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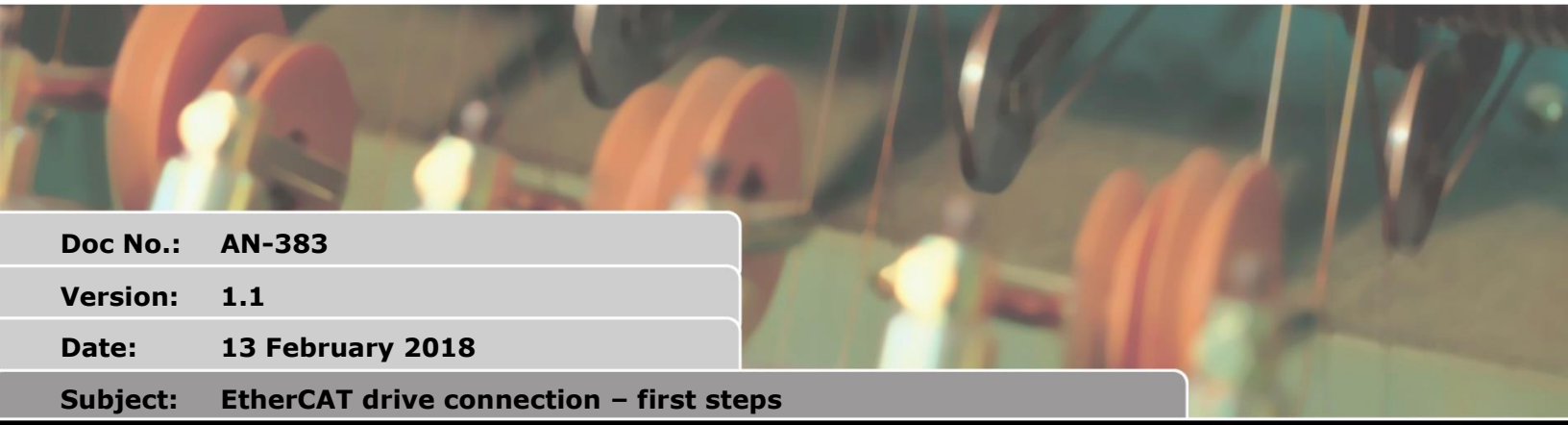

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Subject: **EtherCAT drive connection – first steps**

APPLICATION NOTE

1. Document history

30 January 2018	V1.0	First draft
13 February 2018	V1.1	Added debugging information

2. Introduction

Follow the steps below when connecting a drive to the MC4N-ECAT, MC664(X) or PC-MCAT EtherCAT master. Connection is mostly automatic and does not require use of the supplier's ESI file unless the drive type is new to Trio.

3. Terminology

CoE CanOpen over EtherCAT. The protocol most commonly used by drive manufactures.

SDO Service Data Object. A value that can be read or written on a non-cyclic basis.

PDO Process Data Object. A value that is read or written cyclically in synchronisation with the EtherCAT cycle.

ESI EtherCAT Slave Information. A file in XML format that is provided by the slave manufacturer.

4. Connection

Connect the master and slaves using Ethernet cable of Cat5e or greater, SHIELDED to SF/UTP. (Shield and Foil with Unscreened Twisted Pairs.)

5. Startup and debug

The drive should need no configuration in the Motion Coordiantor EtherCAT master. Simply connect and power up both. The example shown is a Delta ASDA-A2 servo drive. There are some checks you can do after connecting Motion Perfect v4 in Sync mode.

5.1. Using Terminal #0

Open Terminal 0. Then type ETHERCAT(0,0)

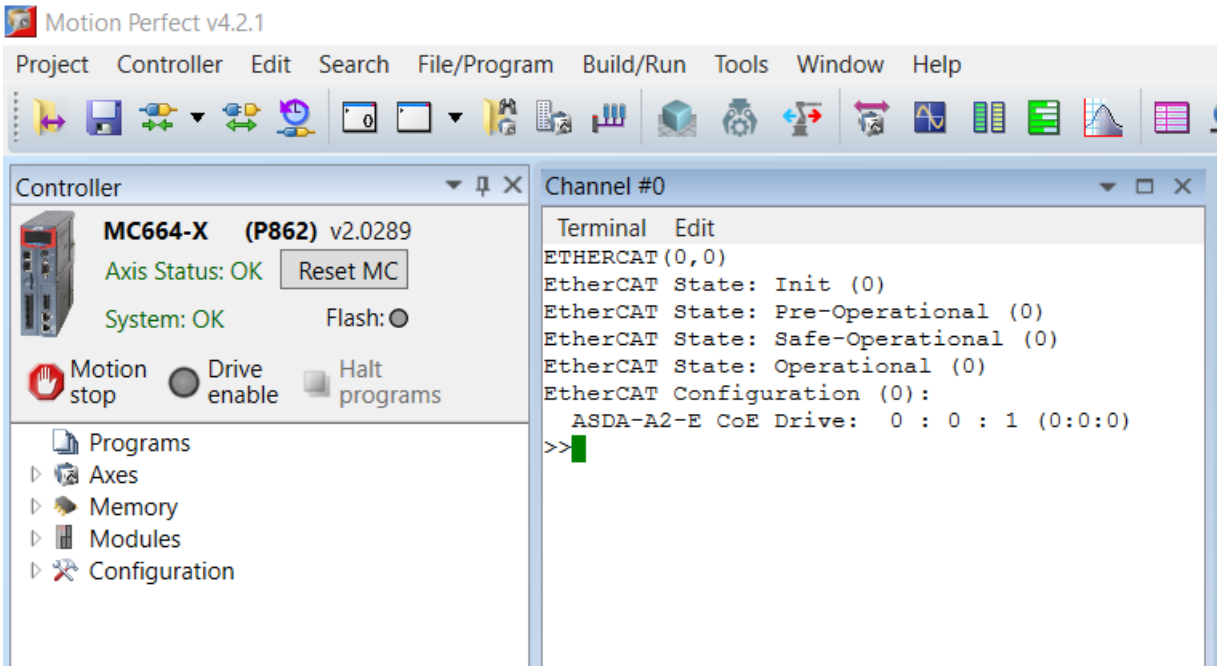

Fig 1. Startup text in terminal #0

If you see the EtherCAT go operational as shown in figure 1, then you are ready to run.

5.2. MC_CONFIG

We recommend you add one line of MC_CONFIG. Click File/Program then New. Select MC config file, then click enable editing. Add an AXIS_OFFSET for the built-in Encoder port.

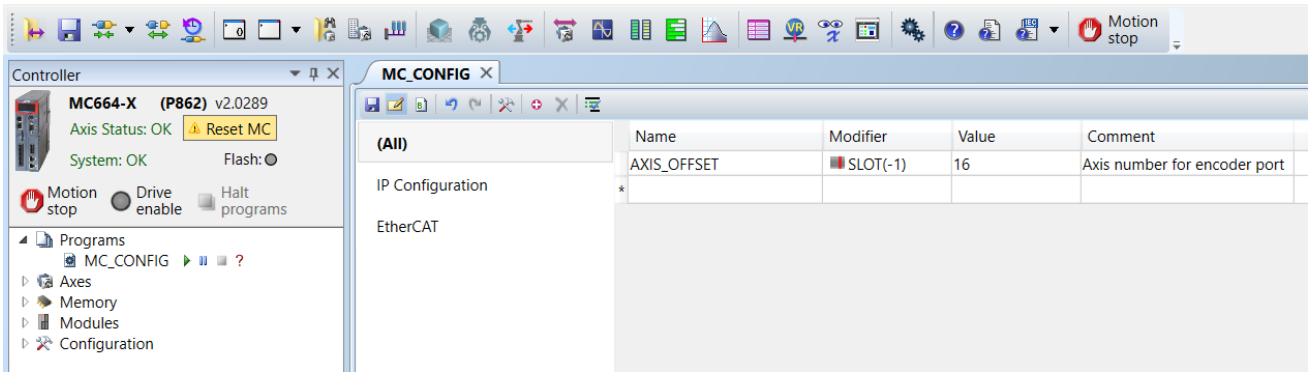

Fig. 2 AXIS_OFFSET in the MC_CONFIG file

Reset the MC664.

5.3. First program

Now you can add a program.

Select menu File/Program and New. Select BASIC and name your program. Put in these lines:

```
' enable and turn the Delta ASDA-A2

  BASE(0) ' this is the axis number of the drive
  SERVO = ON
  WDOG = ON

  UNITS = 1280000 ' number of encoder counts per turn
  SPEED = 2 ' turns per second
```

```
ACCEL = 20 ' turns/second/second
DECEL = 20

MOVE(10) ' move 10 turns
WAIT IDLE

MOVEABS(0) ' move back to 0 position
WAIT IDLE
```

If all is well, the drive will enable and the motor will move. WDOG ON has the action of setting the Enable bits in the CoE Control Word that is sent to the drive.

5.4. Using MC_CONFIG and STARTUP

In the Intelligent drives section you will find some setup information that writes to STARTUP and MC_CONFIG. We suggest that you do not use these until you are familiar with how the EtherCAT works.

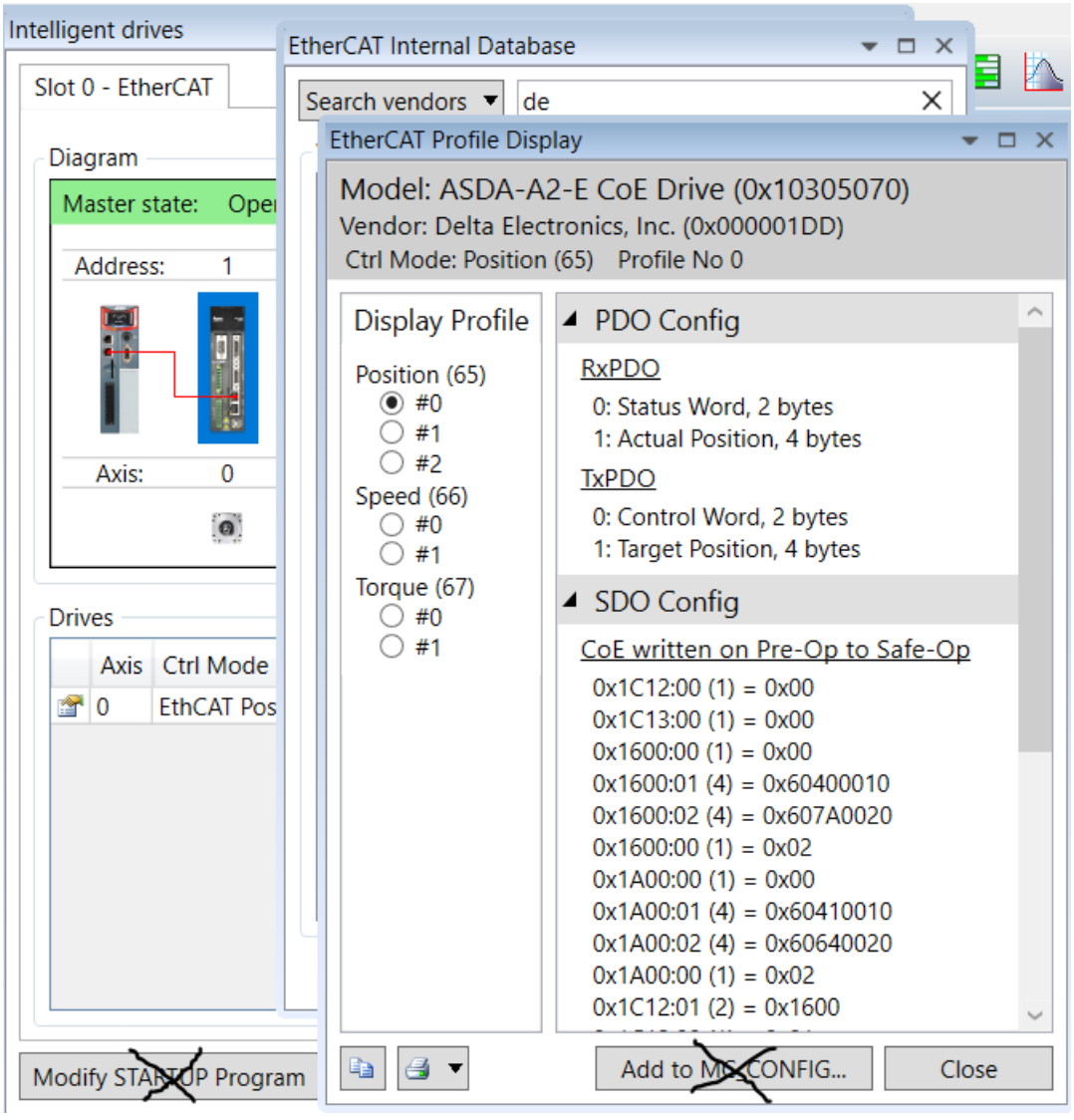

Fig. 3 Options for setting values in STARTUP and MC_CONFIG

Don't use these buttons unless you are an expert.

Instead, add DRIVE_MODE and DRIVE_PROFILE to MC_CONFIG yourself.

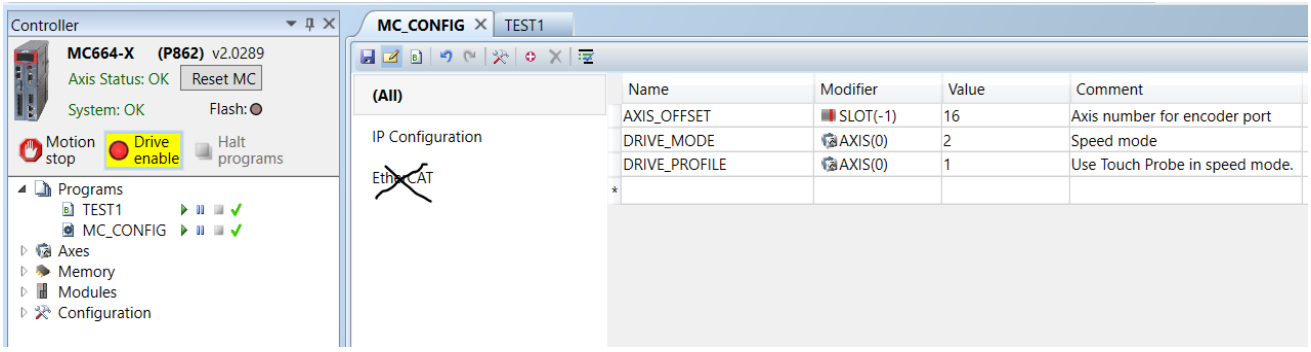

Fig 4. DRIVE parameters set in MC_CONFIG

We recommend that you do not use the EtherCAT part of MC_CONFIG until you are expert. The default setting works very well so there is no need to change it.
Note that Speed mode as shown above requires the P_GAIN, I_GAIN, D_GAIN and VFF_GAIN in the Motion Coordinator to be set up.

6. If things do not go to plan

Please contact Trio if you have any difficulty which you cannot resolve. Send the text you see on startup after ETHERCAT(0, 0).

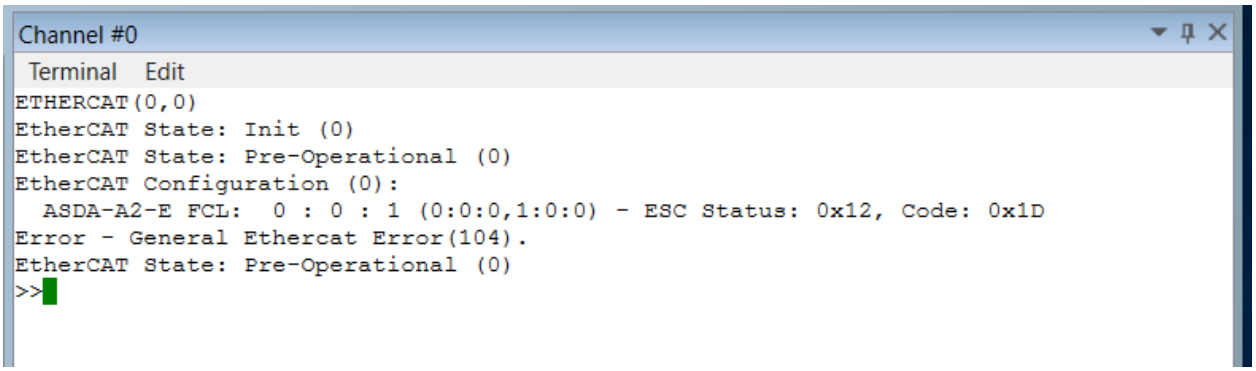

Fig 5. Startup with slave showing an error.

Also download the EtherCAT diagnostic report from Intelligent Drives and send it to Trio.

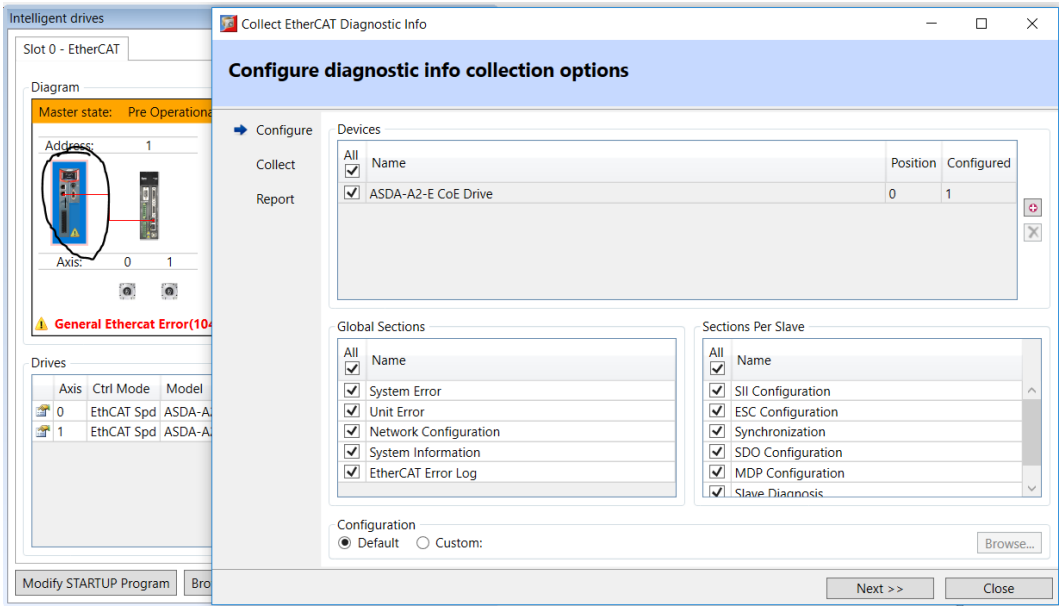

Fig 6. Double Click the image of the Motion Coordinator

Click next to run the report.

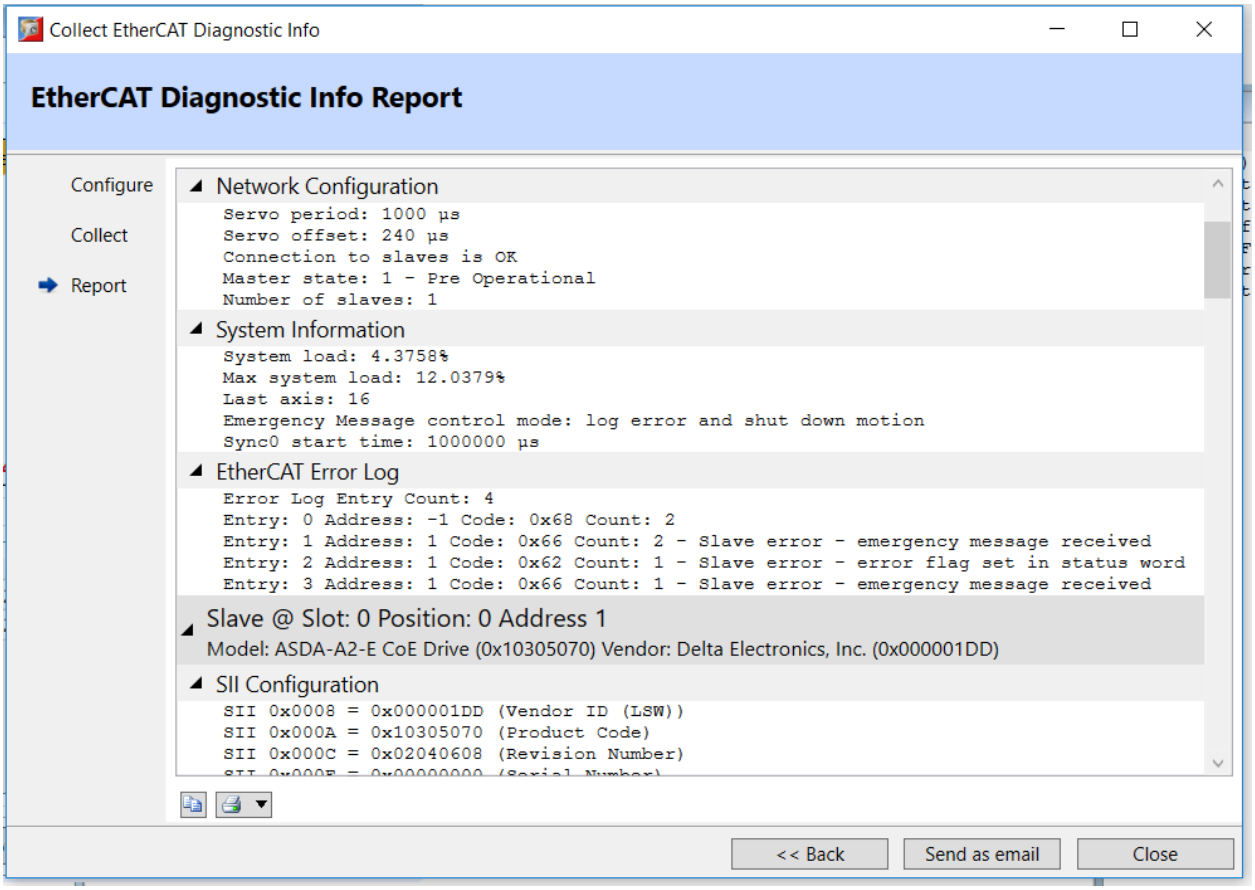

Fig 7. Diagnostic report for EtherCAT network

7. EtherCAT Debug Flow Chart

7.1. Terminology

ESM - EtherCAT State Machine

ESC - EtherCAT Slave Controller (the integrated circuit chip in the slave)

7.2. EtherCAT Overview

When the EtherCAT protocol is started, the controller will attempt to raise the network into the ESM *Operational* state. It is then ready to start executing motion and IO commands. If this is successful the EtherCAT communications are operating correctly. If *Operational* state is not reached then there is a fundamental EtherCAT configuration error.

The start-up message displayed in Terminal 0 from power-on, or after executing the ETHERCAT(0,slot) command indicates whether or not the start-up is successful. If the *Operational* state is reached it displays an overview of the slave devices found on the network. If *Operational* is not reached, it displays error information about the cause of the start-up problem. This message is the first place to look if your network does not go to *Operational* state as expected.

7.3. Initial Power on and Start-up

7.3.1. No drives on network or no cable.

The EtherCAT startup message display:

```
Warning - EtherCAT cable or network not detected (slot 0).
```

Note – we have met a few devices which are not seen on the network, the master-slave fails the Ethernet auto-negotiation process and can't see the device. Workaround is to put a device that can be seen before it in the network. For example; a simple EtherCAT IO or junction device.

If this error is encountered, then check :

1. Is the EtherCAT Ethernet cable present?
2. Is there a slave present and is it powered on? Is the first slave in the network powered on?
3. Some slaves take a long time (eg AKD around 40seconds) from power on before they will communicate on the EtherCAT network.
4. Does the slave have a plug-in EtherCAT module, and if so is it correctly inserted and configured on the slave. (Some devices need manufacturer defined parameters set on before they will enable the EtherCAT plugin module.)
5. Is the EtherCAT Ethernet lead inserted in the correct connection on the drive? Ensure the RJ45 connection is for EtherCAT, and also the correct network receive-in, transmit-out orientation.
6. If the expected IO or axes on EtherCAT devices do not appear – has the protocol been started on the controller? Check the ESM state in Intelligent Drives.
7. Is the protocol explicitly stopped by the AUTO_ETHERCAT = 0 command in MC_CONFIG? If so, has a program run the ETHERCAT(0, slot) command?

7.3.2. Axis assignment Error

The EtherCAT startup message display:

```
Error - unable to assign required axis number.
```

EG:

```
>>?ETHERCAT(0, 0)
EtherCAT State: Init (0)
EtherCAT Configuration (0):
    R88D-KN02H-ECT:  0 : 0 : 1 (-1) - ESC Status: 0x01, Code: 0x00
Error - unable to assign required axis number.
EtherCAT State: Init (0)
```

1. The EtherCAT protocol will attempt to assign axes from the AXIS_OFFSET for the module's slot number. (slot = 0 for the MC4NE) If this axis is already assigned the 'Error – unable to assign required axis number' message will be displayed and the start-up will fail.
2. The error can arise if the slave device has a configured address set to a value beyond the last axis of the controller. This can be resolved either by setting the configured Alias address in the slave to a lower number, or by using the system parameter: NODE_AXIS(slot, node) to set an address for the device.

If the error code 'Too many Axes' is displayed the controller has insufficient feature enable codes to enable the number of axes on the network. Additional feature codes need to be purchased and enabled on the controller.

Checks:

Check the AXIS_OFFSET and slave device configured addresses.

7.3.3. Configuration Error

The controller aborts the start-up in the ESM *Initial* state, displays the Cnn error (where nn is the slot number for the EtherCAT module or port) and the start-up message shows:

```
Error - unable to find slave configuration information.
```

EG:

```
>>?ETHERCAT($0,0)
EtherCAT State: Init (0)
EtherCAT Configuration (0):
    R88D-KN02H-ECT:  0 : 0 : 1 (1) - ESC Status: 0x01, Code: 0x00
Error - unable to find slave configuration information.
EtherCAT State: Init (0)
0
```

If that error message is displayed then the controller is unable to find the configuration information required to start up a device on the network. The most usual reasons are;

1. The device has not been met before and hence the controller does not have the configuration information and there is no EC_EXTEND file with configuration information for the device. In this case, the device name will be shown as 'UNKNOWN'.

   If this is a new device, then the controller might not have its configuration information. This can be verified using the Intelligent Drives in Motion Perfect v4 to check the configuration information held by the firmware release. Click the Browse Database button. This problem can usually be resolved by generating and loading an EC_EXTEND file onto the controller containing the required information. (Note that the configuration information will vary between firmware builds as more profiles are added.)

2. An invalid 'profile' has been selected by the NODE_PROFILE, DRIVE_PROFILE and/or DRIVE_MODE parameters. Usually found in MC_CONFIG.

   If the device was working previously but is now generating this error, then perhaps there is a DRIVE_PROFILE or NODE_PROFILE command in the MC_CONFIG file (or has been executed in a

program or on the command line) that sets an invalid profile for this device. These values can be checked by printing to the command line, eg

```
>>print drive_profile axis(1)
10
```

3. Is an earlier firmware release being used which does not contain the required device configuration information?

Checks:

Check the slave device's Vendor ID and Product Code (using the Intelligent Drives diagnostic report)

Check the NODE_PROFILE, DRIVE_PROFILE and DRIVE_MODE parameters. Check the internally held EtherCAT configuration information.

Verify the controller has the configuration information for the device based on its Vendor ID, Product Code, control mode (for axes), and drive or node profile.

7.3.4. Startup Network Topology

If a device does not appear in the correct physical location in the network list displayed by the controller, then the EtherCAT network in/out connections are probably reversed on the slave device.

7.3.5. Addressing Error

Verify there are no slave devices on the network which have the same configured address.

7.4. Errors raised after the EtherCAT Network has reached Operational State

If the network reaches the ESM operational state the EtherCAT communications are most likely to be ok. Errors raised now are generally because the slave devices have incorrect manufacturer parameter values, or there are actual hardware setup errors (wiring error, missing or faulty encoder cable etc.) The exception to this guideline is the Axis Status 'A' error.

7.4.1. Axis Status 'A' (communications error to remote drive) Error

The axis status 'A' error (communications error to remote drive), or the 'remote drive lost' system error is raised. In these cases the telegram received by the master does not have the expected slave count (the working counter is wrong.) This might occur if:

1. A slave is lost. E.g. powered off, or has dropped out of ESM operational state.
2. A slave does not correctly execute its cyclic process data command.
3. Large axis count or complex multi-axis moves causes a controller timing conflict (where the firmware and FPGA both attempt to access the EtherCAT telegram at the same time.) See 'Axis Count Issues' section of this document.

7.4.2. Axis Status 'M' (Remote Drive) Error

The controller firmware will raise the 'Remote Drive Error' (Bit3, 'M') in the AXISSTATUS axis parameter when the drive sets the error bit in the CoE/SoE status word. This is the **Drive** indicating that it has a fault.

Temporary faults can be cleared by executing the 'reset error bit' procedure for the drive, using function 0x64 of the TrioBASIC ETHERCAT command.

```
ETHERCAT($64,<axis_number>)
```

Eg, for axis 5 :

```
ETHERCAT($64, 5)
```

If the fault is permanently present on the drive, or requires a drive power-cycle to clear, then the above procedure will not reset the 'Remote Drive Error' bit. For example low bus voltage cannot be cleared until the power is re-applied to the drive's motor power stage.

There are many possible reasons why the drive might raise this error – for example

1. An encoder feedback fault.
2. Power stage not enabled.
3. Axis/axes missing (the motors are not connected to the drive).
4. Some drives raise this error when attempting a move with POT and NOT active.
5. Safe-Torque-Off is activated.

Further information about the cause of the fault must be obtained from the drive. Perhaps through an error code shown on a front panel display or LED pattern. Some drives will support the standard CoE 'error code' object. (0x603F:00) Reading this will return an error code which will indicate the fault when cross-referenced to the drive manual. Other drives might have manufacturer specific CoE objects. (refer to the drive manual)

```
>>? CO_READ_AXIS(axis_number,$603f,0,4)
```

7.4.3. Drive sends EtherCAT Emergency message

Some drives will send an 'emergency message' to the controller. If so, these messages are recorded in the EtherCAT error log, and can be read back using the Intelligent Drives diagnostic report.

If an Emergency message is received by the Trio EtherCAT master, then it will raise a SYSTEM_ERROR and set the WDOG to OFF. This over-rides any axis setting for control of the WDOG and enables. For example DISABLE_GROUP will not group axes or nodes regarding a SYSTEM_ERROR.

If it is safe to do so in a system, then the action of the Motion Coordinator on receiving the Emergency Message can be changed to 'Log Emergency Message and do NOT set WDOG to OFF'. This can be set by ETHERCAT function 0xE0, or by setting ECAT_MODE bit 0 to 1 in MC_CONFIG. (Requires firmware version 2.0290 or later)

E.g.

```
ETHERCAT($E0, 0, 1) ' set Emergency telegram mode for slot 0
```

In MC_CONFIG

```
ECAT_MODE SLOT(0) = 1
```

7.5. Errors raised on moving the motor

7.5.1. Motor does not move

How to determine why a motor does not move will depend upon whether you are using a known good drive with the Trio master, or debugging a new drive.

However, first make sure there are no errors displayed by the drive front panel, or EtherCAT module Leds. Is the drive wired correctly?

7.5.2. Known good drives :

If the network has reached the ESM operational state, but the drive motor will not move, then check the following.

1. Is the drive wired correctly?
2. Is the Safe-torque-off plug fitted?
3. External hardware enable not active?

4. Is the power stage energized?
5. Is the 'Servo' axis parameter ON for the axis?
6. Is there torque on the motor shaft?
7. Has the motor reached a drive end limit (eg a manufacturer parameter in the drive.)
8. Is the motor moving but very slowly – EtherCAT devices usually have 32 bit set point and feedback values, and hence can require large demand values (if units =1 for the axis)
9. Check the encoder count per revolution for the drive, these can be very large numbers. Default SPEED is 1000. This is very slow for a 24 bit encoder. 2^24 = 16777216 counts per turn!

7.5.3. New Drives

Does the drive enable and hold position? i.e. torque on the motor shaft.

Check the drive status word – is the "ready to switch on" bit set?

If the drive does not enable, then check the cyclic data mapping to confirm the PDO set, and then check the axis DRIVE_CONTROLWORD and DRIVE_STATUS against values read back over the SDO service channel. In CoE these are objects 0x6040:00 and 0x6041:00 respectively.

Use Intelligent Drives diagnostic report for this. Check the MDP section for the slave to see the PDO map.

If this is ok check the value the drive expects in the control word to enable it (this does vary depending upon control mode.)

Check whether there is a manufacturer specific parameter to enable the EtherCAT interface, particularly if the EtherCAT connectors are mounted on a plug-in module. Perhaps the EtherCAT communications are running correctly, but the cyclic data is not being transferred to the drive's internal target position memory.

7.5.4. Motor moves, but generates a following error trip

If we get a following error, shown by 'E' in the AXISSTATUS, then check that FE_LIMIT is set to at least half a turn.

If the drive profile includes DRIVE_FE, it might be tripping the axis on DRIVE_FE_LIMIT. Set DRIVE_FE_LIMIT to about half a turn and FE_LIMIT to at least 2 turns.

Recheck the actual control mode (Ox6061:00), and the EtherCAT PDO cyclic data mapping. Check the cyclic data using the Intelligent Drives diagnostic report – is the target position, speed or torque DAC_OUT value reflected back in the appropriate CoE object read over the SDO service channel?

7.5.5. Motor moves, but the motion is not smooth

Check that the drive cycle time parameter set correctly.

The Kollmorgen AKD-N drive has the drive internal cycle time parameter (FBUS.SAMPLEPERIOD) which must be the same as the EtherCAT cycle time set by the controller SERVO_PERIOD.

Check the setting of CoE objects 0x60C2 sub indexes 1 and 2. Are they the same as the controller SERVO_PERIOD?

Check to see if a ESC Sync 0 offset is required. The default Sync 0 offset is -70000 nanoseconds for firmware 2.0287 and lower and zero for 2.0288 and above. Use NODE_SYNC_OFFSET in MC_CONFIG to set the Sync 0 offset for specific slaves.

E.g.

```
NODE_SYNC_OFFSET(0, 1) = 150000 ' value in nanoseconds
NODE_SYNC_OFFSET(0, 2) = 400000 ' value in nanoseconds
```

7.6. Errors when using advanced functions

7.6.1. Position Registration/Datum Error

If a slave drive has reached the operational state, and the motor can be moved, but it does not excute a DATUM(1), DATUM(2) or REGIST(20 …) command correctly then check:

1. Has the touch probe profile been selected for the drive? Verify DRIVE_PROFILE and DRIVE_MODE for the appropriate axis. Also verify the value in NODE_PROFILE if used.
2. Verify the selected profile does actually contain the Touch Probe functionality in the firmware release. Use the Intelligent Drives – Browse Database to verify the profile selected does contain the touch probe function and status objects.
3. Check that the drive supports Touch Probe. Does it support Touch Probe Z mark capture?
4. If the motor has an absolute encoder, then Touch Probe functions may be disabled. See drive manual.

7.6.2. Drive Digital IO

Digital IO in the drive can be mapped to the PDO using an EC_EXTEND configuration file. Check to see if the mapping is as expected by typing IOMAP in terminal 0.

e.g.

```
>>IOMAP
Digital Input map :
   0-   7 : Built-in Inputs
   8-  15 : Built-in Bi-Directional IO
  16-  47 : ECAT Servo @ Slot 0 (Auto Inc Address = 1)
  48-  79 : ECAT Servo @ Slot 0 (Auto Inc Address = 2)
  80-1023 : Virtual

Digital Output map :
   0-   7 : Reserved
   8-  15 : Built-in Bi-Directional IO
  16-  47 : ECAT Servo @ Slot 0 (Auto Inc Address = 1)
  48-  79 : ECAT Servo @ Slot 0 (Auto Inc Address = 2)
  80-1023 : Virtual
```