# TMC8461-EVAL

Document Revision V1.00 • 2021-Feb-01

The TMC8461-EVAL is designed for evaluating all features of the TMC8461-BA EtherCAT Slave Controller. It can be used as bus interface module for EtherCAT applications.
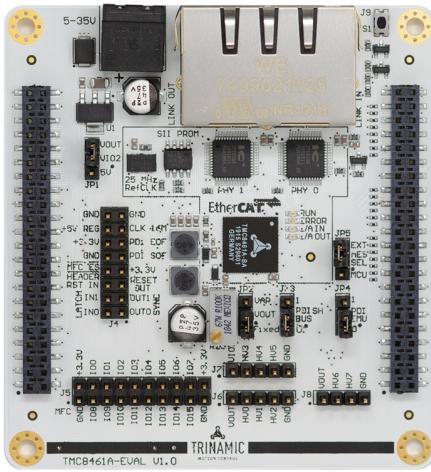
Features

- TMC8461-BA EtherCAT Slave Controller
- Board supply voltage: 5V to 35V
- Dual RJ45 TPC connector
- SPI PDI interface
- SPI interface for TRINAMIC's Multi-Function and Control IO Block (MFC IO)
- Access to all chip functions via pin headers and connectors
- Interface to TRINAMIC's evaluation board concept
- CAD design files available for download on www.trinamic.com

Applications

- Laboratory Automation
- Drives
- Semiconductor Handling
- Robotics
- Factory Automation
- Connected Sensors

Simplified Block Diagram

Read entire documentation.

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Contents

1 Getting Started

You need

- TMC8461-EVAL
- TRINAMIC's Landungsbruecke or Startrampe
- Firmware for Landungsbruecke or Startrampe with simple implementation of the ESM (Ether-CAT State Machine)
- Eselsbruecke connector board
- Power Supply 5V-35V for the evaluation board itself
- Latest TMCL-IDE
- RJ45 TPC cable
- EtherCAT master system (Beckhoff TwinCAT, SOEM, Omron, Ancosys...)
- Additional cables you need for your setup

Precautions

- Do not mix up connections or short-circuit pins.
- Do not exceed the maximum rated supply supply voltage!
- START WITH POWER SUPPLY OFF!
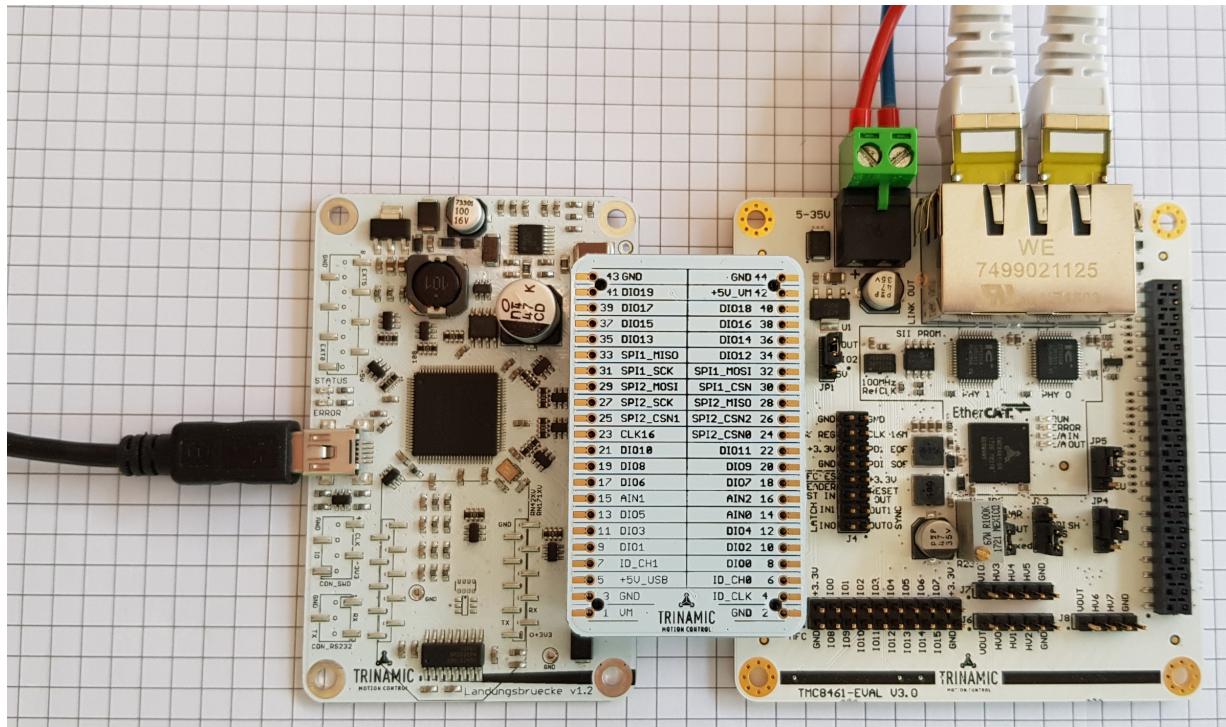
Figure 1: TMC8461-EVAL kit with Landungsbruecke, Eselsbruecke and TMC8461-EVAL

NOTICE   The Landungsbruecke operates on USB Power Supply.
All other voltages are generated from the evaluation board supply 5V-35V.
The kit works only when both supplies are connected.

1.1   First Start-Up

1. Make sure that the latest version of the TMCL-IDE is installed. The TMCL-IDE can be downloaded from www.trinamic.com/support/software/tmcl-ide/.

2. Open the TMCL-IDE and connect the Landungsbruecke or Startrampe via USB to the computer. For Windows 10 no extra USB driver needed. On Windows 7 and 8 machines the TMCL-IDE can install the driver automatically.

3. Verify that the Landungsbruecke or Startrampe is using the latest firmware version. The firmware version is shown in the connected device tree. The latest firmware is always available online at https://www.trinamic.com/support/eval-kits/details/landungsbruecke/ or https://www.trinamic.com/support/eval-kits/details/startrampe/
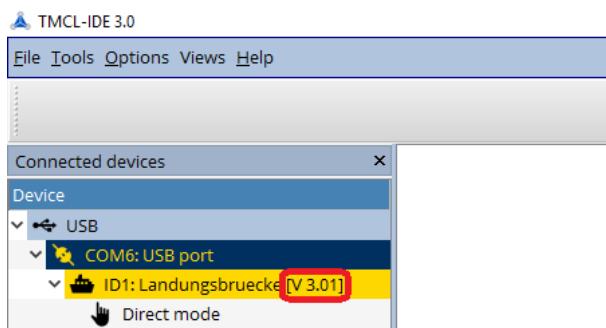
Figure 2: Firmware Version

4. The TMCL-IDE needs room to show all important information and to provide a good overview. Therefore, arrange the main window related to your needs. We recommend using full screen.
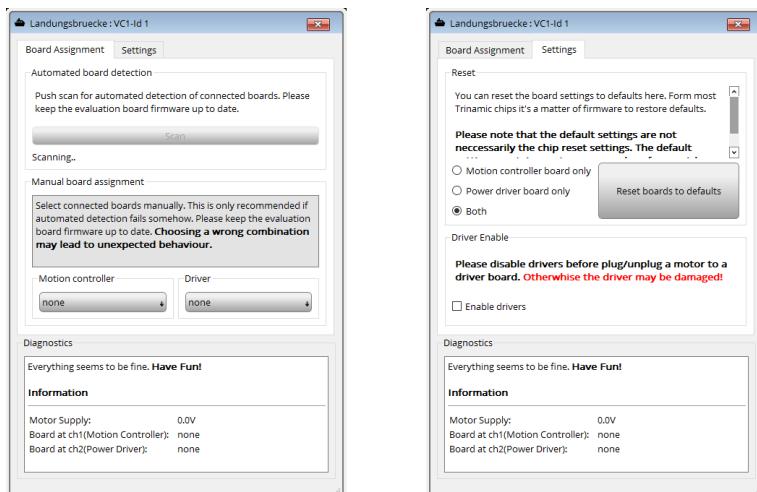
Figure 3: Landungsbruecke Dialogue

5. The TMCL-IDE includes a dialogue for diagnostic tasks for the controller board. Further, the dialogue provides an overview of the connected evaluation board (controller and/or driver). The TMC8461-EVAL should appear under "controller" by automatic detection. In case it does not appear, the evaluation board can also be selected manually. A window should pop up immediately after connecting

the evaluation kit the first time. The window shows the general status of the connected evaluation board. The second tab of the dialogue offers the possibility to choose basic settings or to reset the module.

NOTICE

With TMC8461-EVAL of version V3.0 the automatic detection is not possible. The board must be manually selected in "Motion Controller" drop down list. With TMC8461-EVAL of version V3.1 or higher, the automatic detection of the evaluation board is working properly.


6. If not yet done also connect your Ethernet TPC cables into the RJ45 bus connections of the TMC8461-EVALto connect to other EtherCAT slaves and your EtherCAT master system.

7. For operation with the Landungsbruecke and the TMCL-IDE please make sure that JP3 on the evaluation board is set on positions 1-2. This should basically be the default factory setting. It configures the SPI channels mode. Setting 1-2 is required for the Landungsbruecke.
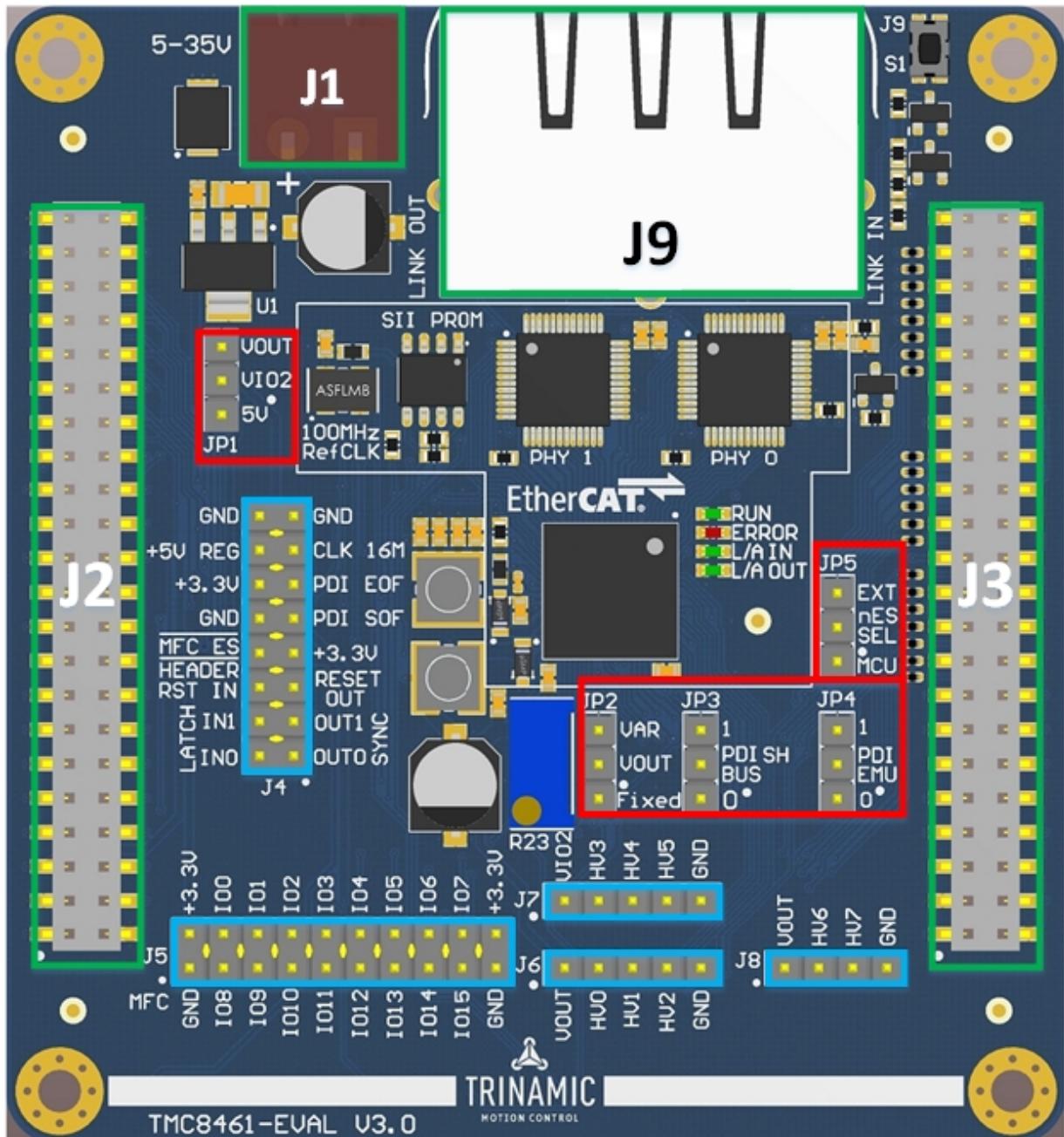
Figure 4: Top view of TMC8461-EVAL

2   Evaluation Board Sections and Components

Figure 4 top view of the TMC8461-EVAL shows the main connectors (green), signal pin headers (light blue), and jumper options (red).
The on-chip reset circuit takes care for proper power-on reset.
The tactile switch S1 in the upper right corner triggers a manual reset of the ESC and the PHYs.

2.1 Evaluation Board Connectors

Connector ID	Description
J1	Power supply connector for the evaluation board. Connect Ground and Supply here (5V-35V). Type: AKL320-02 by RIA
J2	Left side 44-pin connector with control signals going to TRINAMIC's Landungsbruecke or Startrampe controller board or a users own controller board. The Eselsbruecke connector board fits onto this connector. Type: HLE-122-02-F-DV by Samtec
J3	Right side 44-pin connector with configurable MFC IO singnals of TMC8461-BA. Type: HLE-122-02-F-DV by Samtec
J9	Double RJ45 twisted pair copper (TPC) connector to connect the TMC8461-EVAL to the EtherCAT bus. 10/100BaseT with integrated transformers. Type: 7499021125 by Wuerth Elektronik

Table 1: Board connectors

Please check the online available design files and schematic data for the connectors' signal connections and pinning.

2.2 Evaluation Board Pin Headers

There are 5 pin header groups on the TMC8461-EVAL– J4 to J8.

Pin Header ID	Description
J4	General control signals
J5	MFC IO 16x low-voltage/digital IOs
J6	MFC IO 3x high-voltage IOs, pin group 1 using VIO1
J7	MFC IO 3x high-voltage IOs, pin group 2 using VIO2
J7	MFC IO 2x high-voltage IOs, pin group 3 using VIO3

Table 2: Pin header groups

J4 contains various control and debug signals.
The distributed clocks synchronization output trigger signals and input latch signals are available along with some PDI debug signals.
Using a 2-pin jumper bridge across pin 5 and pin 6 (RESET_OUT to RST_IN) enables using the internal reset signal of the ESC. Thereby, the EtherCAT master or the local host can issue a TMC8461-BA device reset by writing a special character sequence into ESC registers 0x0040 or 0x0041.

Pin #	Description	Pin #	Description
1	SYNC_OUT0	2	LATCH_IN0
3	SYNC_OUT1	4	LATCH_IN1
5	RESET_OUT	6	RST_IN
7	+3.3V (= TMC8461-BA SW0 output)	8	MFC_NES_EXT

Pin #	Description	Pin #	Description
9	PDI_SOF	10	GND
11	PDI_EOF	12	+3.3V (= TMC8461-BA SW0 output)
13	CLK_16MHZ_OUT	14	+5V (from LDO U1)
15	GND	16	GND

Table 3: Pin header J4 pinning – general control signals

J5 allows access to all 16 low-voltage MFC IOs. They are using VCCIO = +3.3V. The actual function of these 16 MFC IOs is defined by the configuration of the MFC IO block's crossbar matrix and functional sub-blocks.

Pin #	Description	Pin #	Description
1	GND	2	+3.3V (= TMC8461-BA SW0 output)
3	MFCIO08	4	MFCIO00
5	MFCIO09	6	MFCIO01
7	MFCIO10	8	MFCIO02
9	MFCIO11	10	MFCIO03
11	MFCIO12	12	MFCIO04
13	MFCIO13	14	MFCIO05
15	MFCIO14	16	MFCIO06
17	MFCIO15	18	MFCIO07
19	GND	20	+3.3V (= TMC8461-BA SW0 output)

Table 4: Pin header J5 pinning – MFC IO 16x low-voltage/digital IOs

J6, J7, and J8 allow access to all 8 high-voltage MFC IOs. The voltage at these pins is configurable and can be up to the supply voltage. The 8 high-voltage MFC IOs are divided into three groups where each group has its own supply voltage. On the TMC8461-EVAL VIO1 and VIO2 are the same and directly driven by VOUT . VIO2 can be selected using The actual function of these 8 MFC IOs is defined by the configuration of the MFC IO block's crossbar matrix and functional sub-blocks.

Pin #	Description
1	VOUT (= TMC8461-BA SW1 output, configurable)
2	MFCHVIO00
3	MFCHVIO01
4	MFCHVIO02
5	GND

Table 5: Pin header J6 pinning – MFC IO 3x high-voltage IOs, pin group 1 using VIO1

Pin #	Description
1	VIO2 (= selectable and configurable)
2	MFCHVIO03
3	MFCHVIO04
4	MFCHVIO05
5	GND

Table 6: Pin header J7 pinning – MFC IO 3x high-voltage IOs, pin group 2 using VIO2

Pin #	Description
1	VOUT (= TMC8461-BA SW1 output, configurable)
2	MFCHVIO06
3	MFCHVIO07
4	GND

Table 7: Pin header J8 pinning – MFC IO 2x high-voltage IOs, pin group 3 using VIO3

2.3   Evaluation Board Jumper Settings

Jumper ID	Default Connection Pins	Description
JP1	2-3	JP1 selects the voltage used for bank 2 of the high voltage IOs VIO2. The default setting selects VOUT of the configurable buck regulator of TMC8461-BA. The VOUT itself can further be selected with JP2. The second option of JP1 is to used a dedicated fixed 5V voltage regulator output.
JP2	1-2	JP2 selects the configuration for the output voltage of the configurable internal buck regulator of TMC8461-BA. The default setting ("fixed") uses a voltage divider configuration for VOUT = 5V. The second option ("VAR") allows directly controlling VOUT with the potentiometer R23.
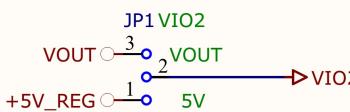
Jumper ID	Default Connection Pins	Description
JP3	1-2	JP3 selects the configuration of the two SPI control interfaces of TMC8461-BA (PDI SPI interface and MFC IO SPI interface). The default setting configures the interfaces to be two separate SPI buses with individual control and data signals. The second option is to physically share the PDI SPI bus and also allow access to the MFC IO SPI via the second chip select line.
JP4	1-2	JP4 selects the EtherCAT operation mode of TMC8461-BA. With the default setting, the EtherCAT slave controller operates in standard mode. TMC8461-BA thereby expects a controller including an EtherCAT State Machine (ESM) implementation at the PDI interface. The second option is to start-up the ESC in so-called PDI- or device-emulation mode, which allows operation without an external controller. State changes are then directly executed in hardware in the ESC.
JP5	2-3	JP5 selects the actual source of the low active (not) emergency switch input MFC_NES. MFC_NES has a weak internal pull down and must be driven high for normal operation. The default setting of JP5 configures the source of MFC_NES coming from pin header J4 at pin 8. The second option is that MFC_NES is driven by pin 23 of the 44-pin connector J2, for example by a connected TRINAMIC Landungsbruecke controller board.
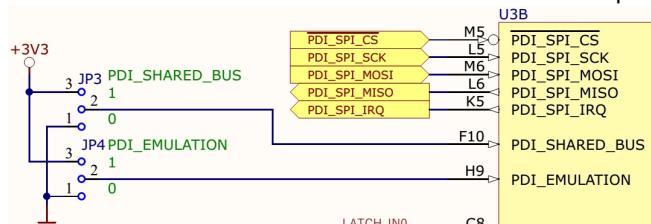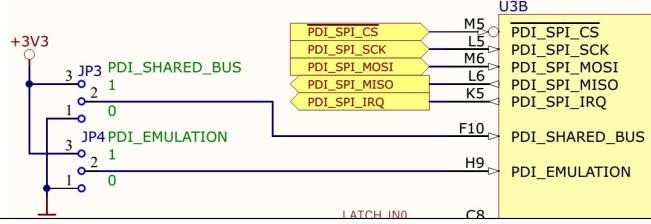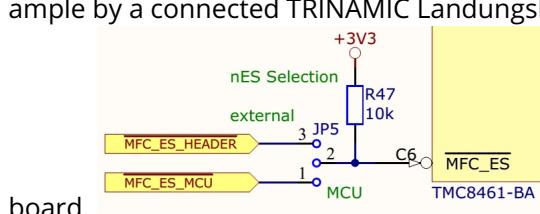
Table 8: Board jumper options and defaults

3 Evaluation Board Design Files

All design files for our evaluation boards are available for free. We offer the original ECAD files, Gerber data, the BOM, and PDF copies. Typically, the ECAD files are in KiCAD format. Some (older) evaluation boards may only be available in Eagle, Altium, or PADS format.
Please check schematics for Jumper settings and input/output connector description.

The files are available on the evaluation board website at https://www.trinamic.com/support/eval-kits/.

Note   If files are missing on the website or something is wrong please send us a note.

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4 Example XML File

The following example XML file is used as default configuration for the TMC8461-EVAL. This XML file is available for download from the evaluation board's webpage. Besides the standard ESI/XML configuration it includes the following blocks:

- The MFC IO configuration vector, which is defined as category 1 data to be automatically loaded in the ESC Parameter RAM at 0x0580-0x05E1. It is all zero in this configuration.

- DC mode configuration example

- ESC configuration <ConfigData> with general/start-up PDI and interface configuration

```xml
1  <?xml version="1.0"?>
   <EtherCATInfo xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
3   xsi:noNamespaceSchemaLocation="EtherCATInfo.xsd" Version="1.6">
     <Vendor>
5       <Id>#x286</Id>
        <Name>Trinamic Motion Control GmbH &amp; Co. KG</Name>
7       <ImageData16x14>424dd602000000000000360000002800000010000000e0000000
                        100180000000000a0020000130b0000130b0000000000000000000
9                       ...
                        b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3acacac1c1c1c
11     </ImageData16x14>
   </Vendor>
13 <Descriptions>
     <Groups>
15     <Group>
          <Type>TrinamicEVAL</Type>
17        <Name LcId="1033">EVAL Boards</Name>
          <Name LcId="1031">EVAL Boards</Name>
19     </Group>
     </Groups>
21   <Devices>
       <Device Physics="YY">
23        <Type ProductCode="#x26483055" RevisionNo="#x00010129">
                          TMC8461-EVAL Default</Type>
25        <Name LcId="1033">TMC8461-EVAL Default</Name>
          <Name LcId="1031">TMC8461-EVAL Default</Name>
27        <Info>
             <StateMachine>
```

```
29          <Timeout>
              <PreopTimeout>2000</PreopTimeout>
31            <SafeopOpTimeout>9000</SafeopOpTimeout>
              <BackToInitTimeout>5000</BackToInitTimeout>
33            <BackToSafeopTimeout>200</BackToSafeopTimeout>
            </Timeout>
35        </StateMachine>
          <Mailbox>
37          <Timeout>
              <RequestTimeout>100</RequestTimeout>
39            <ResponseTimeout>2000</ResponseTimeout>
            </Timeout>
41        </Mailbox>
        </Info>
43      <GroupType>TrinamicEVAL</GroupType>

45      <Dc>
          <OpMode>
47          <Name>Synchron</Name>
            <Desc>FreeRun/SM-Synchron</Desc>
49          <AssignActivate>#x0</AssignActivate>
          </OpMode>
51        <OpMode>
            <Name>DC</Name>
53          <Desc>DC-Synchron</Desc>
            <AssignActivate>#x300</AssignActivate>
55          <CycleTimeSync0 Factor="1">0</CycleTimeSync0>
            <ShiftTimeSync0>0</ShiftTimeSync0>
57          <CycleTimeSync1 Factor="1">0</CycleTimeSync1>
            <ShiftTimeSync1>0</ShiftTimeSync1>
59        </OpMode>
        </Dc>

61
      <Eeprom>
63      <ByteSize>2048</ByteSize>
        <!-- General/Start-up ESC Configuration -->
65      <ConfigData>050E034EC40900000000</ConfigData>

67      <!-- MFC IO configuration vector                              -->
        <!-- Category 1 data is required for the MFC IO configuration   -->
69      <!-- This configuration is automatically written from EEPROM to -->
        <!-- memory area 0x0580:0x05FF (ESC Parameter RAM).            -->
71        <Category>
            <CatNo>1</CatNo>
73          <Data>
              000000000000000000000000000000000000000000000000000000000
75            000000000000000000000000000000000000000000000000000000000
              000000000000000000000000000000000000000000000000000000000
77            00000000000000000000000000000000
            </Data>
79        </Category>
      </Eeprom>

81
  <ImageData16x14>424dd602000000000000360000002800000010000000e0000000
```

```
83                         100180000000000a0020000130b0000130b000000000000000000
                           ...
85                         b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3b3acacac1c1c1c
    </ImageData16x14>
87  </Device>
    </Devices>
89  </Descriptions>
    </EtherCATInfo>
```

5 Revision History

5.1 Document Revision

Version	Date	Author	Description
1.00	2018-02-26	SK	Initial release.
1.10	2018-06-15	SK	Update of getting started section.

Table 9: Document Revision