherCAT

EtherCAT communication with the 4X60 EtherCAT unit uses a data model as described in the ENI file `Eilersen 4X60-3.xml` (preliminary version) or newer. This model is preprogrammed into the 4x60 module and contains these data fields.

| Group | Field | Type | Content |
|---|---|---|---|
| ScaleData (Master input) | LcStatus | BITARR8 | One bit for each loadcell indicating that the loadcell signal is NOT valid |
| | LcNo | USINT | Number of loadcells detected during power-on. Must match the expected number. |
| | Lc1Signal | DINT | Weight signal from loadcell |
| | Lc2Signal | DINT | Weight signal from loadcell |
| | Lc3Signal | DINT | Weight signal from loadcell |
| | Lc4Signal | DINT | Weight signal from loadcell |
| ScaleControl (Master output) | Control | BITAR8 | Not used |
| | MeasTime | USINT | Not used |
| | FilterNo | USINT | Not used |

**LcStatus** is a bit array. Bit 0-3 indicates the status of loadcell 1-4. If the bit is 1 the master must report and error and not use the weight signal from the corresponding loadcell.

**LcNo** holds the number of loadcells detected at power-on. This must match the expected number, if not so the master must report an error.

**LcXSignal** is a double word (four bytes) containing the actual weight signal from loadcell **X** (1-4) in **32 bit signed integer** format. Note that the value is only valid if the corresponding **LcStatus** bit is 0 indicating no error present. The resolution/scaling of the loadcell signal can be selected as described in section – *Set the scaling, sample time and filtering*, page 5.

Since only status and weight for the loadcells can be read, functions such as status handling, calculation of system weight(s), zeroing and calibration **must** be implemented on the Ether-

CAT master. Please refer to the section *Weight calculation*, page 8, for an explanation on how this can be done.

**ScaleControl**, mater output, with fields, **Control**, **MeasTime**, and **FilterNo** is not used

# 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.

## - 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 EtherCAT 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]
   ```

## - Corner calibration of weighing system (optional)

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 calibration factor that should be multiplied on the uncalibrated gross weight of the loadcell in order to achieve correct showing as:

   ```
   CornerCalFactor[x] = (CalLoad)/(LcGross[x])
   ```
4. 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]
   ```

## - Calculation of uncalibrated system weight

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

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

or:

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

### - 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.
3. Calculate the calibration factor that should be multiplied on the uncalibrated system weight in order to achieve correct showing as:

   ```
   CalFactor = (CalLoad)/(Actual Gross)
   ```
4. After this, the determined calibration factor is used to calculate the calibrated system weight as follows:

   ```
   GrossCal = CalFactor * Gross
   ```

If the determined calibration factor 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.

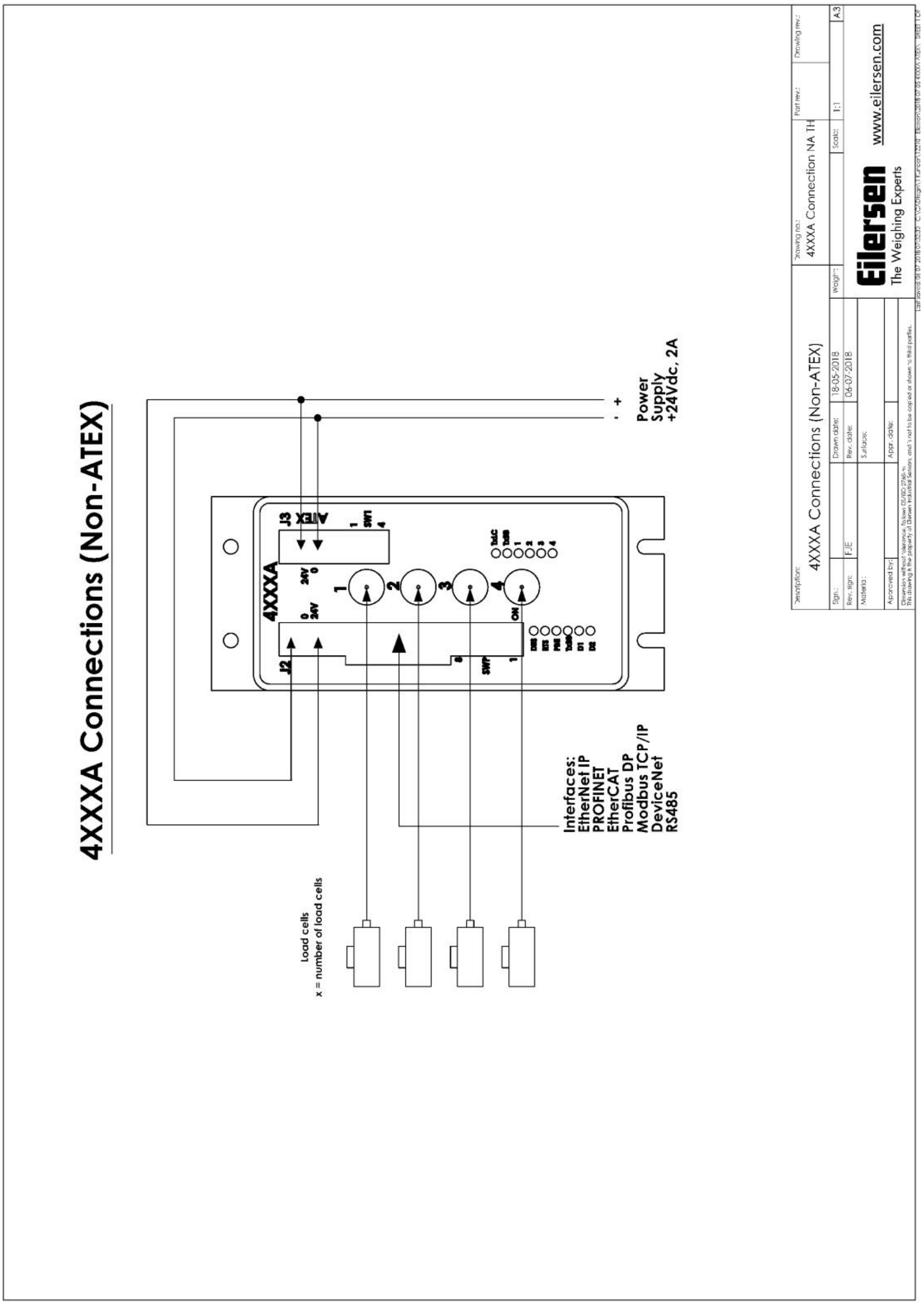
# Trouble shooting

| *Problem* | Solution |
|---|---|
| *No connetion to device* | **Link**<br>*Is the link LED lit/blinking on the device*?<br>Yes: No link problem.<br>No: Check the cabling; Check the power to the device and all devices between the EtherCAT master and the device. |
| *No connection to secondary modules in a chain of 4x60 modules* | *Is the link LED lit/blinking on the secondary devices*?<br>Yes: No link problem.<br>No: Cross-over cables must be needed between the 4x60A modules. |
| | |
| | |
| | |
| | |
| | |

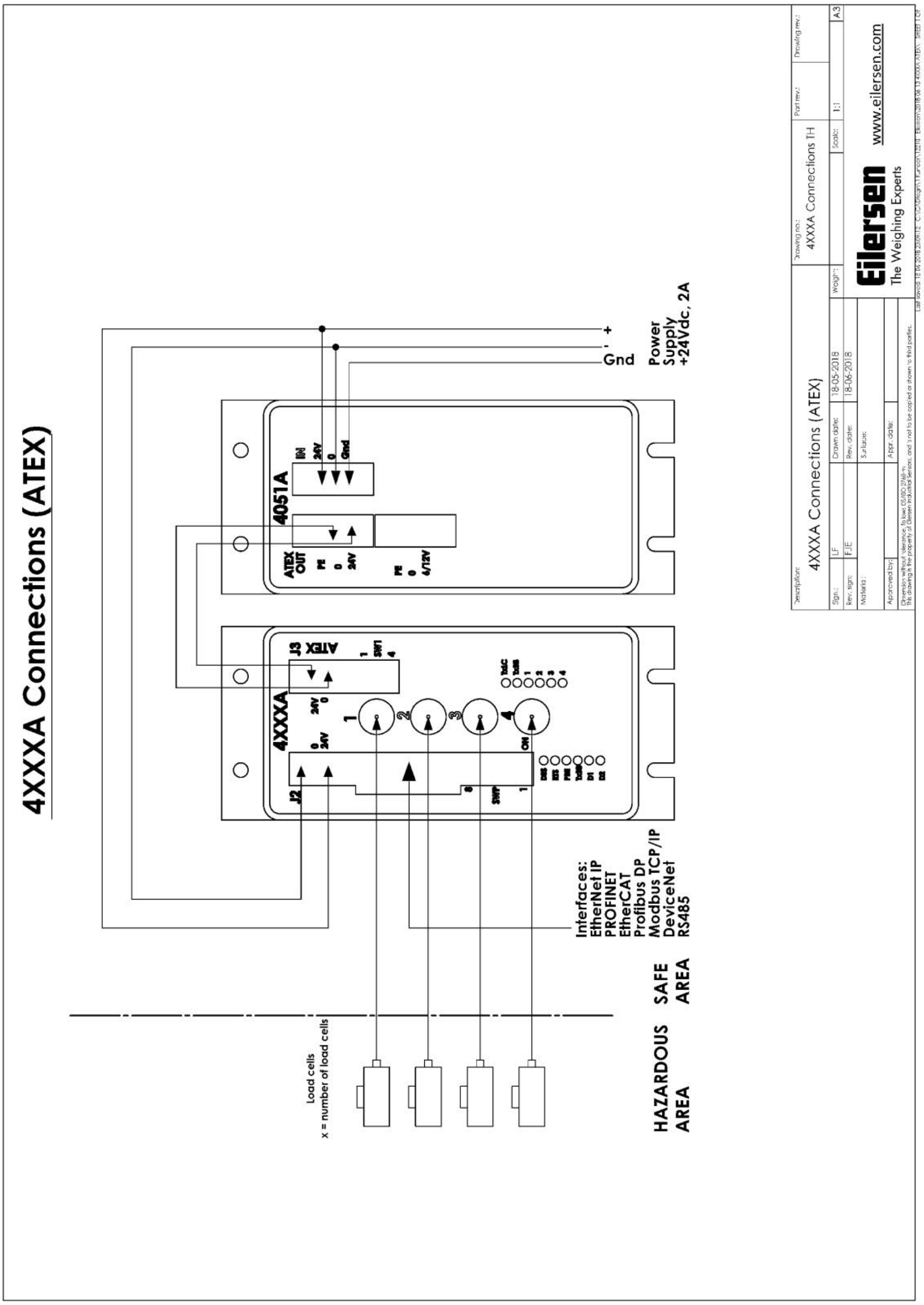
# Appendices

## Appendix A – Connection of power

### Non-ATEX applications



## ATEX applications



## Appendix B – Status indicators

The front panel of the 4X60 system unit is equipped with a number of status lamps (light emitting diodes). These have the following functionality:

| LED | Function |
|---|---|
| IN RJ45 connector<br>Green | Link/Activity (IN)<br>EtherCAT is connected/has activity. |
| IN RJ45 connector<br>Yellow | Reserved for future use |
| OUT RJ45 connector<br>Green | Link/Activity (OUT)<br>EtherCA is connected/has activity. |
| OUT RJ45 connector<br>Yellow | Reserved for future use |
| RUN<br>Green | EtherCAT master is connected and EtherCAT status is operational |
| OK<br>Green | Reserved for future use |
| ERR<br>Red | Error<br>Please se below for further explanation |
| STI<br>Yellow | Internal status<br>Reserved for future use |
| STN<br>Yellow | Network status<br>Reserved for future use |
| TxLC<br>(Yellow) | 4040 communication with loadcells<br>4040 comm. module is communicating with loadcells. |
| TxBB<br>(Green) | 4040 comm. with 4060 EtherCAT module (internal)<br>4040 comm. module is transmitting to 4060 EtherCAT module. |
| 1<br>(Red) | Status for loadcell 1<br>Bad connection, loadcell not ready or other error detected. |
| 2<br>(Red) | Status for loadcell 2<br>Bad connection, loadcell not ready or other error detected. |
| 3<br>(Red) | Status for loadcell 3<br>Bad connection, loadcell not ready or other error detected. |
| 4<br>(Red) | Status for loadcell 4<br>Bad connection, loadcell not ready or other error detected. |

The **ERR** LED blinks red (on time 250ms; off time 250ms) a number of times corresponding to the error detected by the EtherCAT device. If multiple errors are detected at the same time, the **ERR** LED will cyclic blink the different errors as each error (flash sequence) is separated by a 2 second off period. The following errors can be indicated by the **ERR** LED:

| Number of blinks on ERR LED (250 ms) | Description |
|---|---|
| 0 | No errors detected |
| 1 | Error detected on loadcell 1 |
| 2 | Error detected on loadcell 2 |
| 3 | Error detected on loadcell 3 |
| 4 | Error detected on loadcell 4 |

## Appendix C – Status checks

During installation of the system, the following should be checked:

1. All hardware connections are made as described below.
2. Set the scaling/resolution of the weight signal by use of SWE.1 - SWE.2 as described above.
3. Set the desired measurement time by use of SWE.3 – SWE.4 as described above.
4. Select the desired filter by use of SWE.5 - SWE.8 as described above.
5. The loadcells are mounted mechanically and connected to BNC connectors in the front panel of the 4X60 unit.
6. The 4X60 EtherCAT unit is connected to the EtherCAT network using the IN (and possibly also OUT) EtherCAT connector(s) in the front panel.
7. Power (24VDC) is applied at the 2 pole power connectors in the front panel of the 4X60 unit as described in the hardware section, and the EtherCAT communication is started.
8. If necessary, the EtherCAT master should be configured to communicate with the 4X60 EtherCAT unit
9. Verify that the ERR lamp (red) ends up off.
10. Verify that the TxLC lamp (yellow) is “slightly” lit (turns on after approx. 5 seconds).
11. Verify that the TxBB lamp (green) is lit (after 10 seconds).
12. Verify that NONE of the 1, 2, 3 or 4 lamps (red) are lit.
13. Verify that the RUN lamp (green) ends up lit when the EtherCAT master is up and running and connected.
14. Verify that the 4X60 EtherCAT system unit has found the correct loadcells (`LcNo`), and that no loadcell errors are indicated (`LcStatus`).
15. Verify that every loadcell gives a signal (`LcXSignal`) by placing a load directly above each loadcell one after the other (possibly with a known load).
16. The system is now installed and a zero, optional corner calibration and fine calibration can be made as described earlier.
17. 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 EtherCAT master.

## Appendix D – Factory settings

On delivery the 4x60 EtherCAT unit is programmed with the `Eilersen 4X60-3.xml` (preliminary version) or newer ENI file and contains the following default factory settings:

| | |
|---|---|
| Box Name: | 4160 |
| Type: | 4160 Loadcell connector |
| Vendor ID: | 1830 |
| Vendor Name | Eilersen Electric Digital Systems |

## Appendix E – Internal Features (4x60)

This appendix describes possible connections, jumper settings and LEDs that are available internally on the 4060 EtherCAT module. Jumpers will normally be set from Eilersen Electric and should only be changed in special situations.

### Connectors and pin rows

The 4060 EtherCAT module is internally equipped with connectors (and pin rows). These connectors have the following function:

| Connector | Function |
|---|---|
| J1 | 14 pin connector<br>Reserved for future direct connection of 4015 module. |
| J7 | 14 pin connector for 4040 connection<br>Used for connection to 4040 module for loadcell connection. |
| J21 | STM32 JTAG connector (pin row)<br>Not used. |
| J8 | STM32 UART1 connector (pin row)<br>This connector is used when downloading new software to the 4060 module using the JP12 jumper. |

### Jumpers

The 4060 EtherCAT module is internally equipped with 4 jumpers. These jumpers have the following function:

| Jumper | Function |
|---|---|
| JP11 | STM32 RESET<br>The jumper allows reset of the onboard STM32 microcontroller.<br>OFF: Normal operation (normal setting from factory)<br>ON: Reset of the 4060 on-board microcontroller |
| JP12 | STM32 BOOT0<br>The jumper is used when downloading new software to the 4060 module using the J8 serial connector.<br>OFF: Normal power-up/operation (normal setting from factory)<br>ON: Download operation possible |
| JP2 | STM32 configuration jumper tbd<br>(Reserved for future use) |
| JP3 | STM32 configuration jumper tbd<br>(Reserved for future use) |

### Light Emitting Diodes (LEDs)

The 4060 EtherCAT module is internally equipped with 4 LEDs. These LEDs have the following functionality:

| LED | Function |
|---|---|
| D4<br>(Yellow) | RS485 RX<br>Data is received from 4040. |
| D8<br>(Red) | RS485 Enable<br>Transmission to the 4040 is enabled. |
| D9<br>(Green) | RS485 TX<br>Data is transmitted to the 4040. |
| D10<br>(Green) | Power<br>3.3 VDC internal power supply is on. |

## Appendix F – Internal Features (4040 communication module)

For information on jumper settings, DIP-switch settings, LED status lamps etc. on the 4040 communication module that is not covered in the above or below, please refer to the separate documentation that describes the 4040 communication module and its specific software.

### SW2 settings

The 4040 communication module is internally equipped with an 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 |

### 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 | Function |
|---|---|
| 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) |

### 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<br>(Red) | Reserved for future use |
| D12<br>(Red) | Reserved for future use |
| D13<br>(Red) | Reserved for future use |
| D14<br>(Red) | Reserved for future use |

## Appendix G – Data formats

The EtherCAT communication can transfer data in the following three data formats. Please refer to other literature for further information on these formats as it is outside the scope of this document.

### Unsigned integer format (16 bit)

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

| Decimal | Hexadecimal | Binary (MSBtbd 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 |

## Signed integer format (32 bit)

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

| Decimal | Hexadecimal | Binary (MSBtbd 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 |

# Revision History

| Date | Author | Rev. | *Update* |
|---|---|---|---|
| 2018-06-08 | jk | 1v0 | *Initial document created based on **Concentr-180312-1v0a-eng**.* |
| 2018-07-18 | jk | 1v0a | *Inserted warning that cross-over cables could be needed between modules in a chain of 4x60A modules* |
| 2018-08-20 | hja | 1v0b | *Inserted appendix with Non-ATEX and ATEX figures (power connection)* |
| 2018-10-31 | jk | 1v0c | *SWE numbering corrected* |
| 2019-06-07 | jk | 1v0c | *SWE numbering for sample time corrected* |
| 2019-09-05 | jk | 1v1 | *Software version updated* |
| | | | |
| | | | |

# Contact

With further questions or improvement suggestions please contact us:

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