Kyntronics
Innovation in Motion

# TECHNICAL REPORT

# TR-990

## GENERAL INTERFACE FOR ETHERCAT

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|---|---|---|---|
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## TABLE OF CONTENTS

# 1 PURPOSE

To provide guidelines for interfacing Kyntronics Smart Hydraulic Actuator over EtherCAT.

# 2 USER INTERFACE OVERVIEW

Drive control communication utilizes the EtherCAT protocol via RJ-45 ports on the SI-EtherCAT option module.

Drive communication can use both protocols of EtherCat: PDOs and STOs.

PDOs (Process Data Objects) are the faster of the two, but with fixed content. The host PLC continuously writes to the Command register, Target Position, etc. The SHA continuously returns Status, Position, FaultCode, etc.

SDOs (Service Data Objects) can access all of the drive's registers. They are typically used to modify motion parameters which change less frequently. But it is possible to do the whole interface with just SDOs

# 3 STO (SAFE TORQUE OFF)

STO (Safe Torque Off) is a method of reliably disabling a motor for safety purposes, without shutting off the drive's electrical power. This drive is equipped with two electrically isolated 24VDC STO discrete inputs. Typically, they are tied to a safety relay, as part of an E-stop circuit. Turning off STO does not interfere with any logic or communications functions of the drive. The installation print shows the STO terminals on the drive.

If the drive's STO inputs are not satisfied, the display will show "Inhibit" (M70x drive) or "n" (M75x drive) for no torque. If the STO inputs have 24 Vdc applied and the DC bus has full power, the display will show "Stopped" (M70x drive) or "A" (M75x drive) to show torque is being applied to the motor. When a jog or motion command is active, the M70x drive display will show "Run" along with the motor speed in RPM.

# 4 ETHERCAT PDO (SCANNED) COMMUNICATIONS

Process Data Objects is a technology used to make registers in a remote device act like scanned I/O. The host PLC sets up an arrangement with the remote device, detailing how many registers of what length are going to be read and written. Then when the PLC scans the device, it only has to send the outputs and read the inputs. The addresses are implicit.

A "DINT" is a Double precision INTeger. In most computers and PLCs this is a 32-bit (4 byte) variable. All data exchanged over the SHA's EtherCAT interface is in the form of DINTs.

The Outputs PDO interface includes five registers (data from the PLC to the SHA).

COMMAND: (bitmap)

Bit 0 – Enable closed loop control (See text)
Bit 1 – Select Position mode
Bit 2 – Select Force Limiting Position mode
Bit 3 – Select Force mode
Bit 4 – Jog Extend (See Manual Control Section)
Bit 5 – Jog Retract "
Bit 6 – Enable Jog mode "
Bit 8 – Halt. OR this bit ON with a Command active causes the motion profile generator ramp to zero speed using accel rate, similar to a Feedhold. Then, setting this bit back to 0 will cause the motion profile to resume the specified command mode.
Bit 15 – Reset fault (See Faults section)

Position or force control is active when bit 0 is true, one of the three modes is selected, the drive is not faulted, and the STO input is satisfied.

TARGET POSITION:
Desired value in Position and Force Limited Position modes.
Units are scaled 32-bit integer, based on the specifics of the actuator (typically mm *100 for SSI position sensor or inches * 1000 for analog; consult the SHA Technical Report for specifics.

FORCE LIMIT MAX:
Compressive (rod extending) limit in Force Limited Position mode. Units are pounds.
If there is no extension force sensor, then set this value large and positive to disable the limiting.

FORCE LIMIT MIN:
Tension (rod retracting) limit in in Force Limited Position mode. Units are pounds.
Set negative, as the system considers tension to be "negative force". If there is no retract pressure sensor, then set this value large and negative to disable the limiting.

FORCE TARGET:
Desired value in Force mode. Units are pounds. Positive is compression, and negative is tension.
Used with pure Force mode. A positive value will extend, looking for this force, and a negative value will retract looking for this force. If only an extend pressure sensor is present, then a negative value will still cause a retract, but no true retract force can be measured, so care must be taken to stop the retract motion prior to striking the internal retract hard stop inside the actuator.

The Inputs PDO includes four registers (data from the SHA to the PLC).

STATUS: (bitmap)
- Bit 0 - Ready (No faults, and the STO is satisfied. Stays on while moving.)
- Bit 1 - In Position mode
- Bit 2 - In Force Limited Position mode
- Bit 3 - in Force mode (do not use)
- Bit 5 - Faulted
- Bit 11 - STO is satisfied
- Bit 12 - Jogging

The other bits do not apply to this application, but should not be assumed to be zeros.

MEASURED POSITION:
Units are hundredths of millimeter, measured from "zero" as covered in section 3 above.
Its validity is not influenced by SafeTorqueOff or Command or Faults.
Increasing values correspond to extending the rod.

FAULT CODE:
Retains the current or last fault. Does not clear when fault goes away.
But the Faulted bit in Status word does. See Faults section below.

MEASURED FORCE:
This SHA can only measure extend force, and it will be expressed as a positive value, in pounds.
The convention for SHAs is that positive corresponds to compressive (extending rod) force.

They can also be accessed by SDOs or by the keypad/display.

| Name | Units | Keypad Addr | EtherCAT Address |
|---|---|---|---|
| COMMAND | Bitmap | 0.20.035 | Rx Index 0x2014 Subindex 0x23 |
| Target Position | MM * 100 | 0.20.036 | Rx Index 0x2014 Subindex 0x24 |
| Force Limit Max | Pounds | 0.20.037 | Rx Index 0x2014 Subindex 0x25 |
| Force Limit Min | Pounds | 0.20.038 | Rx Index 0x2014 Subindex 0x26 |
| Force Target | Pounds | 0.20.039 | Rx Index 0x2014 Subindex 0x27 |
| STATUS | Bitmap | 0.19.051 | Tx Index 0x2013 Subindex 0x33 |
| Measured Position | MM * 100 | 0.19.052 | Tx Index 0x2013 Subindex 0x34 |
| Fault Code | See Faults | 0.19.053 | Tx Index 0x2013 Subindex 0x35 |
| Measured Force | Pounds | 0.19.054 | Tx Index 0x2013 Subindex 0x36 |
| | | | |

# 5 ETHERCAT SDO MESSAGING INTERFACE

EtherCAT Process Data Objects (PDOs) are used for data such as Command and Status. They are rapidly and constantly scanned in a background task, which makes programming easy. But there are other motion parameters which are changed infrequently or never. Having the PLC read the current values and transmit new values would require exchanging many more bytes. This would slow scanning down for no good reason.

Service Data Objects (SDOs) are the alternate method of data exchange in the EtherCAT protocol. It allows the PLC to read or write one register only when desired. For example, the host could read all of the default values at startup, and adjust any as desired.

SDO messaging can address any parameter in the drive, bar none. Therefore, one should be cautious when first testing a new bit of software. Consider for example reading a particular parameter first as a test. Use the keypad to modify the value and read again. The idea is to verify that you really are addressing the parameter you think you are, before you write to the drive.

All data exchanged over the SHA's EtherCAT interface is in the form of a 32-bit (4 byte) variable. In most computers and PLCs this is referred to as a Double precision INTeger or "DINT".

Drive parameters are structured in the form: Device.Menu.Element In this system, devices are numbered 2, 3, and 0 (blank on the keypad).

The most frequently adjusted/monitored parameters are listed in the PDO section above. These are the less frequently adjusted motion parameters. The addresses are used for the keypad/display or SDOs, which can be either Download or Upload.

| Name | Units | Keypad Addr** | EtherCAT Address** |
|---|---|---|---|
| Position Jerk | Mm/Sec^3 * 100 | 3.70.001 | Index 0x2370 Subindex 0x01 |
| Position Accel | MM/Sec^2 * 100 | 3.70.002 | Index 0x2370 Subindex 0x02 |
| Position Velocity | MM/Sec * 100 | 3.70.003 | Index 0x2370 Subindex 0x03 |
| | | | |
| Current/Torque Limit | Percent | 3.70.084 | Index 0x2370 Subindex 0x54 |
| | | | |
| For Force mode: | | | |
| Pump Speed Max | RPM | 3.70.080 | Index 0x2370 Subindex 0x50 |
| Pump Speed Min | RPM | 3.70.081 | Index 0x2370 Subindex 0x51 |
| Force Jerk | Lb/Sec^3 | 3.70.091 | Index 0x2370 Subindex 0x5B |
| Force Accel/Decel | Lb/Sec^2 | 3.70.092 | Index 0x2370 Subindex 0x5C |
| Force Velocity | Lb/Sec | 3.70.093 | Index 0x2370 Subindex 0x5D |

** Consult the SHA Technical Report for these addresses. M70x drives will use the 3.70.001 address and EtherCAT address shown in the table. M75x drives typically have these same parameters but in option slot1 on the drive, so the parameter address is 1.70.001 and the EtherCAT address would be Index 0x2170 Subindex 0x01, etc.

The Pump Speed parameters may be used to limit top speed while in force mode.

This can be useful when engaging before contact is made with the load, to prevent charging forward.
Note that the Pump speed limits are measured in rotations per minute of the pump itself.

The pump is essentially positive displacement, so this can be converted to linear travel.
Since the piston rod is not zero diameter, it takes less fluid to move the piston in the retract direction.
Therefore, retract will move faster than extend, when both motions use the same motor RPM.

# 6 FAULTS

The built-in (single digit) display will signal trip codes by scrolling in the form “E###-###”.
The first number is the trip code, and the second is the subtrip code.
Hardware faults are signaled in the form “HF-###”.

The optional display/keypad decodes most faults to a description in English.

The red Reset button on the keypad will clear a fault unless its cause persists, such as undervoltage.

Bit 15 in the COMMAND register performs the same function as the red Reset button on the keypad.

The FAULTCODE input register in the interface holds the current or last fault code reported by the drive.
It does not go to zero when the fault is cleared. (But the Faulted bit in STATUS does.)
Its value is a composite of two fault registers within the drive.

The MSW (top 16 bits) are the Trip Value, from drive menu 10.020.
The LSW (bottom 16 bits) are the Sub-Trip Value from menu 10.070.

The Nidec/CT M750 User Guide section 13.4 has 35 pages of trip codes. Here are the common ones:

2 : OverVolts – Energy from an overhauling load or fast decel has raised the DC bus too high.
3 : Instantaneous Overcurrent – Cannot be reset for ten seconds.
6 : External Trip.3- Load dump resistor thermostat tripped, if equipped. See below.
19 : Brake R Too Hot – Energy dumped into the braking resistor during fast decels has overheated it.
20 : Motor Too Hot – This is estimated by a mathematical model; not a sensor.

The pump is supervised by a thermostat, which is closed when temperature is below the trip point.
The thermostat is monitored by drive input 6, readable at menu 08.006. It should be high (on) when OK.
If the thermostat trips, the keypad will announce this fault as “User Trip.001”.
If you see this error during startup, verify the wiring of the PUMP THERMAL cable.
If you see this error on every powerup, and the reset button clears it, see section 16.4 of this manual.

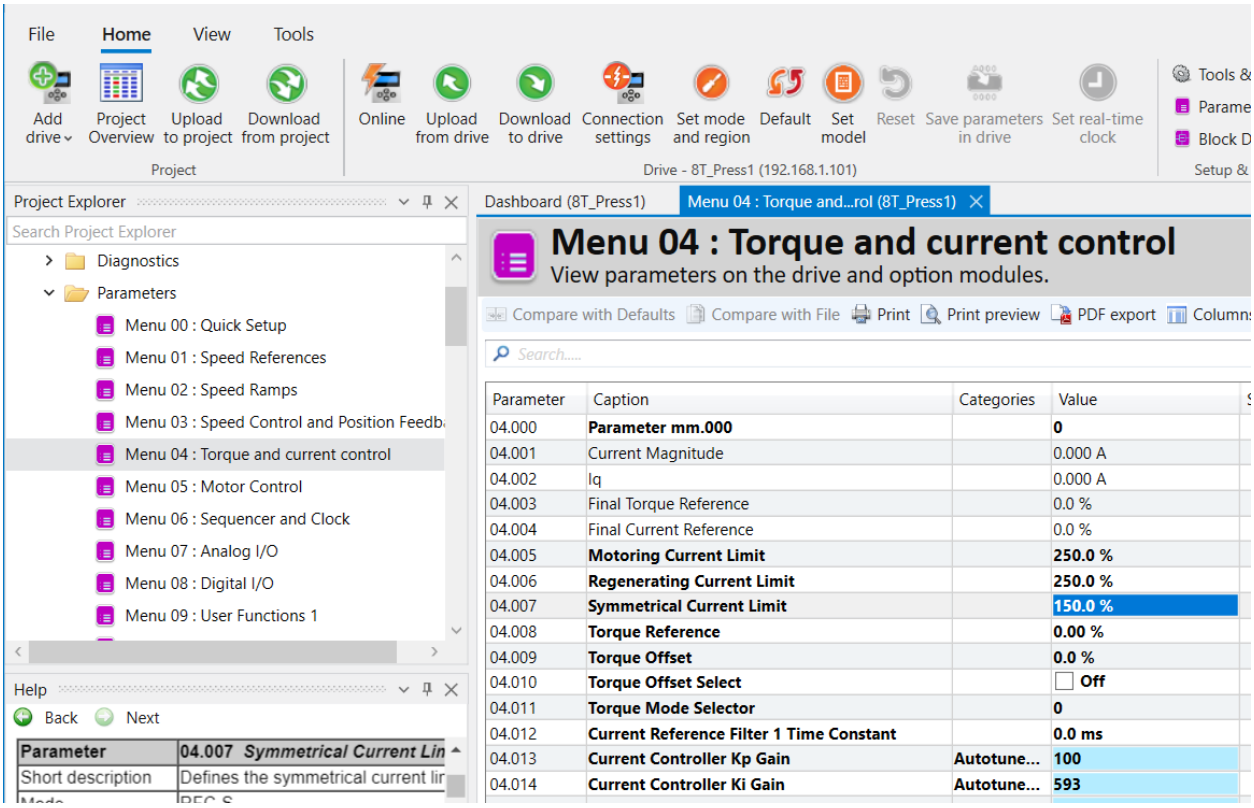
The actuator has internal relief valves on extend and retract, which limit the internal pressure of the actuator. These valves are spring-loaded. When tripped, they provide a “short-circuit” path for the fluid to relieve/limit the internal pressure; however, this can cause the pump to heat up very quickly (in a matter of seconds). If the pump thermal switch trips, allow at least 5 minutes of cool down time before resuming operation, and try to determine the cause of the overheating.

The braking resistor also has a thermal switch, which opens if the trip point is reached. It is monitored by drive input 5, readable at drive parameter 08.005 and will result in an External Trip.3 error.

# 7 DRIVE TORQUE AND CURRENT

During startup or for troubleshooting, it may be necessary to view or monitor the drive torque and current values. These items are available through the Connect software in Menu 04: Torque and current control, in parameters 0.04.003 Final Torque Reference and 0.04.004 Final Current Reference.

During operation, the motion logic will set 0.04.007 Symmetrical Current Limit using the value in 3.070.084 Pump Current Max. The factory default value is 150, which is 150%.



# 8 ETHERNET ADDRESSING

EtherCAT determines addressing by the order of devices on the cable.

The drive uses an independent Ethernet (“IP”) address for Ethernet/IP and programming. As shipped, the system’s drive is typically given an IP address of 192.168.1.101.

M75x drives ship with the Compact Display, which includes two 16-position selector switches. Changing these to anything but 00 overrides the rightmost byte of the IP address with their hex combo.

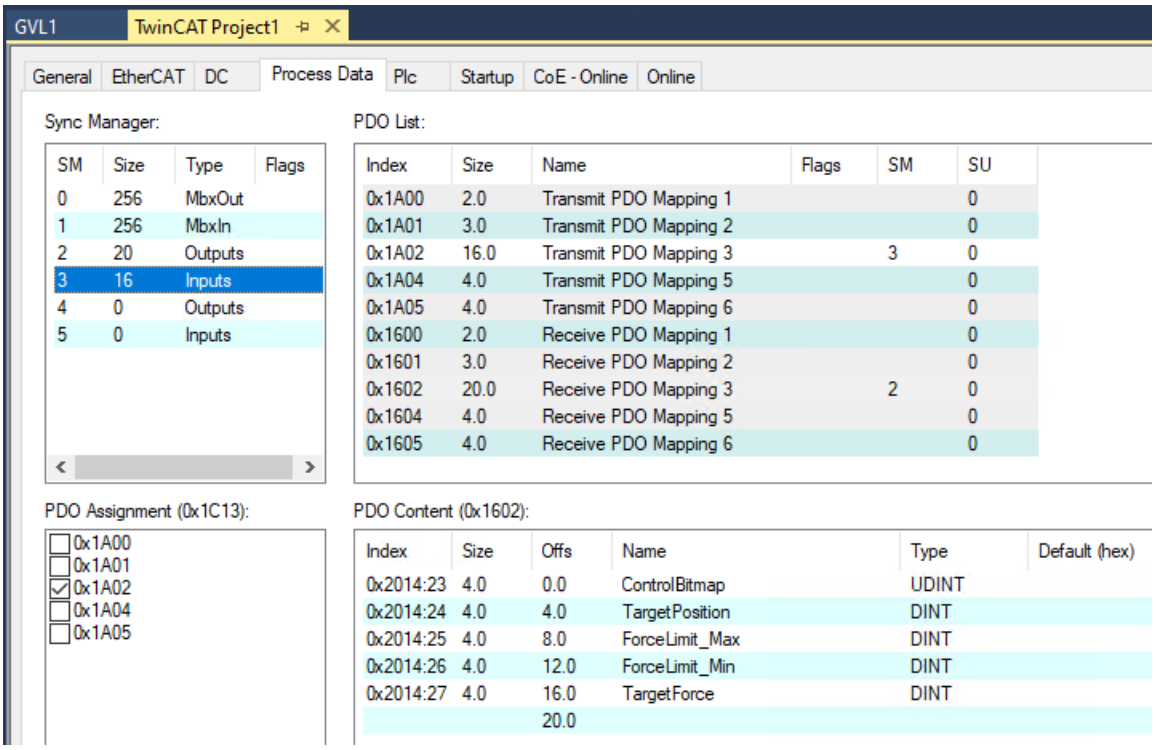
As shipped, the drives subnet mask was set to 255.255.255.0. This requires that for two devices to see each other, the first three bytes of their IP addresses must match. (This puts them in the same subnet).

These parameters may be changed with any of the methods covered in Changing Drive Settings below. Depending on the Drive type, the IP address is menu 3.02.006 or 1.02.006. The subnet mask is menu 3.02.007 or 1.02.007. Refer to the Technical Report for the actuator for specifics.

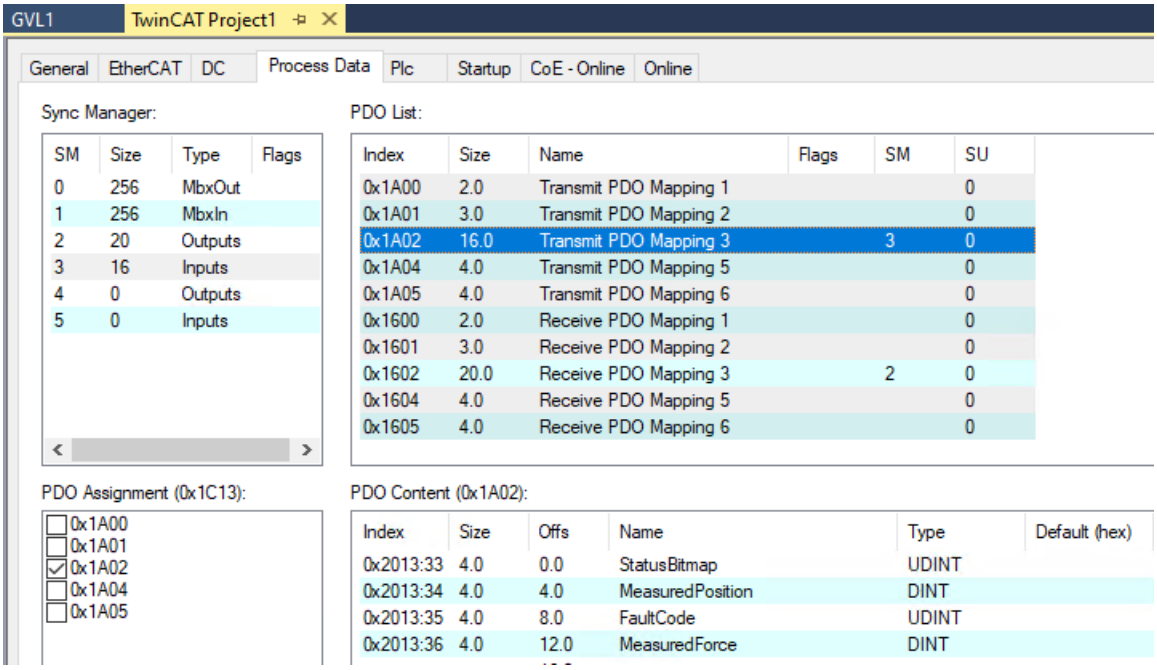
After changing either parameter, do the Making Changes Permanent procedure described in a section below. Then cycle power to force the Ethernet port to change

# 9 SETTING UP ETHERCAT PDO IN TWINCAT

A sample TwinCat configuration is available from Kyntronics.




This shows the Receive (outputs) PDO mapping.




This is the Transmit (inputs) mapping.

# 10 MANUAL CONTROL

Occasionally you might need to move the SHA without an EtherCAT host; for example, during installation. Jogging can be done through the optional remote keypad/display or through Connect software.

Jogging is done by running the pump at a constant speed. No position loop control is involved.
Manual jog speed is set at menu 1.005. It is scaled in pump RPM.
500 RPM is a nice starting point, and this is what it will default to on power-up.

Jogging is armed by setting Drive menu 18.047 = "on". At power-up it *should* default to off. See below.
When Menu 18.047 is on, the system will ignore most of the COMMAND word. Instead the green and blue keypad keys will jog at the speed specified in 1.005, as mentioned above.

Green → key = Jog Extend
Blue ← key = Jog Retract

Bits 4 and 5 of the Command register can function the same as the green/blue keys:

Command.bit 4 = Jog Extend
Command.bit 5 = Jog Retract

Setting Command bit 6 performs the same function as setting menu 18.047.

**Don't forget to set 18.047 OFF or cycle power to give control back to EtherCAT.**

IF you find that the system is powering up with Jogging enabled, someone left 18.047 on and executed the "Making Changes Permanent" procedure. Turn it off, then do the procedure again.

# 11 TUNING

Refer to the actuator Technical Report for details.

# 12 ETHERNET DIAGNOSTICS

A green LED is located directly (within a quarter inch) below each of the drive's Ethernet sockets. If this is not flashing, check the network connections and power to the device on the other end of the cable. There is almost no software misconfiguration which will prevent this LED from flashing. One exception may be the presence of another device with the same IP address.

The drive requires about 20 seconds after power-up before becoming active on the Ethernet.

If the host device is unable to establish a connection with the SHA, consider connecting it to a laptop and pinging it. From the Windows or Linux command line, type PING 192.168.1.101 or whatever address you have set if you changed from the factory default.

The host computer or PLC and the SHA will only be able to communicate if they are on the same *subnet*. In most networks, the Ethernet subnet mask is set to 255.255.255.0. In this case, the first three numbers of devices address must match to be on the same subnet.

If still no response, verify the drive's IP address using the procedure in ETHERNET ADDRESSING above.

Each drive has two Ethernet ports, marked 1 and 2.
Port 1 is optimized for Ethernet/IP. Port 2 is used with programming software.

The registers being exchanged using Ethernet can be inspected and modified with the keypad & display. This can be useful when debugging the PLC interface.
The menu elements for the other parameters are itemized in MOTION PARAMETERS above.

Sometimes you suspect that the Ethernet/IP interface is constantly writing *something* to a given register, but can't be sure because it never changes. Try using the keypad to temporarily write a different value. See if the Ethernet/IP interface stomps on your change, reverting to the previous value.

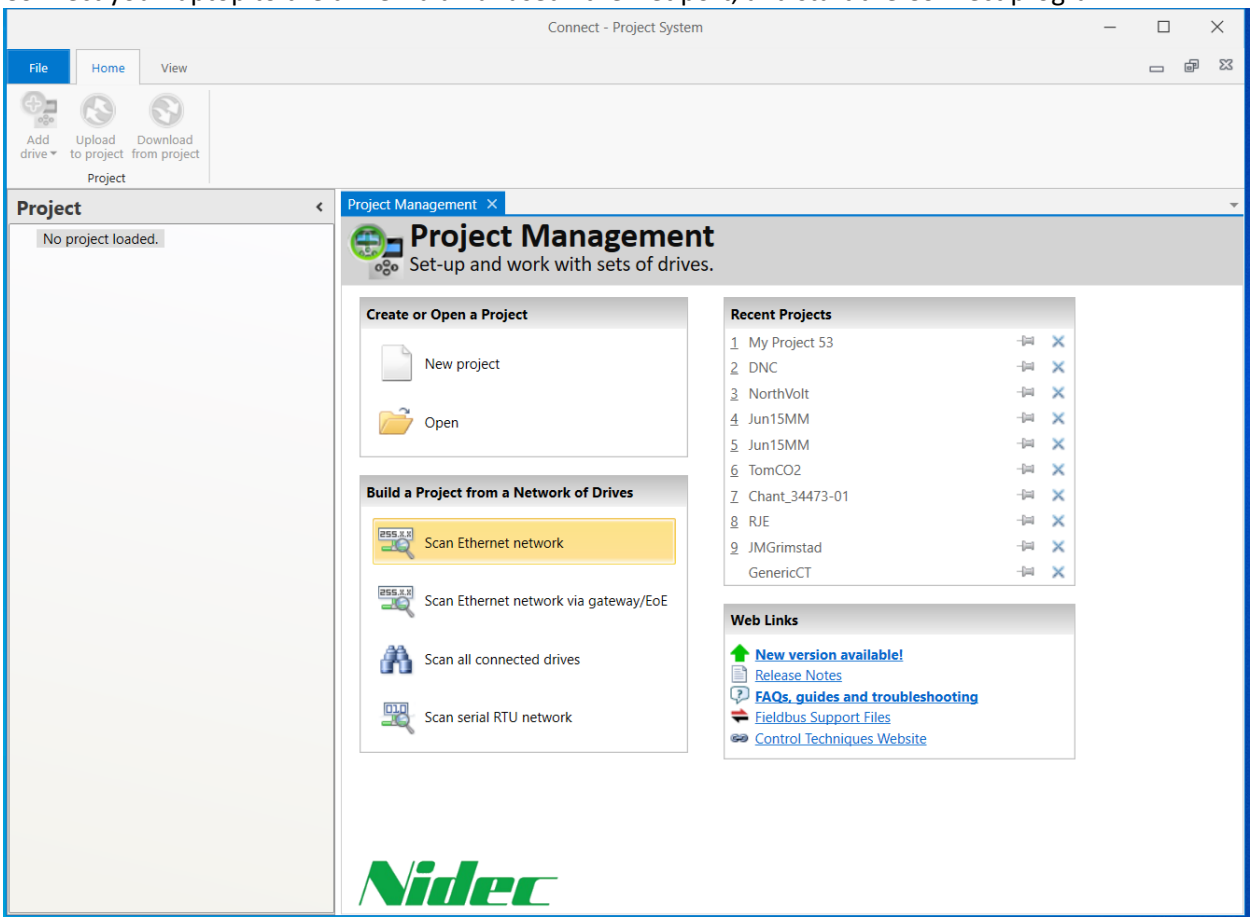
Windows 10 Firewall has been known to block Connect in rare instances.

# 13 CHANGING DRIVE SETTINGS

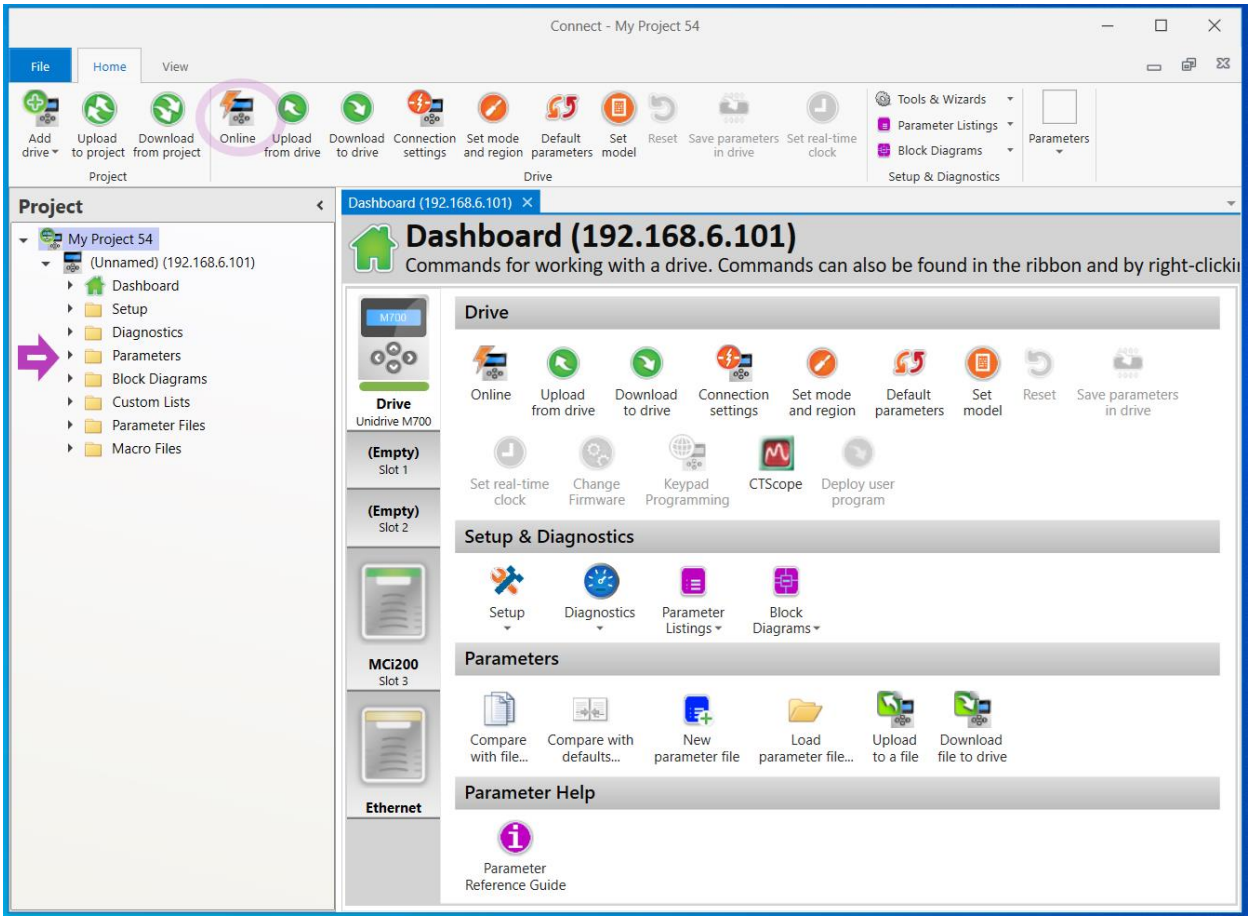
## 13.1 Control-Techniques “Connect” Software

The servo drive manufacturer, Nidec/Control Techniques, named its configuration software Connect. It is a free download from the web, and requires no job-specific files or password to access the drives. On the download site, look for the Connect Software bundle, Issue: v02.18.02, zip file (as of February, 2023). You will need to setup a login/email but the download is free.

Connect your laptop to the drive via an unused Ethernet port, and start the Connect program




Click “Scan Ethernet Network” and the software will find the drive.
If there is more than one drive on the net, it will find them all.
If more than one is found, you can click “wink” and the corresponding drive will flash its red LED at you.

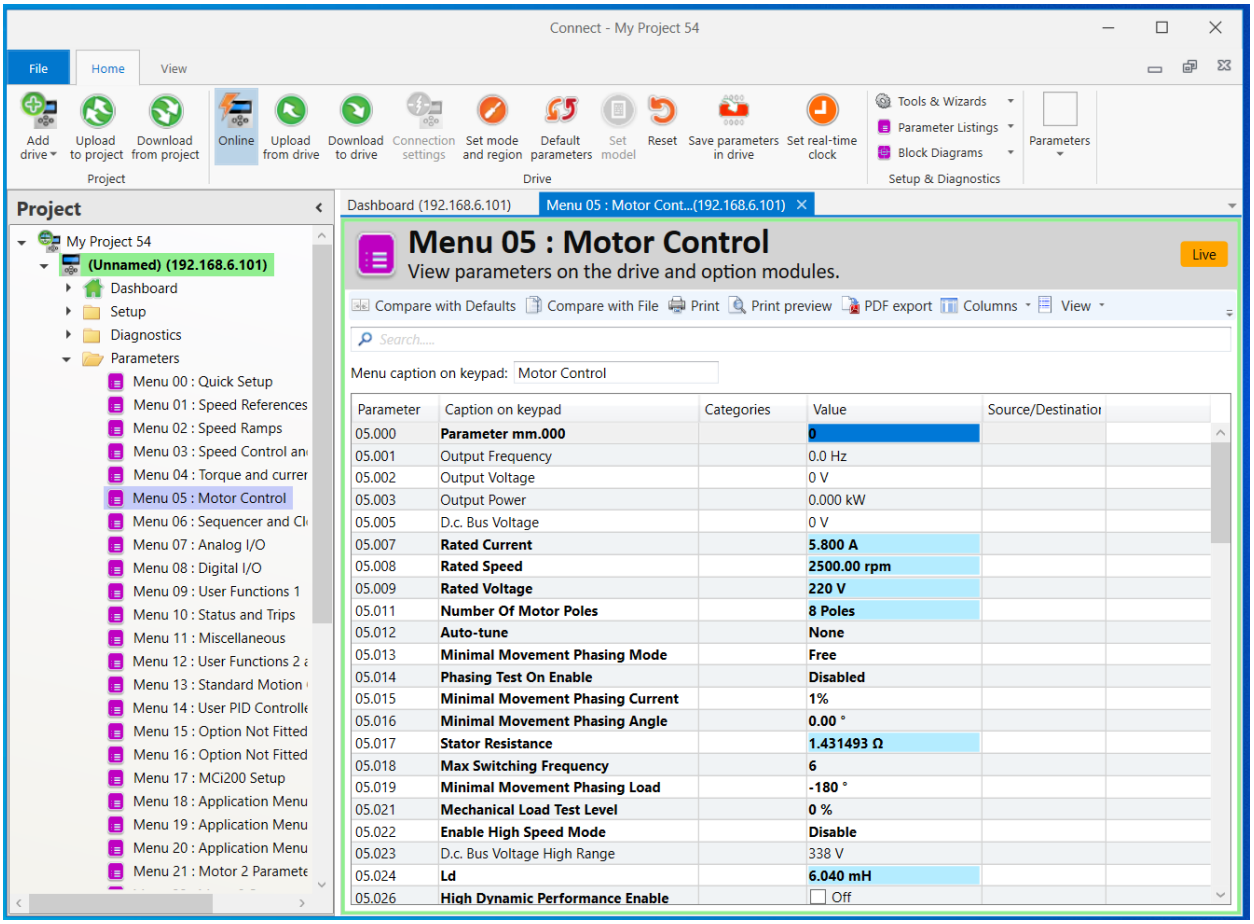



Connect has created a new file called “My Project ##”. On my machine there were already 53 others.

If you expand the tree structure at left by clicking on “Parameters” (magenta arrow) you could inspect any menu item, thinking these are the drive settings. And you would be wrong. This is one of the two gotchas in Connect. The software has fetched the drive type and filled in the option slots. (My drive happens to have an Mci200 in slot three.) But all of the menu items are populated with default values, not the ones on the drive. If you were to close Connect now, the file it saves on your laptop will NOT have the values from the drive.

Clicking “Upload from drive” will copy the drive value to your laptop. Now when you close Connect, the saved file will contain the drive settings.

Notice the Online icon at top, circled in magenta. It is not highlighted. This signifies that we are not live with the drive. Click it, and expand the Parameter tree at left.



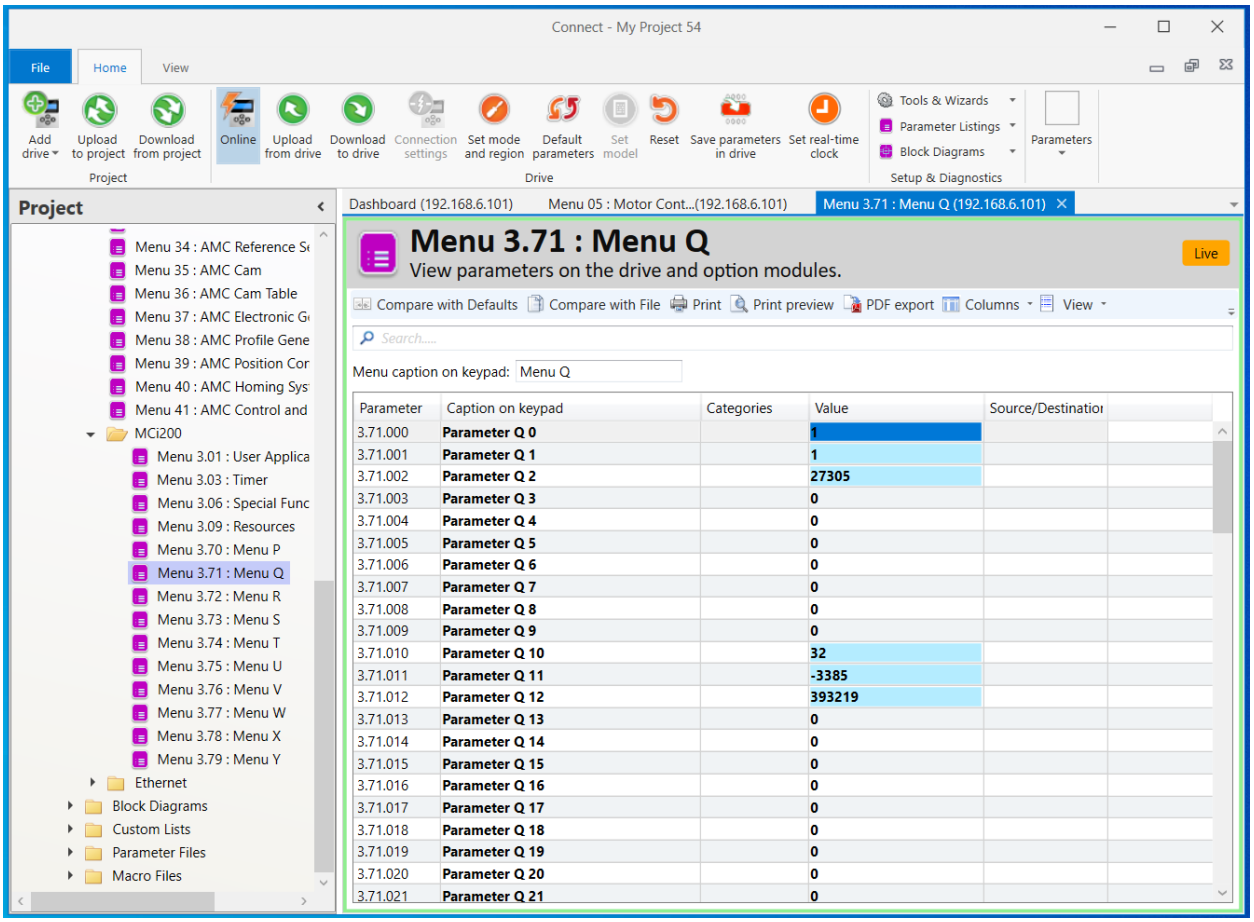

Notice how the Online icon is now highlighted; bluelighted on my machine.
This tells you that you are looking at live values on the drive. This brings me to the other gotcha: Forgetting that you are offline and making changes and wondering why they don't do anything.
It happens.

Notice that only some of the names and values are in bold. The ones not in bold are read only.
You can edit the ones in bold by clicking on the value itself. Be careful. Its live.

Notice that some values are backlighted in pale blue. These deviate from the default values.

Once you have made a flock of changes, you may want to save them on the laptop, so you click the File tab and look for "save as" and its greyed out. Don't panic. This is because you are on line. Click the Online icon to unhighlight it and then "save as" will become available. BUT WAIT! If you click it now, the settings you save will not reflect those changes you just made online. Click "Upload from drive" before saving.

All of the parameters shown in this snip are for the drive itself (device zero).
On the left hand window pane, slide the vertical scroll bar down a bit…




Here is where the non-drive menu items are hiding. All menu items have three fields, such as 3.71.003. The first field specifies the device, the second field is the menu, and the third is the specific parameter. The drive itself is device zero, and the option modules use their slot number.

All drives have an Ethernet interface built in to the drive, but it acts like an option module.
M750 drives have it at slot 3. M700 drives have it at slot 4.

All Kyntronics SHA drives are equipped with either an MCi200 or MCi210 module to do the heavy computation. M750 drives have it in slot 1. M700 drives have it in slot 3.

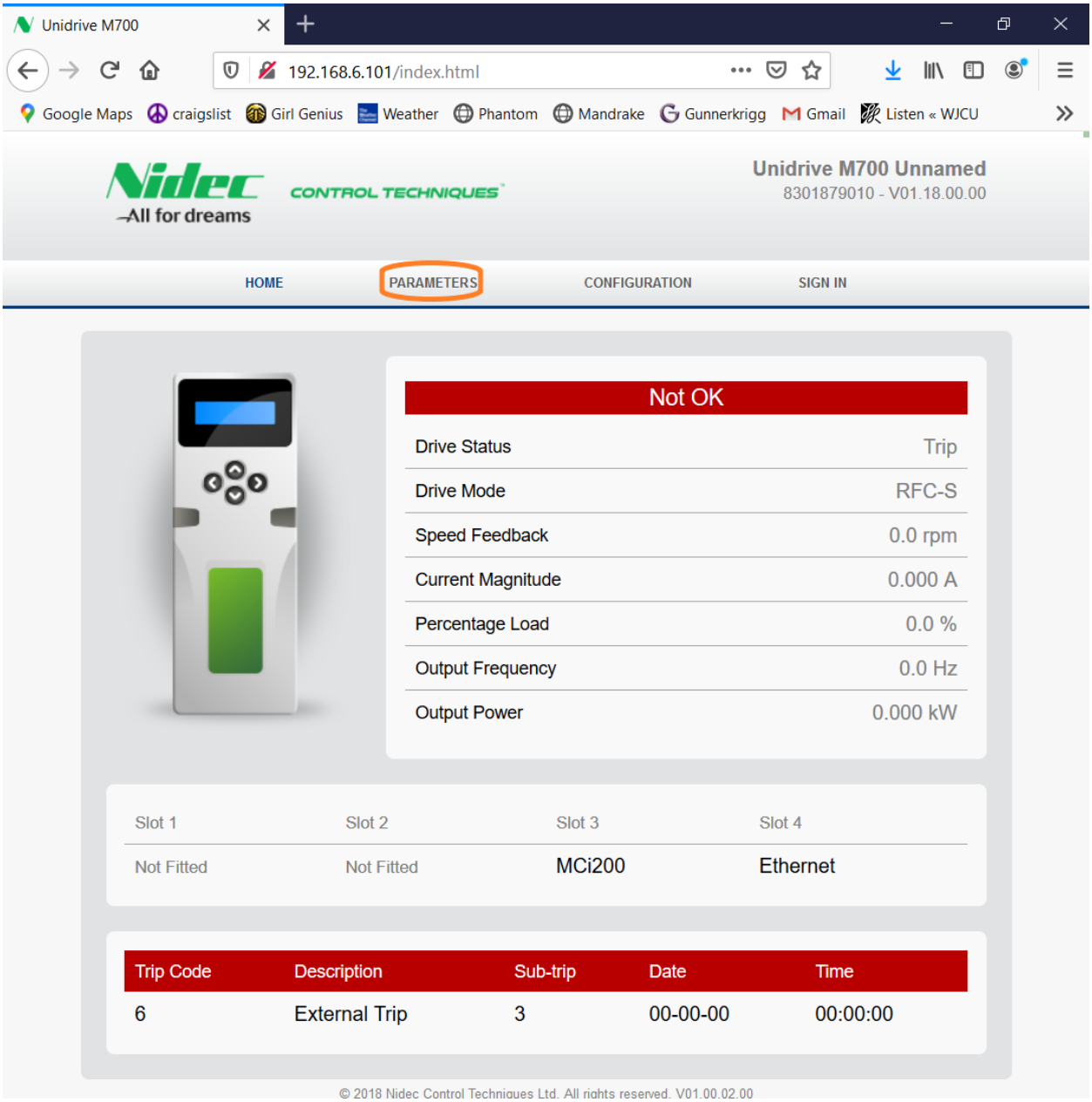
An MCi210 module also has its own Ethernet ports, that stick out the top of the drive.
When a drive is equipped with an MCi210, such as the master on a master/follower system, the ports on the MCi210 should be used instead of the drives native Ethernet ports.

Should you happen to be changing an Ethernet address, be sure you are changing the ports on the device you think you are.

The MCi210 Ethernet settings on an M750 drive are at Menu 1.02.0xx.

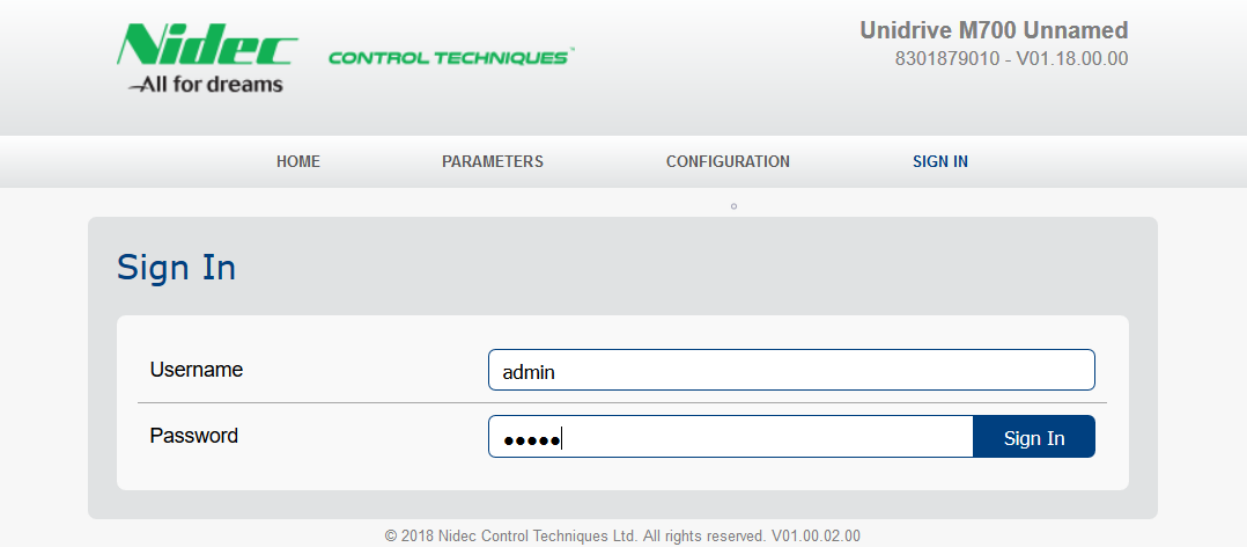
## 13.2 Web Browser

A laptop connected to the drive via Ethernet can view and modify any parameter, using its web server. Open your preferred web browser and enter the IP address of the drive, like so:

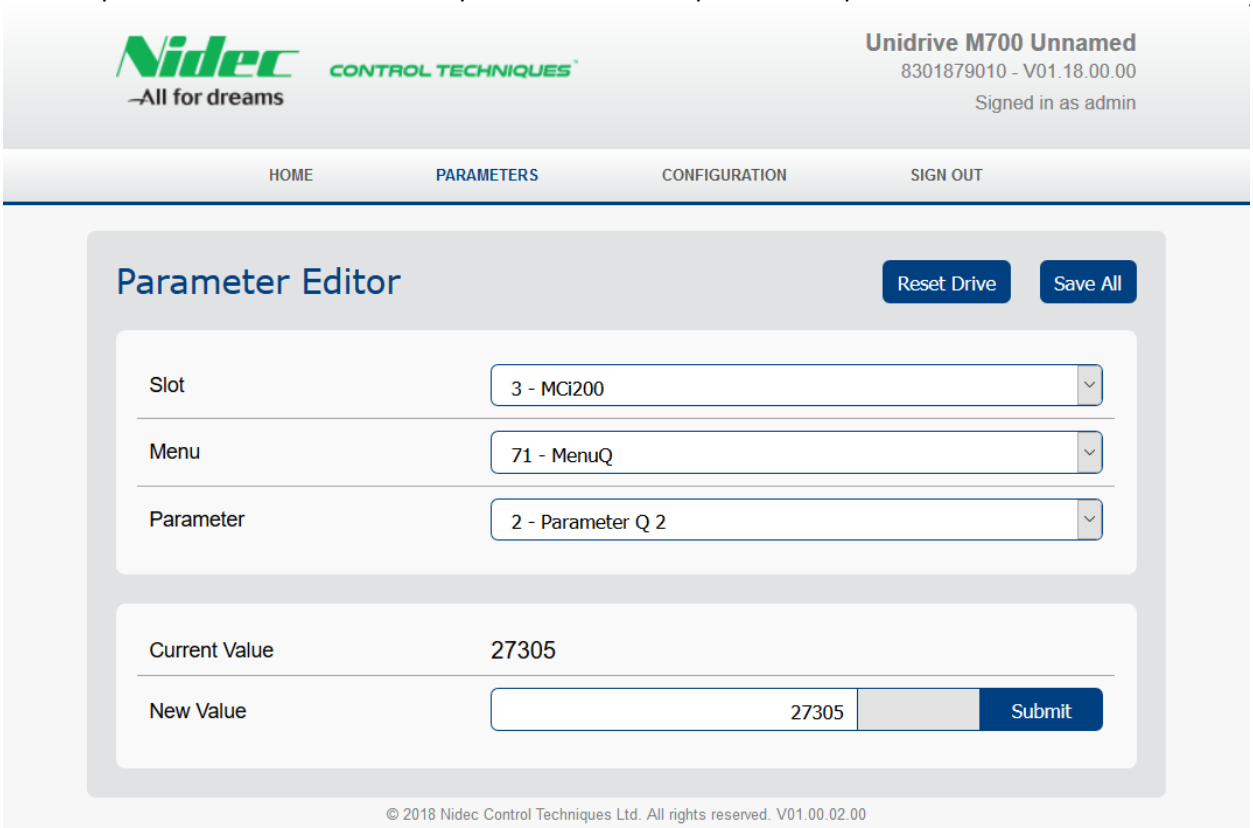



Click the PARAMETERS tab circled at top center.

Enter Username “admin” and Password “admin”. Yes really.



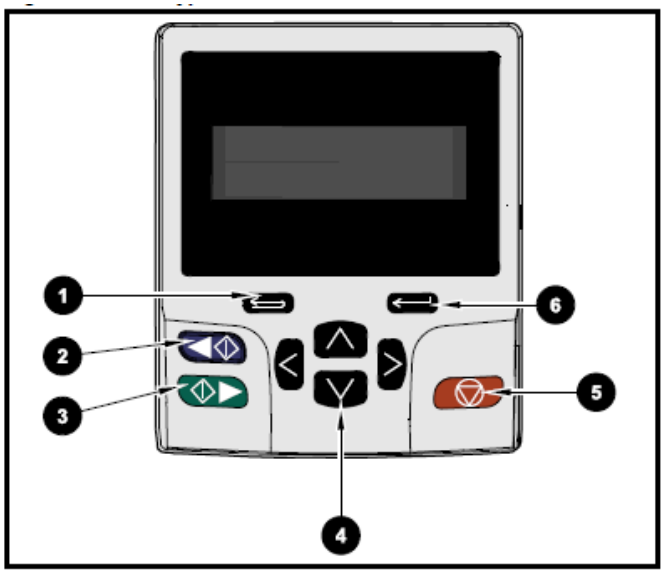

Use the pull-down boxes to select the parameter. This snapshot corresponds to menu 3.71.002.




To change a value, enter “New Value” and click “Submit”.

## 13.3 Optional Keypad/Display

Any of the servo drive can be equipped with a keypad and display. This shows status and fault conditions and allows various motion parameters to be modified. It requires the KI-Compact RS485 adapter as well. It also allows Jogging of the actuator without the fieldbus host connection, which is useful for setup.




1 = Escape. Backs out. Always safe.
2 = (blue) Jog Retract.
3 = (green) Jog Extend.
4 = Arrow keys. See text.
5 = (red) Reset. See FAULTS section.
6 = Enter. Use caution. See text.

### 13.3.1 Inspecting Parameters

Parameters are structured in the form: **Device.Menu.Element**
The left and right arrows scroll thru the **Device.Menu** combinations.
In this system, devices are numbered 0, 1, 2, and 3.
Some devices will not be visible until the drive has been powered for at least 20 seconds.

The keypad/display does not show the “0.” on the front of the addresses for Device zero.
For example, the address 0.18.047 is shown as 18.047.

The left and right arrows never modify anything unless you have first pressed the Enter key.

The up and down arrows scroll thru the elements of a given menu.
They stay within the menu, and do not jump to the next one when you scroll past the last element.
As soon as you select an element, its value and terse description are displayed.
Looking at a parameter will never interfere with the operation of the system.

### 13.3.2 Modifying Parameters

To modify a value, inspect it as detailed above, then press the Enter key.
A digit of the value will begin flashing.
While flashing, the left and right arrows select digits, and up and down arrows change them.
Pressing Enter again will accept the changed value. Think “Key on the RIGHT does a WRITE”.
Pressing Escape instead will back out, with the old value intact. Think “Key on the LEFT LEFT it alone.”

Some parameters are Boolean instead of numeric. These only accept values ON or OFF.
In these cases, the up arrow always selects ON, and the down arrow selects OFF.

Note that changes take effect instantly, even before you press Enter. Yes, really.
For example, setting menu 18.047 = ON will arm the jog keys immediately.
Using arrow keys to step thru values on the Command word can pass thru unintended commands.

## 13.4 Making Changes Permanent

In some cases, changes must be saved to nonvolatile memory, or they will be lost when power is removed. This is not true of any of the parameters in device <Mci2x0 Slot #>.xx.xxx.

First, put the system in the state you want it to powerup in.
For example, turn JogEnable off if you have left it on.

Next set menu 0.10.034 to a value of 1. This prevents a spurious pump thermostat fault at powerup.

If using Connect, click the Save Parameters in Drive icon.
If using the browser interface, click the SaveAll icon.
If using the optional keypad/display:

1. Select element zero of *any* drive.menu; for example 0.07.000 or 0.18.000.
2. Press the Enter key (upper right). At this point, “no change” should start flashing.
3. Press the Up arrow, and the display should change to “save parameters”.
4. Hit Enter and then the red reset button. The display will change back to “no change”.

# 14 GLOSSARY

| | |
|---|---|
| H | Hexadecimal (suffix). The attached value is expressed in base 16. |
| IP Address | Four-byte address used by Ethernet. Expressed in the form 192.168.001.002 |
| MSW | Most Significant Word. The upper 16 bits of a 32-bit value. |
| LSW | Least Significant Word. The lower 16 bits of a 32-bit value. |