

Mint^{Multi-Tasking} MT Application Note**AN00174-001: Modbus/TCP Fieldbus Option for MotiFlex e100**

Overview

The Baldor Modbus/TCP Fieldbus Option Card (FOC) for MotiFlex e100 allows the drive to provide 10/100 Mbit/s full/half duplex Modbus/TCP communications (up to 4 simultaneous connections).

Note: The Fieldbus Option must be plugged into option slot 1 on the MotiFlex e100.

Please refer to the MotiFlex Fieldbus Option Card Installation manual MN1954 for full connection details and information about the various diagnostic LEDs fitted to the Fieldbus Option.

Typically the Fieldbus Option would be used as a 'Gateway' between a PLC (or other such client device on Modbus/TCP) and a NextMove e100 (or other such device on Ethernet Powerlink). This Application Note details how this configuration can be achieved.

The client must be capable of addressing the standard Modbus TCP Port (502) on the Fieldbus Option.

The Fieldbus Option's default IP address is 0.0.0.2, but this can be changed via WorkBench if required.

Note: If the Modbus/TCP IP address is set identical to the EPL IP address it is important not to directly connect the Modbus/TCP network to the EPL network.

The Fieldbus Option handles the transmission of data to and from the Modbus/TCP network. Data items are stored in Application Data Instances (ADIs) of the Application Data Object (ADO) maintained by the MotiFlex e100. This fieldbus data, both in and out of the drive, is 'mapped' to the drive's standard Ethernet Powerlink (EPL) object dictionary entries. Since an EPL manager node (MN) such as a NextMove e100 has access to all of the drive's object dictionary entries it can therefore also access any fieldbus Process Data. The drive's objects can also be mapped to EPL PDOs, allowing the MN to provide cyclic updates of fieldbus related data. The correlation (mapping) between the drive's object numbers and the ADI numbers (and related Mint keywords) is shown in the Fieldbus Option's object dictionary which is listed in the Mint Help File that installs with WorkBench v5.5.

The Modbus/TCP side of the Fieldbus Option allows for up to 512 bytes of Process Data (256 16-bit registers) to be mapped in each direction (read/write), which corresponds to 128 32-bit Process Data items. However, the number of Process Data items that can actually be mapped to the MotiFlex e100 over EPL and also over Modbus/TCP is limited to 64 on each (64 transmit and 64 receive Process Data items on each of the networks). So this determines the maximum amount of data that can be transferred between the two network segments.

Part Number/Ordering Information

The MotiFlex e100 Fieldbus Option Cards comprise a fieldbus module which must be fitted to a carrier card. This two part construction allows a different fieldbus to be fitted at a later date without changing the carrier card.

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A wide range of fieldbus modules are available (contact your local Baldor office or distributor for a full list):

- **Carrier card: OPT-MF-030**
- DeviceNet: OPT-FB-001 (Anybus AB6201)
- PROFIBUS DP-V1: OPT-FB-002 (Anybus AB6200)
- EtherNet/IP: OPT-FB-004 (Anybus AB6214)
- **Modbus/TCP: OPT-FB-005 (Anybus AB6213)**
- PROFINET IO: OPT-FB-006 (Anybus AB6215)

Separate application notes are available on setting up these alternative Fieldbus Options.

Modbus/TCP Function Codes

The Modbus/TCP Fieldbus Option supports the following Modbus function codes:

- 1 - Read Coils
- 2 - Read Discrete Inputs
- 3 - Read holding Registers
- 4 - Read Input Registers
- 5 - Write Single Coil
- 6 - Write Single Register
- 15 - Write Multiple Coils
- 16 - Write Multiple Registers
- 23 - Read/Write Multiple Registers
- 43 - Read Device Identification

Modbus/TCP Register Implementations

The Modbus/TCP Holding (4x) Registers are mapped as follows:

Modbus Register Range	Contents
0000 - 00FF hex (0 to 255 dec)	Read Process Data (data written by PLC)
0100 - 01FF hex (256 to 511 dec)	Write Process Data (data read by PLC)
0210 - FFFF hex (528 to 65535 dec)	Application Data Instances (ADIs)

The Modbus/TCP Input (3x) Registers are mapped as follows:

Modbus Register Range	Contents
0000 - 00FF hex (0 to 255 dec)	Write Process Data (e.g. Input register 0 is mapped to Modbus Register 0100 hex)

The Modbus/TCP Discrete Input (1x) Registers are mapped as follows:

Modbus Register Range	Contents
0000 - 0FFF hex (0 to 4095 dec)	Write Process Data (e.g. Discrete Input register 0 is mapped to Modbus Register 0100 hex)

The Modbus/TCP Discrete Output (0x) Registers are mapped as follows:

Modbus Register Range	Contents
0000 - 0FFF hex (0 to 4095 dec)	Read Process Data (e.g. Discrete Output register 0 is mapped to Modbus Register 0000 hex)

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Configuring the Drive

Configuring the drive's Modbus/TCP settings is very simple. Using WorkBench v5.5 Build 5621 or later connect to your MotiFlex e100 drive (the drive must be running firmware build 5613 or later).

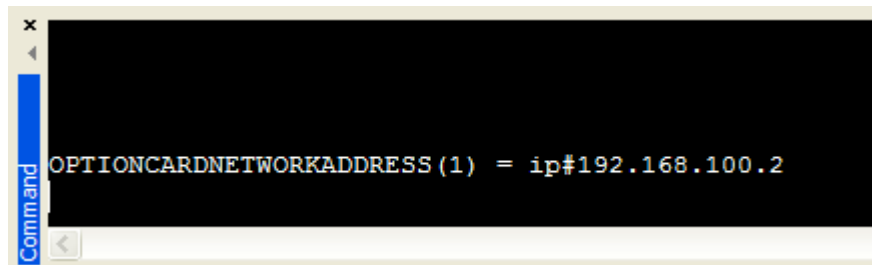
Communications Settings

WorkBench will automatically detect which type of fieldbus module has been installed. Each communication channel can be allocated a unique node address and baud rate (where applicable).

In the case of Modbus/TCP the baud rate is fixed at 10/100Mbps and the default IP address is set to 0.0.0.2.

The IP Address can be set using the OPTIONCARDNETWORKADDRESS(1) keyword or by using the Connectivity tool in Workbench. For this example a Node address of 02 has been used and a full IP address of 192.168.100.2.

The IP address can be set at the command line using OPTIONCARDNETWORKADDRESS as follows:

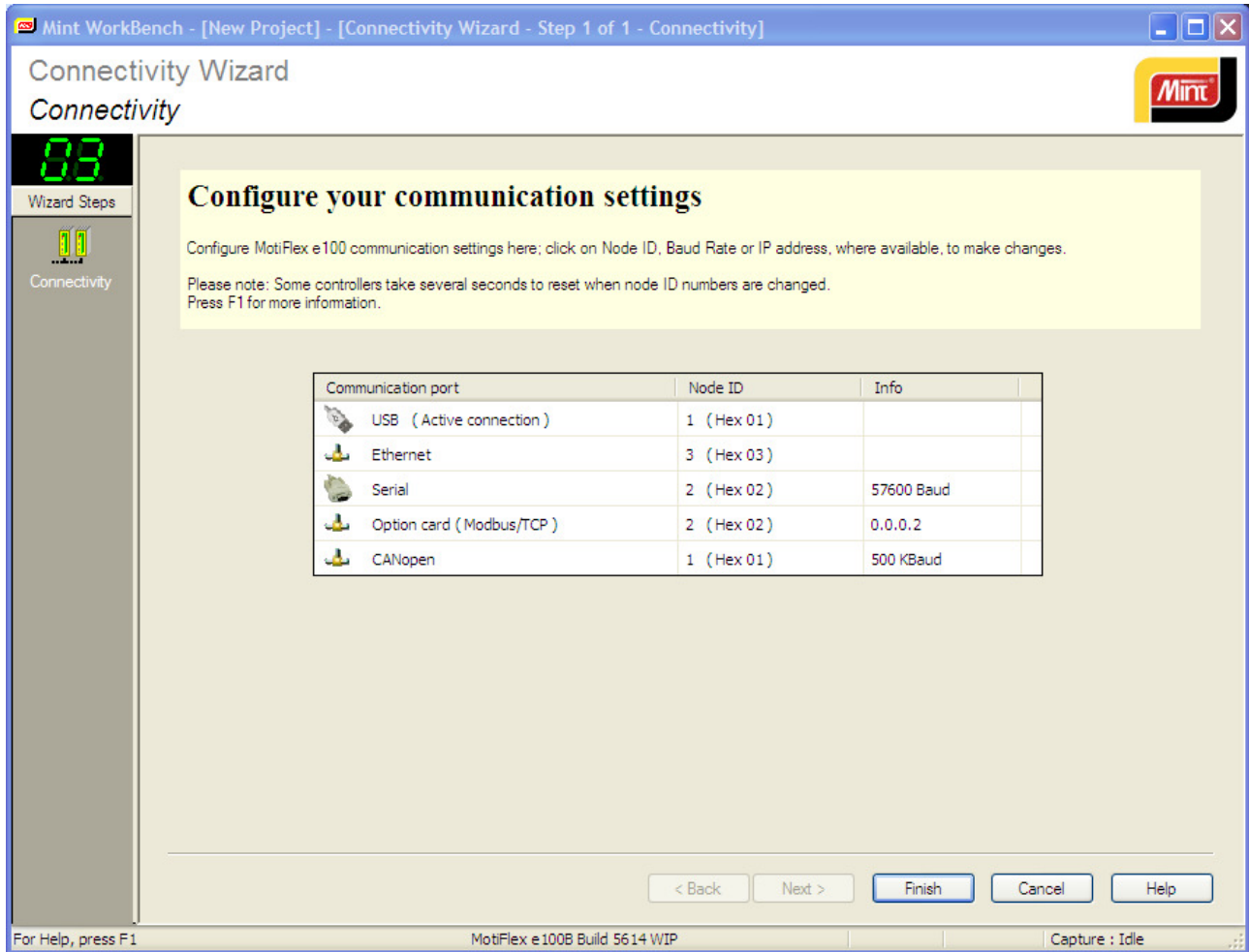


```
OPTIONCARDNETWORKADDRESS(1) = ip#192.168.100.2
```

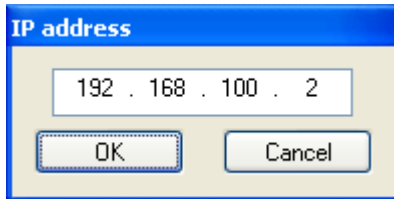
Or more easily, click on the Connectivity tool in the left hand tool bar of Workbench and click on the Info box next to the Option Card (Modbus/TCP) port settings. Then type in the required IP address as four separate octets. Please note that changing the Node ID will automatically change the last octet of the IP address and vice versa. Press the Finish button to complete the process. This setting will now be stored permanently as a drive parameter.

Any IP address can be used and it does not need to match the EPL IP address set on the drive.

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Click on the IP address and this can be edited to suit the application. Below we have set our drive to 192.168.100.2 (which just happens to match the EPL IP address)...

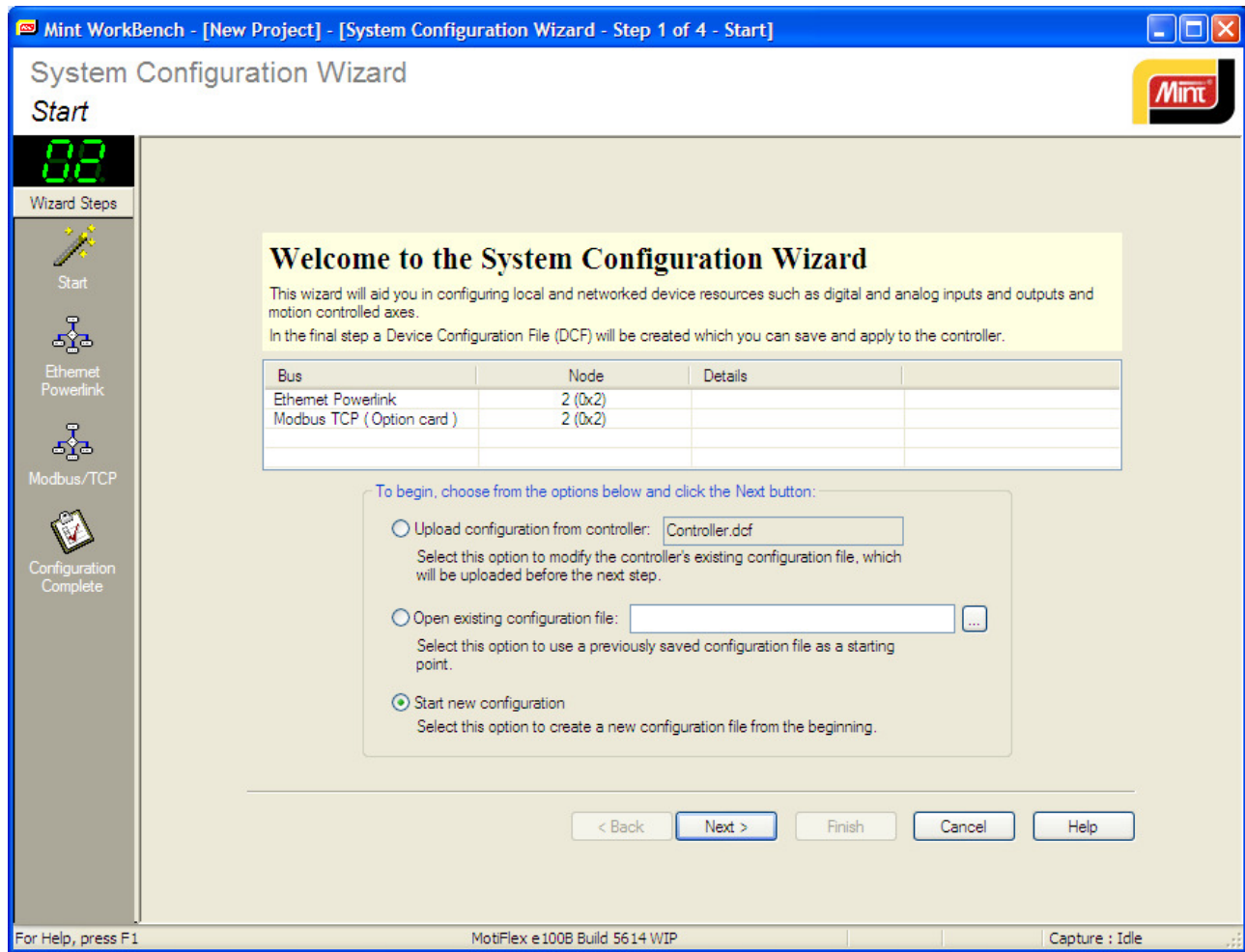


Click on OK to accept the new IP address

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Process Data Configuration

Click on 'System Configuration' in the left hand toolbar. WorkBench will now display the setup screens for the MotiFlex's Device Configuration File (DCF).

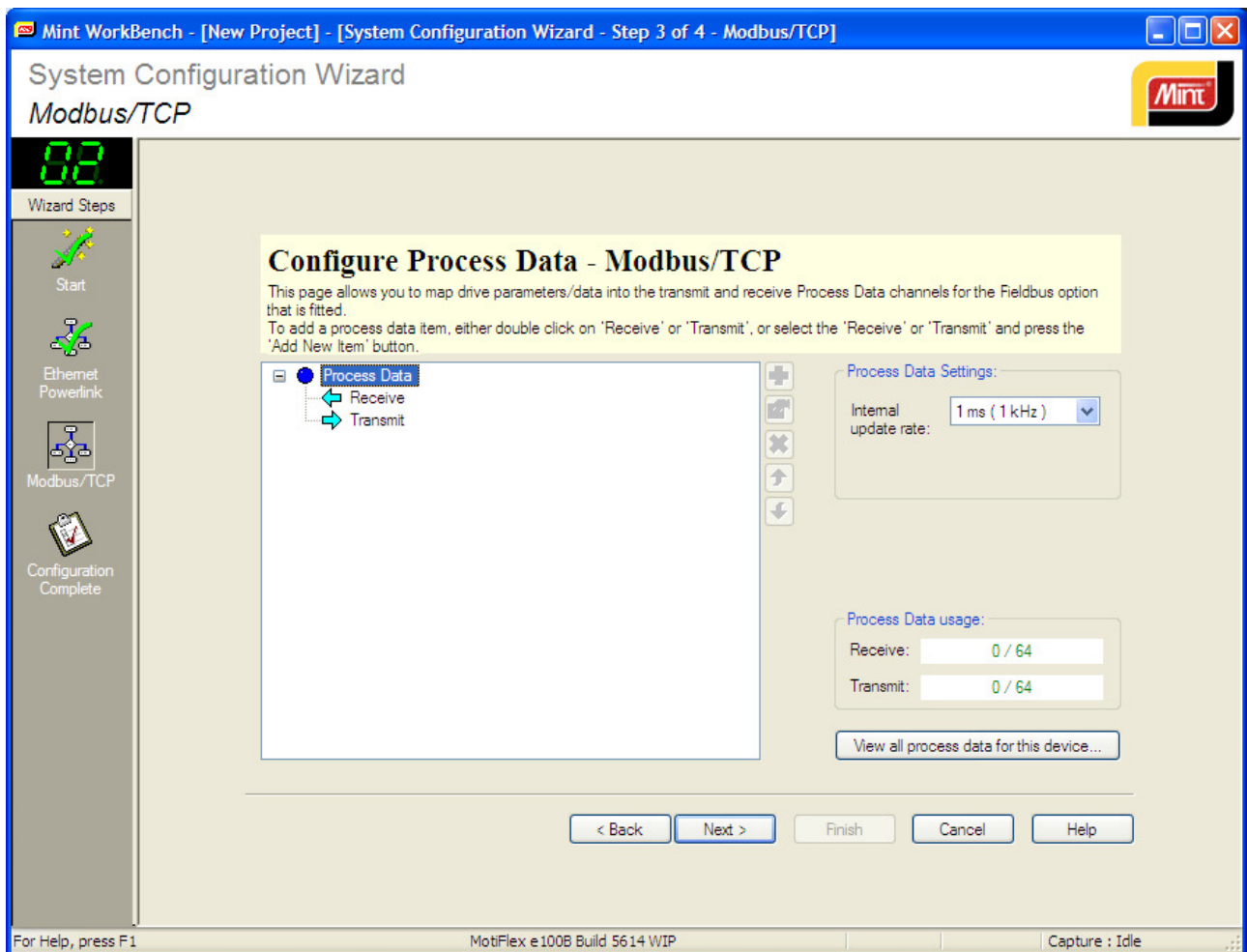


The initial screen shows our EPL Node ID (set via the rotary switches on the front of the MotiFlex drive – in our example 02 hex) and the Modbus/TCP Node ID (the last Octet of our IP address), which is set to the same value. If we've configured a MotiFlex in the past we have the option to open a saved DCF file or we can choose to start a new configuration. We'll select this option – Start New Configuration. Click on Next to continue.

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WorkBench now displays a screen allowing the user to configure EPL side Process Data mappings in and out of the drive. As the comments on this screen detail, these mappings should be performed on the EPL network manager node (i.e. NextMove e100) if there is one. As we're going to want to pass data to/from a NextMove e100 as part of this Application Note we will detail later how to configure the NextMove e100 to do this so for now we can skip this page of the drive setup and move onto the next page – Click on Next.

WorkBench now displays the mapped Process Data objects for the Modbus/TCP side of the fieldbus interface:



This screen allows the user to configure how often the drive updates the drive side of the interface (i.e. the Internal data). How often the Modbus/TCP master (e.g. PLC) reads/writes the Modbus/TCP side of the interface is down to how the Modbus/TCP scanner/client is configured.

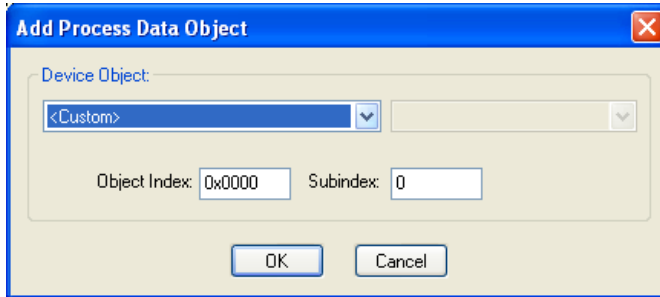
We will leave the Internal Update Rate set to its default of 1ms.

The screen also shows how many of the possible 64 Process Data items (in each direction) we have allocated (as we've just started a new configuration these are both set to zero initially).

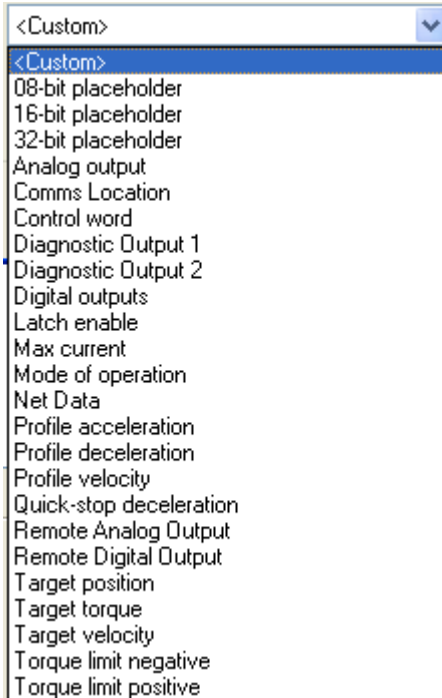
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There are two icons for mapped Process Data:

- Receive – data sent from the PLC to the drive
- Transmit – data sent from the drive to the PLC



Double click the Receive icon (or single click and then click on the yellow + button). WorkBench now displays a dialog allowing the user to select where the first PDO data received from the PLC should be mapped to on the drive:



Click on the dropdown to see the full list of pre-defined objects (the Custom object can be used to access a wider range of drive objects – see the Mint Help File for full details of the drive’s object dictionary).

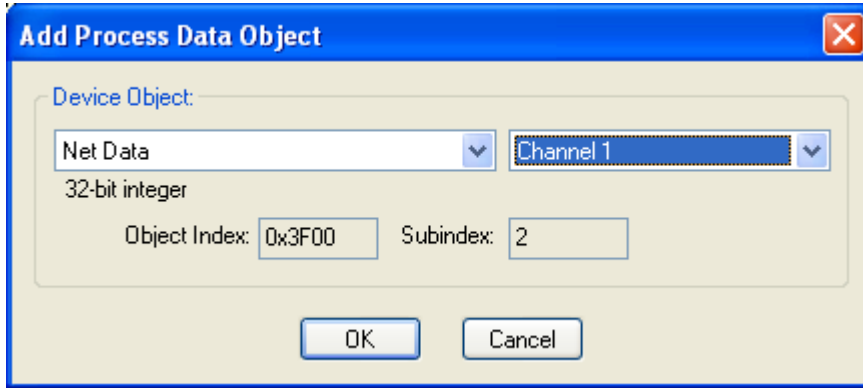
For the purposes of this Application Note we are going to map two NetData Process Data Objects from the PLC to the drive.

Later on we will map these two NetData values to our NextMove e100 so effectively the PLC is able to write two data values to the NextMove using the drive as a Gateway.

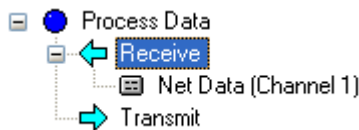
Select NetData from the list.

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There are 1000 NetData channels available (0 to 999). We will start our mappings from Channel 1...



Click on 'OK'. WorkBench will now update the list of Receive and Transmit Process Data items...



Repeat this process adding three more channels of NetData (Channels 2 to 4) to the Receive Process Data.

The order of these entries is important. The first item in the list will correspond to the lowest register address in the Read Process data area (0000 hex).

NetData is a 32-bit value so each NetData object will consume two 16-bit registers. How this data is encoded is down to the Modbus/TCP client (e.g. the PLC). The client can load these registers in a number of different formats (e.g. LONG, FLOAT).

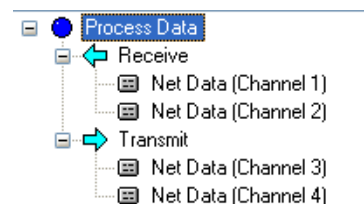
The read the correct data values on the drive (and NextMove e100 once the data is mapped onwards) you must be aware of the data format used by the client. We will illustrate this further later in the Application Note.

The Up/Down arrows to the right of the mapped Process Data list allow you to modify the order of the configured Process data if necessary.

Double-click the Transmit icon to configure the Process Data the PLC is going to read from the drive. Repeat a similar process to that used to configure the receive data. Add two further NetData objects (channels 3 and 4).

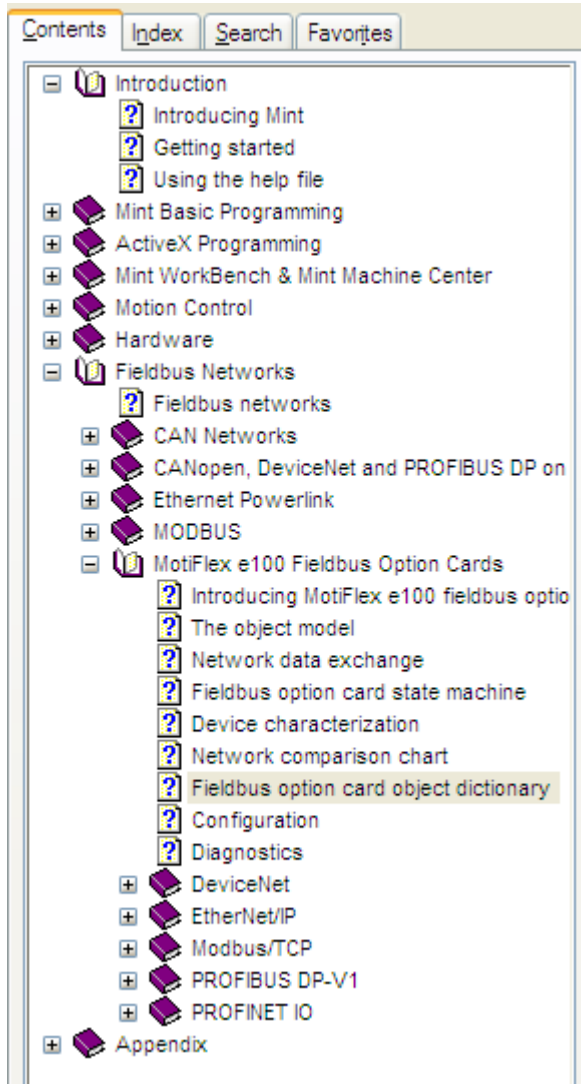
Your dialog should look like this:

Again the order of the Transmit data is important. NetData Channel 3 will map to the first Modbus register in the Write Process data area (0100 hex).



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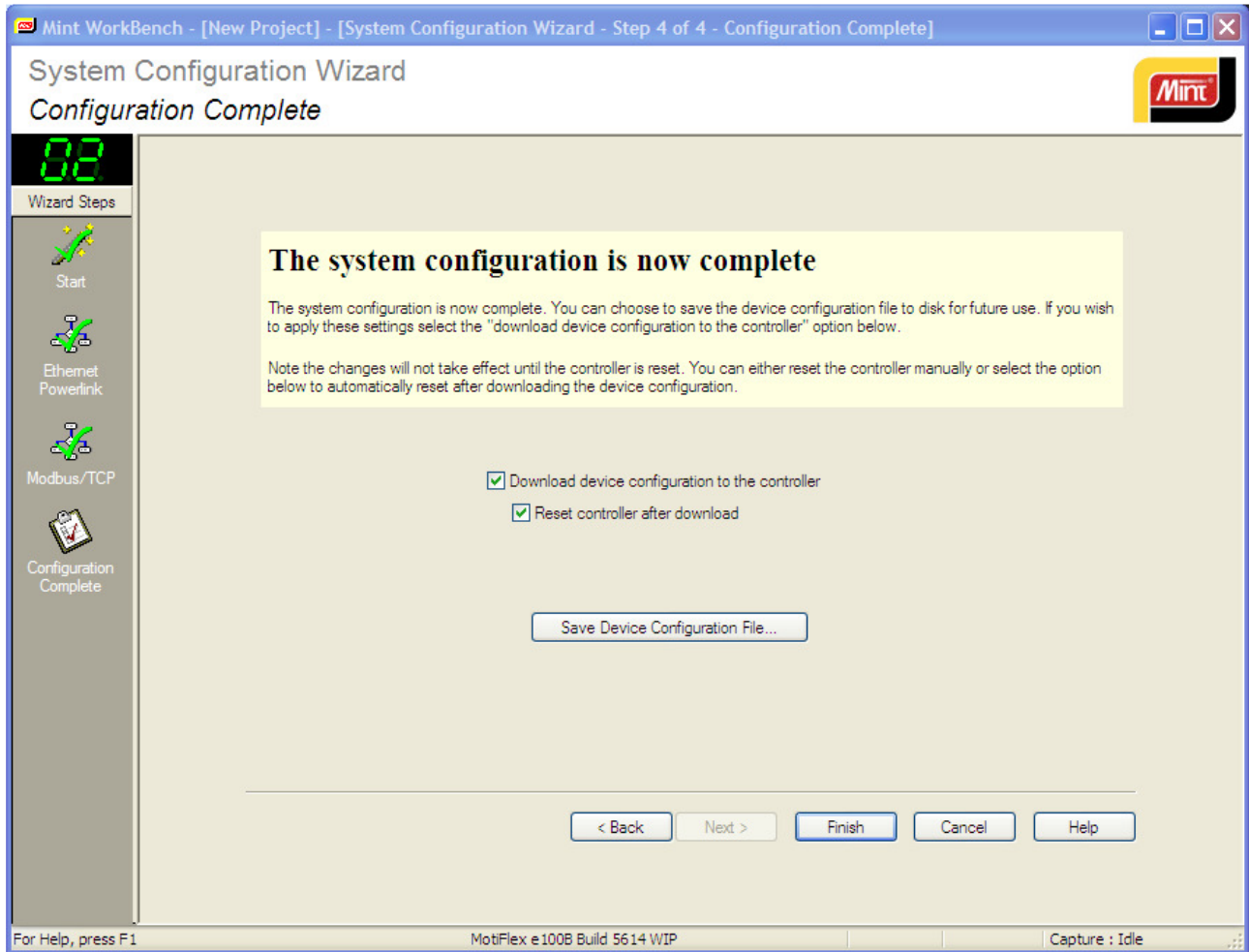
The Mint Help file details the data types and sizes for all the drive parameters/objects...



We have now finished mapping all the Process Data we need for our example, so click on the 'Next' button.

WorkBench now gives us an option to save our Device Configuration File (should we need to repeat this setup for additional drives or future machines). Check 'Download device configuration to the controller' and 'Reset controller after download' and click on Finish to transfer the configuration to the MotiFlex and automatically restart it.

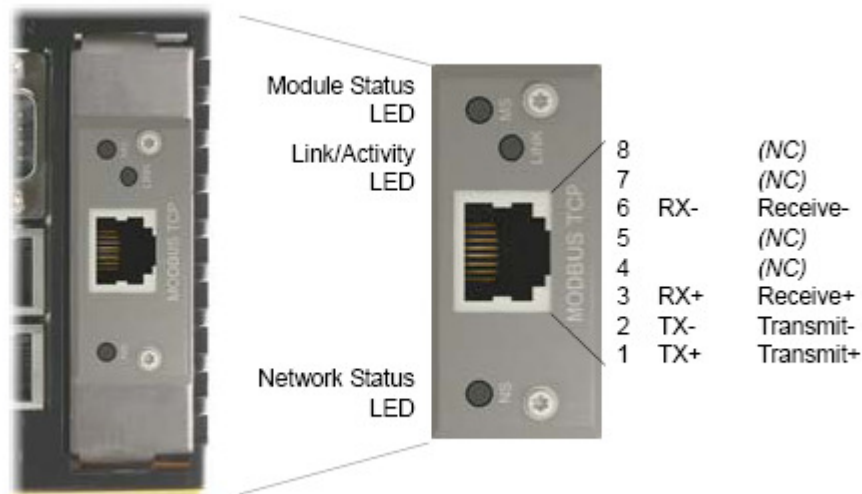
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Our drive side configuration is now complete!

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Application Note**Physically adding a MotiFlex e100 drive to a Modbus/TCP network**

The diagram below indicates the pin-out of the Modbus/TCP connector on the edge of the Modbus/TCP Fieldbus Option card (remember this card **MUST** be plugged into slot 1 of the MotiFlex drive):



A 'crossover' CAT5e (screened) Ethernet cable should be used to connect the Fieldbus Option to the Modbus/TCP network.

Once the drive has been physically connected to the network it is ready for communication with the Modbus/TCP client (e.g. PLC). As mentioned previously, the default drive's Modbus/TCP address is 0.0.0.2, which can be changed using the Connectivity Wizard in Workbench.

Refer to MotiFlex Fieldbus Option Card Installation Manual MN1954 for full details on the physical installation of the option card/module including information about the status LEDs on the card.

Testing Read and Write Data

For the purposes of this Application Note we have used a PC based Modbus/TCP client (a demo application from Automated Solutions called MiniHMI that illustrates the use of their Modbus/TCP ActiveX control). See <http://www.automatedsolutions.com> for further details on their range of controls. The Modbus/TCP ActiveX and MiniHMI application is available to trial free for 30 days.

The communication parameters for the TCP connection were set as follows:

Communications

Node Address	192.168.100.2	?
Connect Timeout	2000	(mSec)
Transact Timeout	800	(mSec)

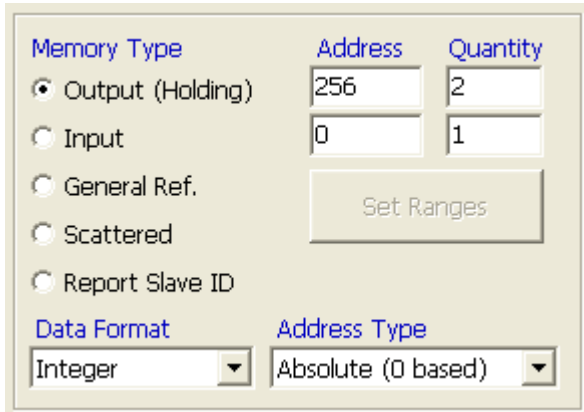
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The MiniHMI application allows the user to Read and Write all of the various Modbus register types.

For the purpose of this Application Note we have used the Read Registers and Write Registers pages to illustrate the operation of the MotiFlex Fieldbus Option...

Reading Process Data

Using the Read Registers page of the MiniHMI application we set the following parameters:



We selected Output (Holding) registers as the memory type as these are the registers that PDO data is mapped to (see Modbus/TCP Register Implementations earlier).

Modbus register 256 is the first register in the Write Process Data area (data read by the client). We have set the quantity of registers to read to 2 (i.e. registers 256 and 257).

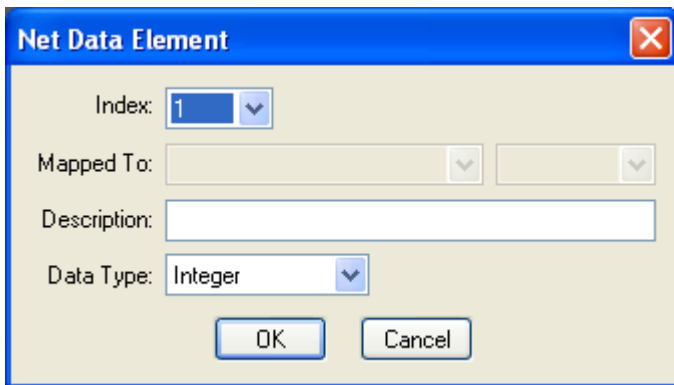
Note that the data format initially is INTEGER (i.e. 16 bit data) and the addressing is zero based.

Before we click on a button to initiate the read we need to load some data into the relevant NetData locations on the MotiFlex drive...

Start WorkBench v5.5, start a new project and connect to the MotiFlex e100 drive. Select the Edit & Debug icon in the left hand toolbar.

Now select the NetData tab in the Spy window on the right hand side of the WorkBench screen...

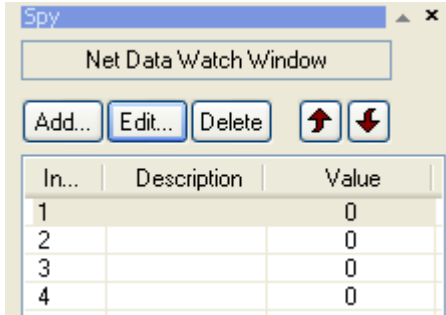
Click on the Add.. button and add a Watch to NetData Channel/Index 1 (Data Type: Integer)



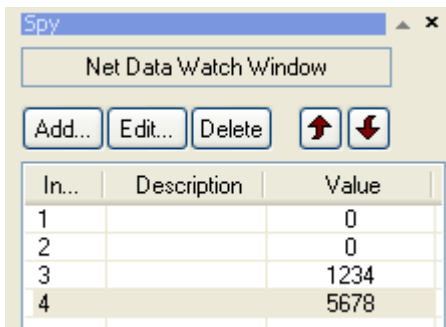
Repeat this process for Channels/Indexes 2, 3 and 4.

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Your Spy Window should look something like this...



NetData Channels 3 and 4 are the Transmit PDOs so use the WorkBench Spy Window to 'poke' some Integer range (+/- 32767) data into these two locations (highlight element 3 or 4 in the WorkBench Net Data Watch Window and enter a new value at the bottom of the Spy Window (click on the Green Tick to accept this).



We entered 1234 for NetData 3 and 5678 for NetData 4...

Now we returned to the MiniHMI application and clicked on the 'Synch Read' button to initiate a read of the Modbus registers. The following data appeared in the data view area...

	+0	+1
256	1234	0

Note that our value in NetData 3 (1234) consumed two Modbus registers. This is because NetData is a 32-bit value and the Modbus registers area all 16-bit.

Next we changed the Quantity of registers to read to 4 and clicked on 'Synch Read' again...

	+0	+1	+2	+3
256	1234	0	5678	0

Now we can see the value for NetData 3 in register 256 and the value for NetData 4 in register 258. If we try to read a value greater/less than +/-32767 then the data becomes 'corrupted'.

We can see from these results that the data is loaded into the least significant word and the upper word is not used when using Integer (16-bit) data.

Next we changed the data format to LONG (32-bit integer) and the Address/Quantity to 256 and 2 respectively...



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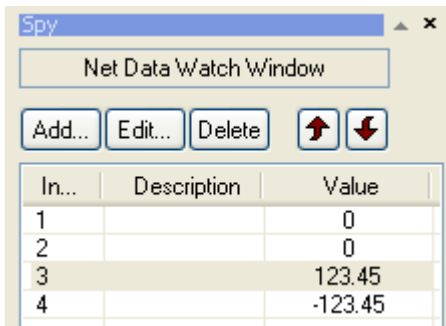
Now when we read the Process Data from the drive the data view area displayed the following result (note that the MiniHMI software automatically displays only registers 256 and 258)...

	+0	+2
256	1234	5678

Because we are now using 32-bit data we are able to load full 32-bit values into our Integer NetData values on the drive....

	+0	+2
256	3456789	-9876543

Using Modbus/TCP it is also possible to transfer floating point data. Switch to WorkBench v5.5 and edit the NetData spy entries for Channels 3 and 4 so their data type becomes Float. Now enter some floating point data via the Spy window (we used 123.45 and -123.45)...

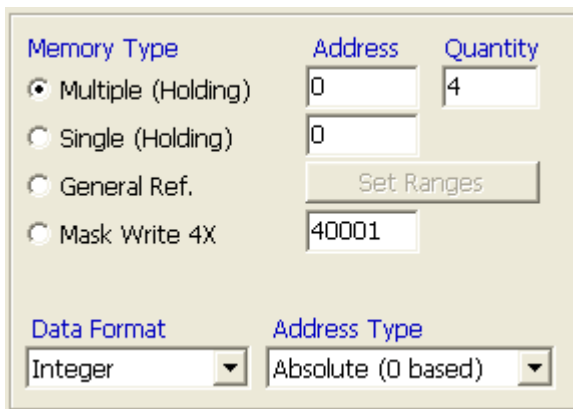


Now change the Data Format in the MiniHMI application to FLOAT (leaving the Address and Quantity set to 256 and 2 respectively). Click on the Synch Read button and the client now displays the correct floating point values in registers 256 and 258...

	+0	+2
256	123.45	-123.45

Writing Process Data

Using the Write Registers page of the MiniHMI application we set the following parameters:



We selected Multiple (Holding) registers as the memory type as these are the registers that PDO data is mapped to (see Modbus/TCP Register Implementations earlier).

Modbus register 0 is the first register in the Read Process Data area (data written by the client). We have set the quantity of registers to write to 4 (i.e. registers 0 to 3). We know from our read tests 4 registers will be needed to write 2 values.

Note that the data format initially is INTEGER (i.e. 16 bit data) and the addressing is zero based.

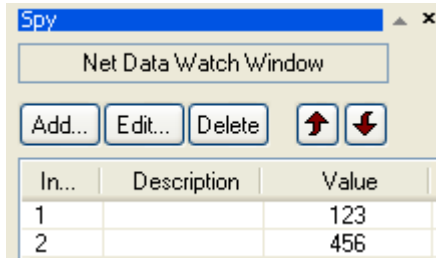
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Before we click on a button to initiate the write we need to load some data into the relevant registers on the MiniHMI data grid...

	+0	+1	+2	+3
0	123		456	

We set register 0 to 123 and register 2 to 456 and then clicked on the 'Synch Write' button

Our WorkBench Spy Window now looked like this...



NetData Channels 1 and 2 are the Recieve PDOs so use the WorkBench Spy Window now shows the 16 bit integer data we sent from the client.

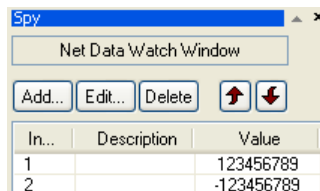
Next we changed the data format to LONG (32-bit integer) and the Address/Quantity to 0 and 2 respectively...



We also loaded some data outside the 16 bit range to test the transmission of 32 bit values (we used 123456789 and -123456789)

Now when we write the Process Data from the client the WorkBench Spy window displays the correct 32-bit integer values (note that the MiniHMI software automatically displays only registers 0 and 2)...

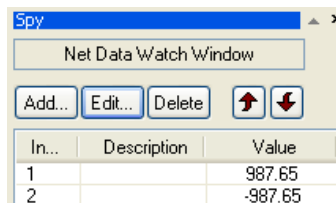
	+0	+2
0	123456789	-123456789



Using Modbus/TCP it is also possible to write floating point data. Switch to WorkBench v5.5 and edit the NetData spy entries for Channels 1 and 2 so their data type becomes Float.

Now change the Data Format in the MiniHMI application to FLOAT (leaving the Address and Quantity set to 0 and 2 respectively). Enter some floating point data into the MiniHMI data grid (we used 987.65 and -987.65) and click on the Synch Write button. The WorkBench now displays the correct floating point values in NetData Channels 1 and 2.

	+0	+2
0	987.65	-987.65



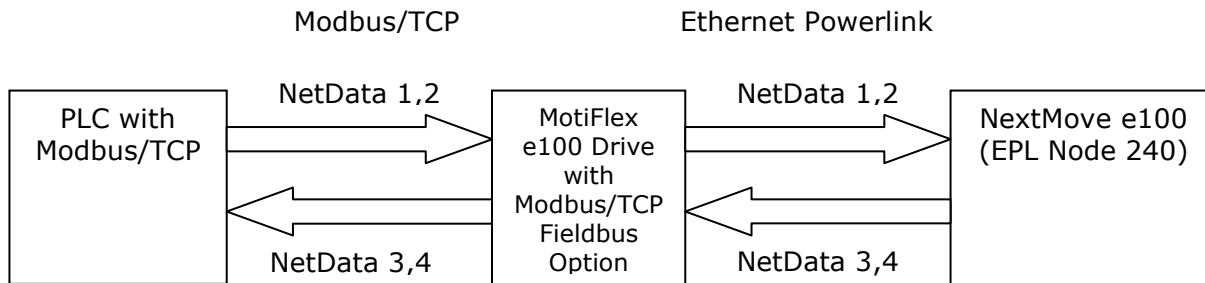
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Mapping the Data to a NextMove e100

If you've followed this Application Note so far (and you have a Modbus/TCP client to use) then you will have two process data objects being sent from the client/PLC to the MotiFlex drive (mapped as NetData channels) and two process data objects being read by the client/PLC from the MotiFlex drive (mapped as NetData channels).

The remainder of the Application Note shows how this data can be passed onto a NextMove e100 (via Ethernet Powerlink), effectively turning the drive into a Gateway between a Modbus/TCP network and the Ethernet Powerlink network.

The diagram below illustrates this:

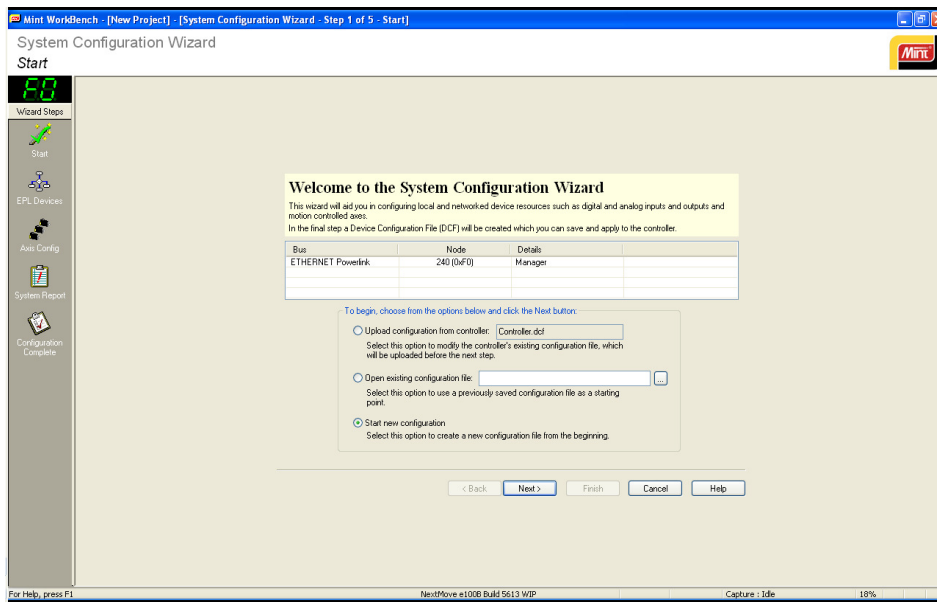


To achieve this transfer of data we must add the MotiFlex drive to the NextMove e100's Device Configuration File (DCF) and include the NetData channels in the list of additional Process Data to be mapped between the NextMove and MotiFlex on the EPL network.

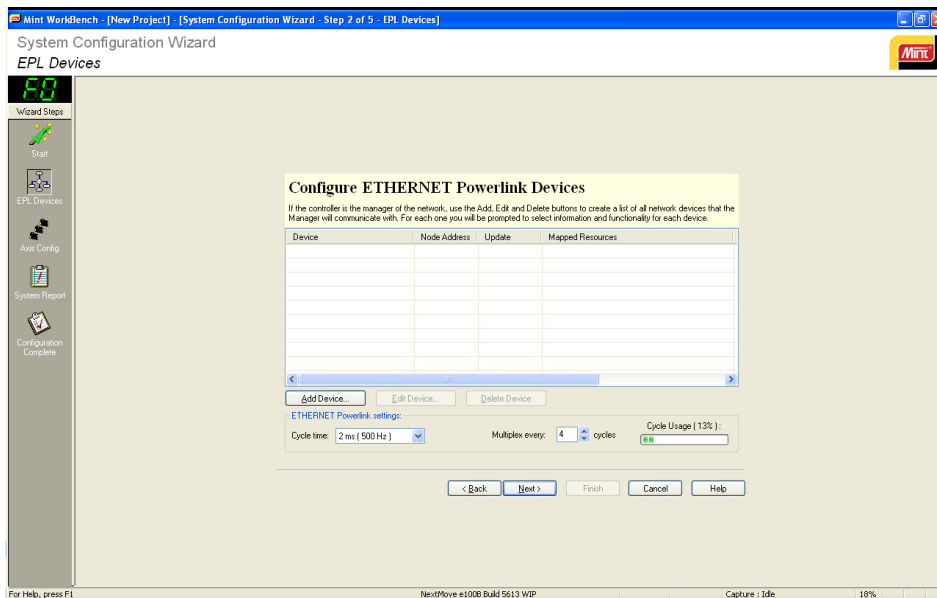
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Mapping EPL Data

Connect your PC to the NextMove e100. Note that this NextMove e100 must be the EPL network master (Node F0 hex, 240 decimal). Start WorkBench v5.5 and then click on the System Configuration icon in the left hand toolbar.

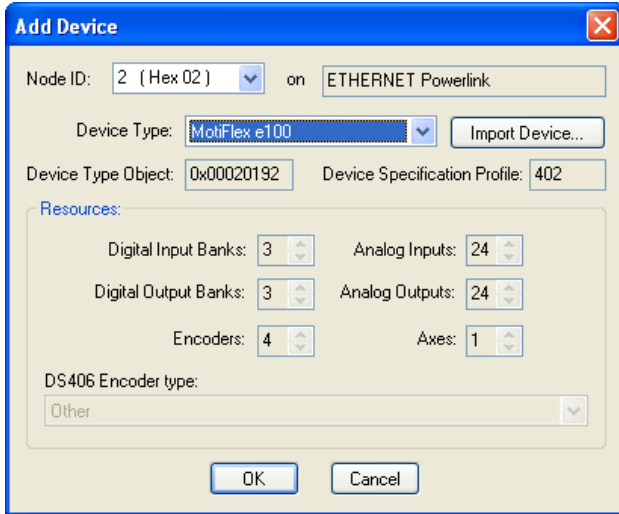


If there is already an existing EPL network configured then select 'Upload configuration from controller' (or if you want to modify an existing configuration that has been saved in the past select 'Open existing configuration file'). We are starting a new configuration so have selected 'Start new configuration'. Click on Next.



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WorkBench shows us which EPL devices have already been added to the NextMove's DCF (in our case none as we have started a new configuration). Click on 'Add Device...' to add a new EPL node (click on 'Edit Device...' if you already have the MotiFlex e100 with Fieldbus Option included in the DCF).

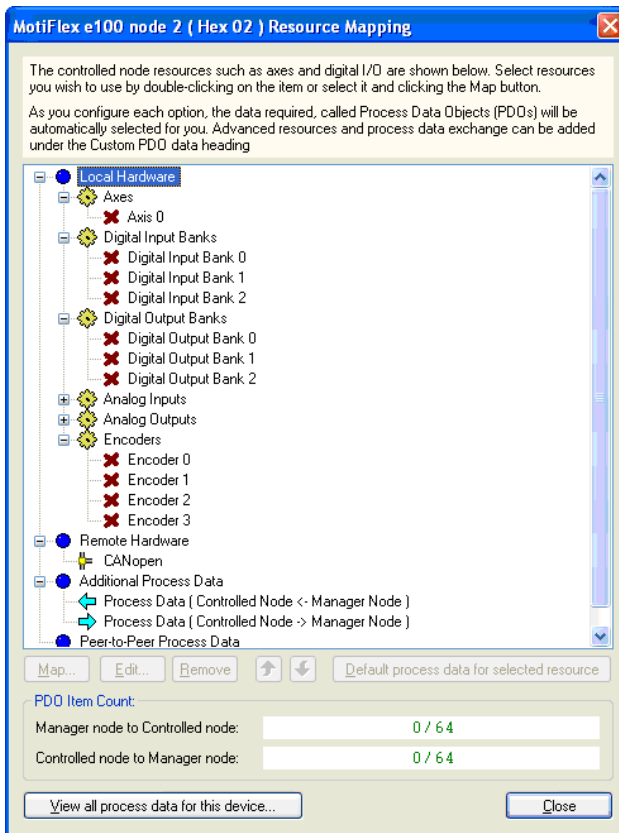


Select MotiFlex e100 as the device type and select the appropriate Ethernet Powerlink Node ID.

As described earlier we set our EPL rotary switches to 02 to select EPL Node ID 2.

The dialog shows the available resources on the MotiFlex e100 that can be mapped back to the NextMove e100.

Click on 'OK'.



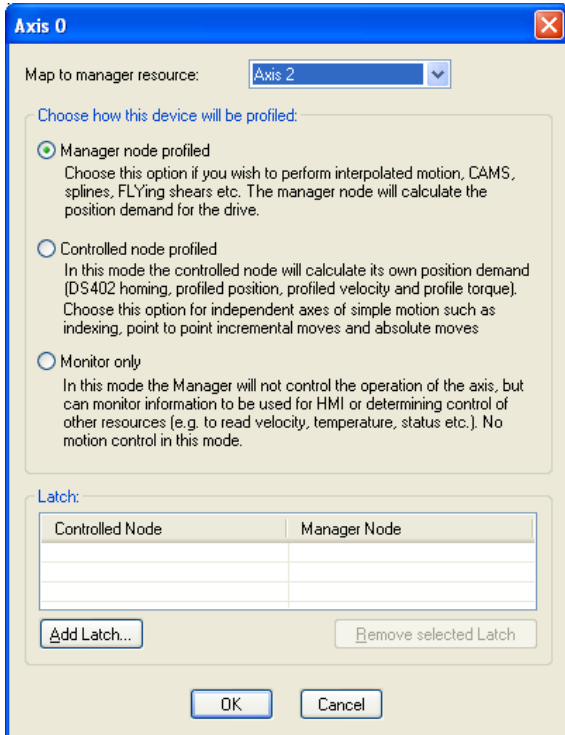
WorkBench v5.5 now displays a dialog that shows which resources have been mapped from the drive to the NextMove e100. Initially (as we've only just added this drive as a new device) there are red crosses against everything to show nothing is mapped).

The dialog also shows how many of the possible 64 PDO items to and from the MotiFlex have been mapped. Note that mapping an Axis and drive resources will consume some of these PDOs thereby restricting the amount of data that can be passed to/from the FOC.

For the purposes of this Application Note we don't need to map an Axis, Digital I/O or an Encoder but as it's most common to actually be using the drive as a controlled axis (rather than just as a Gateway) we will illustrate this just for reference.

Double-click the 'Axis 0' icon to display the Axis 0 mapping dialog.

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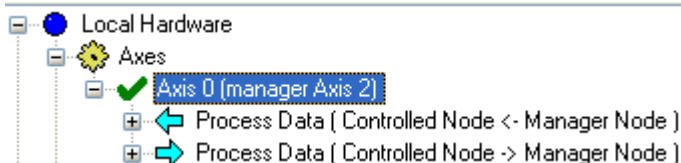
We can choose whether the drive is to be manager profiled (the NextMove e100 provides the profile data – useful for interpolated motion, CAMs, FLYs, etc.), Controlled Node profiled (the drive calculates its own position demands – useful if the only motion required from the drive is MOVEA, MOVER, INCA, INCR and HOME), or Monitored only (no motion).

We have selected the most common profile method – Manager profiled.

We have also decided to map the drive’s axis 0 as the NextMove’s axis 2 (it is typical to match the axis number to the EPL node ID as it makes tracking which axis is which much easier!).

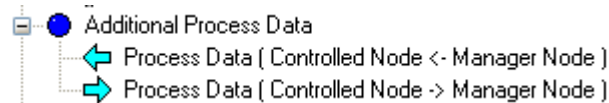
Click on 'OK'.

Now we’ve mapped the axis the Resource Mapping dialog will show a green tick against Axis 0 and indicate in brackets which axis this has been mapped to on the NextMove...



The dialog also indicates that some Process Data associated with Manager Profiled operation of the axis has been configured (we don’t need to look at this in detail for this Application Note).

Scroll down the Resource Mapping dialog until you find the 'Additional Process Data' section. This is the section we need to edit...



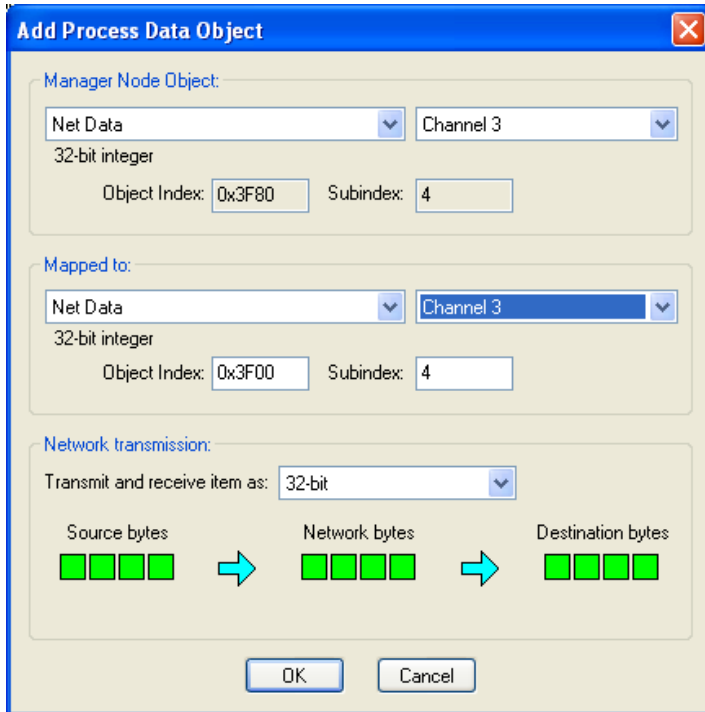
There are two elements to this section:

- Process Data (Controlled Node<-Manager Node) – this is the Process Data that is to be passed from the NextMove e100 to the drive (in our case this corresponds to NetData Channels 3 and 4 which we want to pass from the NextMove e100 to the client/PLC ultimately – via the MotiFlex Fieldbus Option)

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- Process Data (Controlled Node->Manager Node) – this is the Process Data that is to be passed to the NextMove e100 from the drive (in our case this corresponds to NetData Channels 1 and 2 which we want to pass from the client/PLC to the NextMove e100 via the MotiFlex Fieldbus Option

Double-click the Process Data (Controlled Node->Manager Node) icon. WorkBench will display the 'Add Process Data Object' dialog. We are configuring the first object to pass from the NextMove e100 to the MotiFlex e100 (NetData Channel 3) so our dialog needs to be set as shown below:



We mapped NetData Channel 3 on the NextMove e100 to NetData Channel 3 on the MotiFlex e100. The channels don't have to match but we did this so it is easier to follow the logical path for the data.

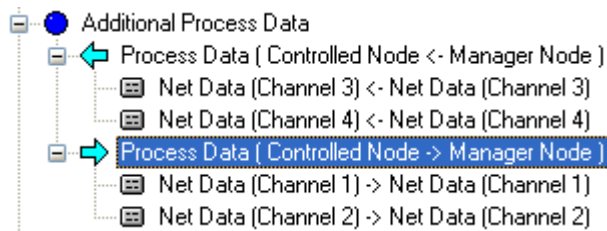
As we are sending and receiving 32 bit values we selected 32-bit for the Network Transmission data. The dialog allows you to specify different data types so that the data can be padded correctly when sending and receiving other data formats (e.g. Booleans or 16 bit data).

Note also that the dialog shows NetData is a 32-bit integer. You may recall from earlier that we used these 32 bits to store either a 32 bit (IEEE) float, a 16 bit Integer or a 32 bit Long Integer. How this is decoded is determined by the keyword ultimately used to extract the data (NetFloat or NetInteger).

Click on 'OK' to accept this mapping and then repeat for NetData Channel 4 (the second Process Data item to be passed from the NextMove to the MotiFlex).

Now double-click the Process Data (Controlled Node->Manager Node) icon to setup the mappings from the drive to the NextMove (NetData Channels 1 and 2). Again we maintained a direct relationship between the drive's NetData channels and the channels on the NextMove (e.g. NetData Channel 1 was mapped to NetData Channel 1).

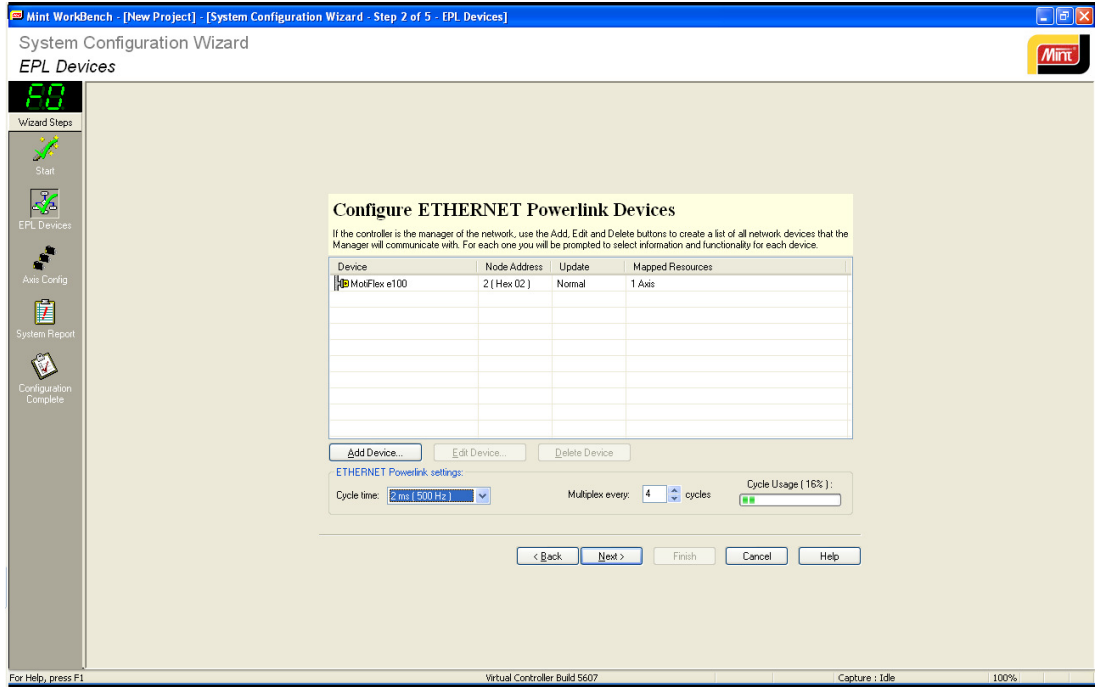
If you've added these mappings as described then your Additional Process Data section should look like this:



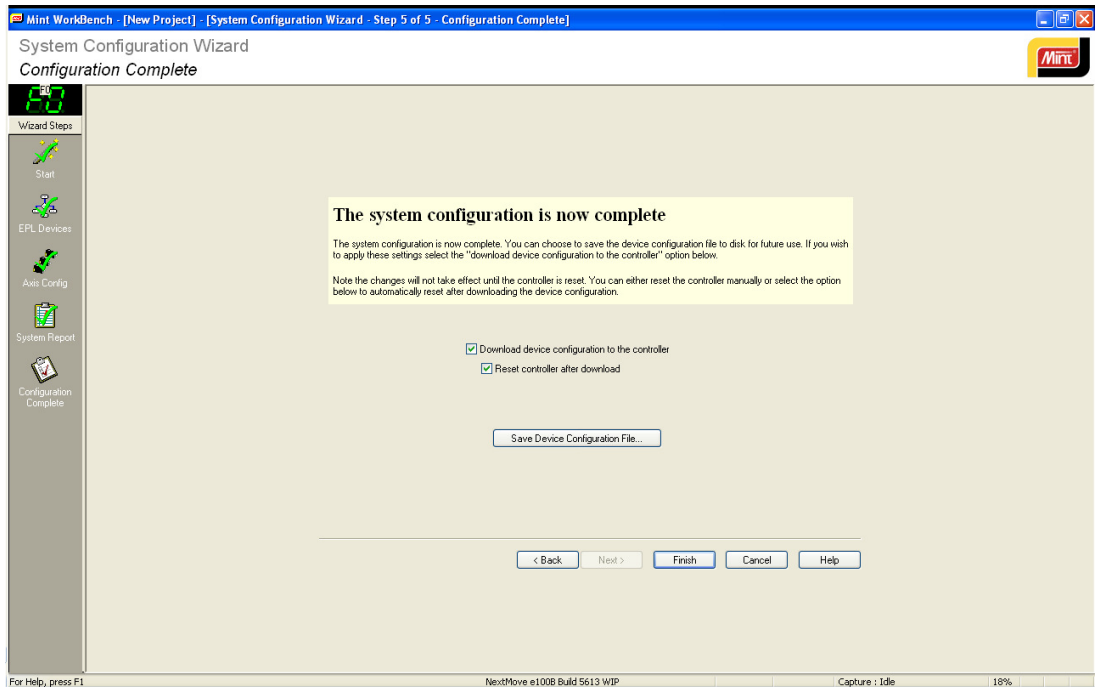
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Click on 'Close' to shut the Resource Mapping dialog.

WorkBench now shows that a MotiFlex e100 at EPL Node Address 2 has been added to the EPL network and one axis has been mapped...



Keep clicking on 'Next' until the 'System Configuration is Complete' screen is reached...



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The 'Save Device Configuration File...' button can be used to save the DCF file to PC disk should you need to save this for future use. Check the 'Download device configuration to the controller' and 'Reset controller after download' boxes and click on 'Finish' to transfer the DCF file to the NextMove e100 and force it to restart.

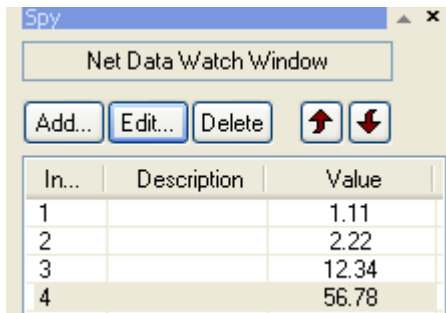
Once the NextMove e100 has restarted you are ready to test if the client/PLC is able to read/write data on the NextMove.

Testing the Exchange of Process Data

Whilst connected to the NextMove e100 use WorkBench v5.5 to select the 'Net Data' tab within the Spy Window on the right hand side of the Edit & Debug area.

Click on the Add... button and add a Watch to NetData Channel 1 (Data Type Float). Repeat this for NetData Channel 2 (Float), NetData Channel 3 (Float) and NetData Channel 4 (Float).

Your Net Data Watch Window should look something like this...



In...	Description	Value
1		1.11
2		2.22
3		12.34
4		56.78

Now poke some values into NetData Channels 3 and 4 on the NextMove (we entered 12.34 and 56.78 as you can see above).

Ask the Modbus client/PLC to read Modbus registers 256 and 258 and you should receive the values entered for these two NetData channels.

Now using the Modbus/TCP client/PLC, write some Float data to Modbus registers 0 and 2 (i.e. the first two floats). You should see these appear in the NextMove's NetData Watch Window (as you can see from above, we wrote the values 1.11 and 2.22).

Congratulations! You have now completed this Application Note. You can now see how simple it is to exchange data in either direction between a Modbus/TCP client device and a NextMove e100 using the MotiFlex e100 with Modbus/TCP Fieldbus Option Card.