Kyntronics
Innovation in Motion

TECHNICAL REPORT
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PROFINET GENERIC INTERFACE

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1 PURPOSE

To provide guidelines for interfacing Kyntronics Smart Hydraulic Actuator (SHA) over ProfiNet.

2 USER INTERFACE OVERVIEW

The system consists of one SHA (Smart Hydraulic Actuator) with an enclosure containing controls.

The system presents a user interface consisting of an STO (Safe Torque Off) signal and ProfiNet port. In addition, there is a keypad/display integral to the servo drive which may be used to inspect and modify settings.

The drive has two RJ45 sockets specifically for ProfiNet. These are located on a module snapped onto the drive under the “Nidec” plastic cover. These have been run to M12 connectors on the enclosure marked “J2” and “J3”.

Additionally, two regular Ethernet sockets are on the drive itself, right below the keypad, labeled 1 and 2. These are used for Ethernet communication with a laptop for programming or monitoring the drive. Note that the enclosure has 480Volt power running around on it. Be cautious.

As with all ProfiNet slave devices, communication is configured by the host device, usually a PLC.
It is suggested that the drives interface be distributed between RT and NRT channels.

RT(Real Time) also called Cyclic communications has fixed content. The host PLC continuously writes to the Command register, Target Position, etc. It continuously fetches Status, Position, Fault Code, etc.

NRT (Non-Real Time) is acyclic. It can access all of the drive’s registers. This is typically used to modify motion parameters which change less frequently.

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 an electrically isolated 24VDC STO discrete input.

On this particular system, the STO is being satisfied with a jumper on the subpanel terminal blocks.

When part of the system, it’s usually 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.

4 TRANSDUCERS AND SCALING

Position of the cylinder rod is measured by a non-contact linear transducer. It senses the absolute position of the rod as soon as powered, without a homing procedure or external reference or battery.

The transducer output is digital, with a resolution of 50 steps per milliMeter.
The value increases as the rod extends. The transducer has no internal adjustments.
The transducers actual zero position is always inboard of the rods fully retracted position.
The system subtracts a constant called ZeroOffset to define a reachable position as “zero”.
This constant is set at the factory extremely close to the fully retracted position.
ZeroOffset is readable and adjustable via the keyboard/display at menu 18.051.

After adjusting the ZeroOffset parameter just right, you will want to execute the “Make Changes Permanent” procedure in the Keypad/Display section.

There is a pressure sensor built in to the SHA manifold which monitors the pressure on the extend side of the piston. This also drives an Analog to Digital Converter. This value is scaled per the swept area of the piston, to produce force in pounds. Full scale on this device is 37700 pounds.

Note that pressure on the rod (retract) side of the piston is not sensed. Therefore, this device is incapable of measuring a force in the retract direction. This is not to say that it can’t exert force in the retract direction. It most certainly can. Use Position mode or Jogging.

The raw ADC value is viewable with the keypad. It is displayed scaled 0-100%.
Force ADC: Menu 07.001

5 CONTROL MODES

The interface supports three closed-loop control modes; Position, Position with force limit, and Force.
By closed-loop we mean that the pump is controlled to achieve a target force or position using feedback.

Jogging, which spins the pump at a constant speed, is not a closed-loop mode. See Manual Control.

Position is measured with an absolute encoder, hence there is no requirement to “home” the system at startup or ever. Extending the rod is considered more positive.

Force is deduced by measuring the pressure on the extend side of the piston, which is considered positive. Attempting to regulate tension (negative force setpoint) while using the pressure sensor will fail.

Closed loop control is activated by setting COMMAND bit zero (Enable closed loop control) along with one of the three Select mode bits. You can switch modes without going thru “none”.
Selecting more than one mode at a time will pick one and you don’t know which; so don’t.

In POSITION MODE

Position Target determines final value.
Position Jerk, Accel, and Velocity govern the motion profile.

In FORCE LIMITED POSITION MODE

Target Position determines desired position.
Position Jerk, Accel, and Velocity govern the motion profile.
Force Limit Max limits compressive (rod extending) force.
Force Limit Min must be set significantly negative to prevent uncontrolled action.
Force Jerk, Accel, and Velocity affect the slew rate of the force limits.

In FORCE MODE

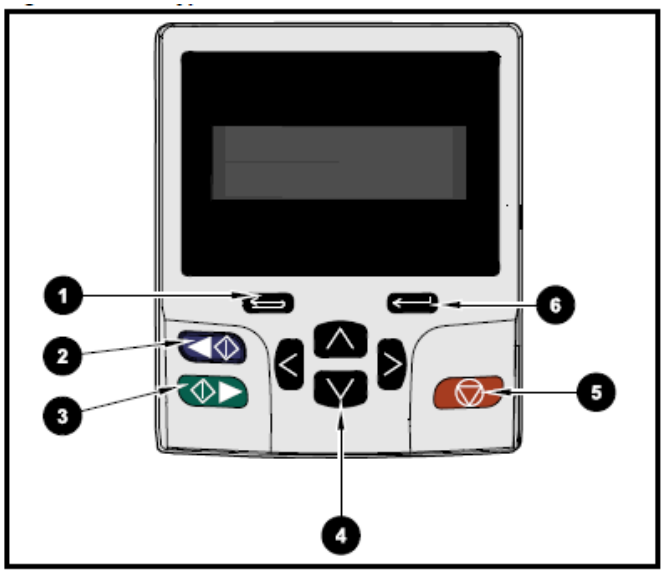
Force Target determines final value
Force Jerk, Accel, and Velocity govern the force profile. An S curve, but with lbs instead of mms.
Pump Speed Max limits pump speed in RPM while extending.
Pump Speed Min limits pump speed in RPM when retracting. SET NEGATIVE.

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.
54.7 RPM should produce 1.0 mm/sec in the extend direction.
41.0 RPM should produce 1.0 mm/sec in the retract direction.

6 THE KEYPAD/DISPLAY INTERFACE

The servo drive is equipped with a keypad and display.
This shows status and fault conditions and allows various motion parameters to be modified.

Using the keypad requires accessing the subpanel with power applied. DEADLY VOLTAGE (240/480VAC) is present at terminals elsewhere on the subpanel. Care must be taken when using the keypad. Metal jewelry or bracelets are a monumentally bad idea here.



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.

6.1 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, 3, and 4.
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.

6.2 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 even while ON is still flashing.
Using arrow keys to step thru values on the Command word can pass thru unintended commands.

6.3 Making Changes Permanent

In some cases, changes made via keypad must be saved to nonvolatile memory, or they will be lost at power-down. This is not true of any of the parameters in device 03.xx.xxx.

1. Put the system in the state you want it to powerup in.
   For example, turn JogEnable off if you have left it on.
2. Change menu item 10.034 from “none” to “1”.
   Failing to do this can cause a spurious “user trip” indication at every powerup.
   Not lethal, but a pain. It’s never too late to fix it.
3. Select element zero of *any* device.menu; for example 18.000 or 3.71.000.
4. Press the Enter key (upper right). At this point, “no change” should start flashing.
5. Press the Up arrow, and the display should change to “save parameters”.
6. Hit Enter and then the red reset button. The display will change back to “no change”.

7 PROFINET RT COMMUNICATIONS

The Profinet RealTime channel 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.

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 ProfiNet interface is in the form of DINTs.

All registers within the drive and its accessory modules are mappable via the GSDML file provided by the drive manufacturer; Control Techniques. The file is GSDML-V2.31-CT-UniDriveM600-800-20170912.xml as of the writing of this manual. This file provides predefined modules such as “Drive Position Feedback” all of which should be ignored. The drive is being operated by an amped-up motion controller in slot 3. The motion controllers interface parameters are available as “Flexible Modules”, which do not have luxurious descriptive text names. Use the ProfiNet host configurator to select these registers by address.

Because there are many PLCs which host Profinet, we are unable to describe the exact terminology used by each one. When this manual specifies an address as [3.70.005] it signifies slot 3, menu 70, entry 5.

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

COMMAND: (bitmap) [3.71.001]

Bit 0 – Enable closed loop control (See
Bit 1 – Select Position mode
Bit 2 – Select Force Limiting Position mode <do not use>
Bit 3 – Select Force mode <do not use>
Bit 4 – Jog Extend (See Manual Control Section)
Bit 5 – Jog Retract “
Bit 6 – Enable Jog mode “
…
Bit 13 – Select Loadcell 1
Bit 14 – Select Loadcell 2
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: [3.71.002]
Target in Position and Force Limited Position modes.
Units are hundredths of a millimeter measured from “zero” as covered in section 3 above.

FORCE LIMIT MAX: [3.71.003]
Compressive (rod extending) pounds limit in Force Limited Position mode.

FORCE LIMIT MIN: [3.71.004]
Tension (rod retracting) pounds limit in in Force Limited Position mode.
Set negative, as the system considers tension to be “negative force”.

FORCE TARGET: [3.71.005]
Target in Force mode. Units are pounds. Positive is compression.

The Input interface includes four registers (data from the SHA to the PLC).

STATUS: (bitmap) [3.71.010]
- 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
- 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: [3.71.011]
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 value corresponds to extending the rod.

FAULT CODE: [3.71.012]
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: [3.71.013]
Units are Pounds. Measured by whichever force sensor is selected in the COMMAND word above.
Bipolar value. Positive corresponds to compressive (extending rod) force.

8 PROFINET NRT COMMUNICATIONS

RT (RealTime) communications is 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.

NonRealTime (NRT) is the alternate method of data exchange in the ProfiNet 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.

All registers within the drive and its accessory modules are mappable via the GSDML file provided by the drive manufacturer; Control Techniques. The file is GSDML-V2.31-CT-UniDriveM600-800-20170912.xml as of the writing of this manual. This file provides predefined modules such as “Drive Position Feedback” all of which should be ignored. The drive is being operated by an amped-up motion controller in slot 3. The motion controllers interface parameters are available as “Flexible Modules”, which do not have luxurious descriptive text names. Use the ProfiNet host configurator to select these registers by address.

ProfiNet 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 ProfiNet 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 3, 4, and blank.

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 NRT, which can be either Download or Upload.

Name	Units	Keypad Address
Position Jerk	Mm/Sec^3 * 100	3.70.001
Position Accel	MM/Sec^2 * 100	3.70.002
Position Velocity	MM/Sec * 100	3.70.003
Pump Speed Max	RPM	3.70.080
Pump Speed Min	RPM	3.70.081
Force Jerk	Lb/Sec^3	3.70.091
Force Accel	Lb/Sec^2	3.70.092
Force Velocity	Lb/Sec	3.70.093
Jog Speed	RPM	0.01.005

9 FAULTS

The display/keypad on the front of the drive 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 M700 User Guide has 35 pages of error codes. Here are the common trip values:

1: Reserved 001 - Pump Thermostat tripped. See below.
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. 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 “Reserved 001”.
If you see this error right out of the box, verify the wiring of the PUMP THERMAL cable.

The load dump resistor array is supervised by a thermostat, which is closed when temperature is below the trip point. The thermostat is monitored by drive input 5, readable at menu 08.005. It should be high (on) when OK. If the thermostat trips, the keypad will announce this fault as “External Trip.3”.

If you see the “Reserved 001” or “External Trip.3” on every powerup, someone botched the Make Changes Permanent procedure. Redo it.

10 ETHERNET ADDRESSING

ProfiNet assigns addresses on their private wire using voodoo.
The drive uses its regular Ethernet (“IP”) ports for programming.
As shipped, the system’s drive was given an IP address of 192.168.1.101.
It can be inspected and changed with the keypad at menu element 4.02.006.

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*). It is adjustable at menu element 4.02.007.

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

11 MANUAL CONTROL

Occasionally you might need to move the SHA without a network host; for example, during installation. This can be done with the drive's keypad/display.

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 ProfiNet.

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.

12 TUNING

The tuning parameters for several control loops are adjustable via the keypad. The unit ships tuned for good performance, however it can be optimized for the specific load characteristics.

Name	As Shipped	Address
Position Proportional Gain	6000	3.70.050
Position Integral Gain	50000	3.70.051
Force Proportional Gain	3000000	3.70.070
Force Integral Gain	1000000	3.70.071

13 ETHERNET DIAGNOSTICS

Most of this section is not applicable to the ProfiNet network, but could still be handy for connecting a laptop to the drives standard ports for programming.

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 192.168.1.100 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.

The registers being exchanged using ProfiNet 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.

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.