Hello Angles...

A First Use Guide to the SOLAR Product Series:

RS485 Interface with
ModBus RTU Communication Protocol.

level developments

Who Is This Guide For?

The purpose of this guide is to show the correct procedure for connecting and using the SOLAR inclinometer with a Windows PC for the first time.

This document can be followed by users of all skill levels including absolute beginners.

What products can I apply these instructions to?

This guide can be used for any SOLAR products (including 360° variants) that feature the **RS485 ModBus** interface option. All applicable part numbers will start with "**SOLAR**" and end with "**RS485M**".

Note: If you are using a "**SOLAR- … -RS232**" or a "**SOLAR- … -RS485**" search for your full part number on our website then go to its web page & download the document that specifically applies to your device as shown below.

Additional Information:

Take care while making all connections. To avoid damaging your product, do not allow any wires to make contact with anything you do not intend (especially a source of power).

Once your connections have been made and the unit is responding correctly, please refer to the product datasheet for the full command list(s) and more information about the communication protocol.

Step 1: **Ensure You Have a Working COM Port (Hardware).**

To communicate with the inclinometer you'll need a USB to RS485 adapter that's configured for or natively 2-wire (half duplex), these can be found inexpensively online and for this guide we've used the "Hjelmslund USB485-STISO" product:


Hjelmslund have now replaced this product with the USB485-STIXL the only difference to our model is the larger screw terminals.

Step 2: **Ensure You Have a Working COM Port (Software):**

On your computer go to "Device Manager" which can be accessed via the control panel:

Follow the manufacturer's instructions to install your driver and check that it has installed properly as shown below:
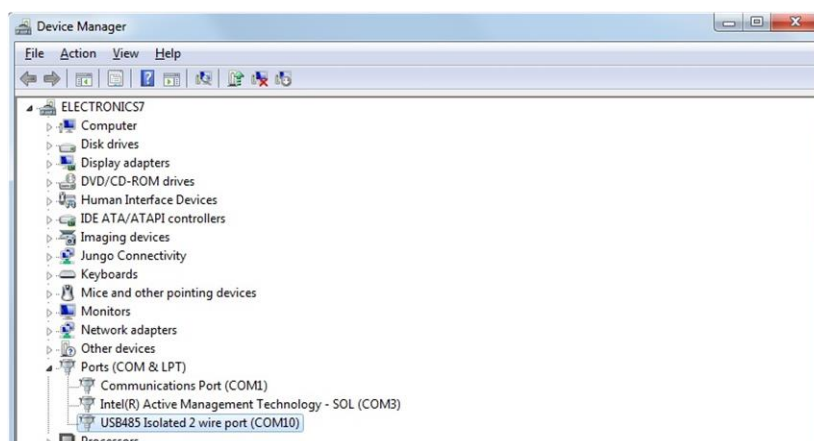
The name & port number that's automatically allocated to the USB to RS485 device can vary. Make a note of the port number that the device is allocated. Our example device is using "COM10" so this is the port number we would use to communicate with the inclinometer.

If the COM device symbol looks like this: 🔌⚠ then you will need to troubleshoot the device driver problem. (A good place to start is the website for the manufacturer of the hardware).

Step 3:   **Connect the Inclinometer wires to the USB COM Port:**

Full RS485 connections for the SOLAR inclinometer are as follows:

SOLAR Wire Colour	Solar Wire Function	Connects to… (Function)	Note
Red	+ve Power Input	+ve Supply (12 to 30V)	Don't connect to power source yet
Blue	0V Power input & RS485 GND	COM GND & 0V Supply	Don't connect to power source yet
Yellow	RS485 -	RxD / D-	
Green	RS485 +	TxD / D+	

We've extended the connection from the screw terminal block of our USB device to make connection the Inclinometer easier. This also allows us to connect the (inclinometer's) blue wire to both the "Gnd" point of our USB device and our Power supply 0V.

Step 4: Connecting the Inclinometer to the Power Supply / Power Source:

Ensure the power source is switched off & connect the Inclinometers red wire to the +Ve node.
The power source should provide between 12V (minimum) & 30V (maximum).
If you are using a battery or have no on/off option available then leave the red wire disconnected for now.

Connect the blue wire to the 0V (-Ve) node of the power source whilst it's still connected to the Gnd point on the USB-RS485 device as shown in the illustration below.
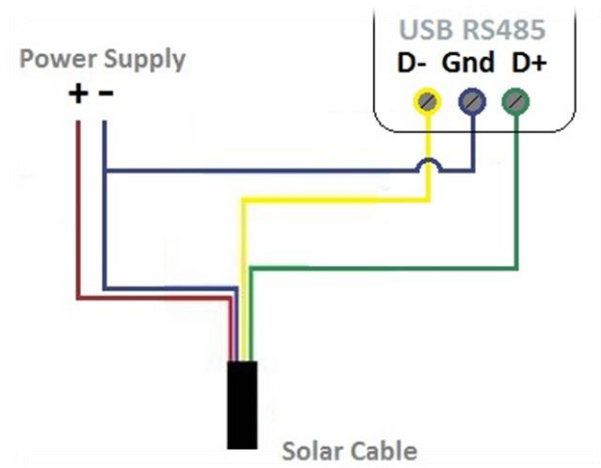

There are many ways to achieve this & for this demonstration we've used the extension cable shown on the previous page with stackable banana plugs, a simple straight-through connections box & spring terminal posts. Here is our complete setup:

Once you've made all of the necessary connections you can switch on the power source or connect the red wire to "+" if using a battery.

Step 5:   Connecting an Inclinometer to the Level Developments Modbus App:

We recommend using the Free Level Developments ModBus App before attempting to create your own more advanced commands, this ensures that you have the correct connections and your hardware is working as it should. Download and install the application from our website:
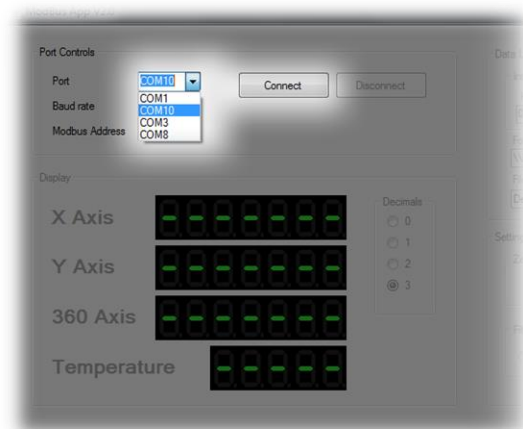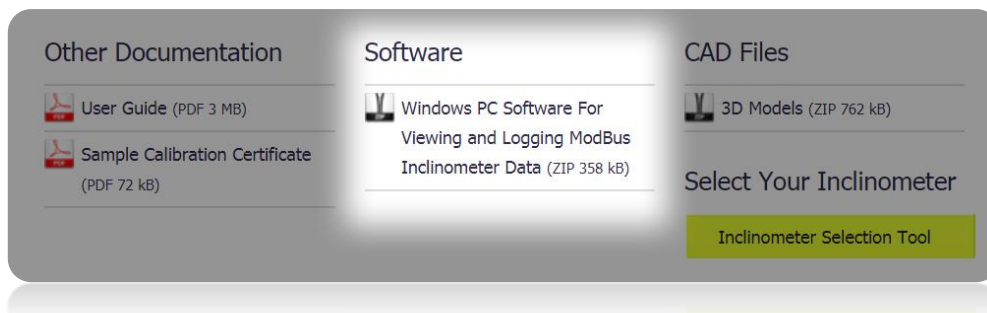
Run the ModBus app and select the port number that was determined earlier in Step 2.

By default the inclinometers baud rate setting is 38400(bps) and address is 100, ensure these are selected and click on "Connect".

You should now see angles being displayed on the screen.
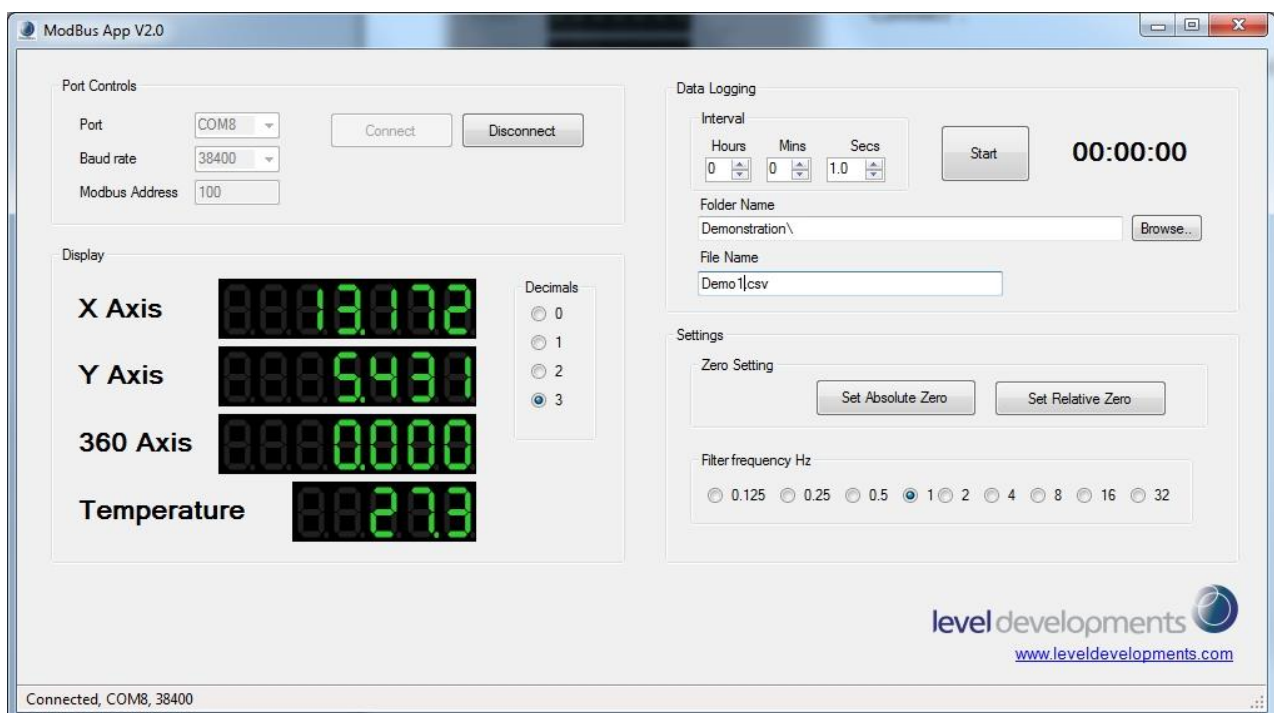
Step 6:   Sending Your Own Commands Using an RS485 Terminal / Serial Monitor Program:

To create your own commands you will need a serial monitoring application. For the purpose of this demonstration we are using Docklight but there are many to choose from. *The layout and terminology used in your terminal program may vary.*

A free trial version of Docklight can be downloaded from *https://docklight.*de with some minor limitations. Please see their website for more information.

Open your application and locate the project settings window. In Docklight this can be accessed by double-clicking the highlighted area below or going to tools, project settings.
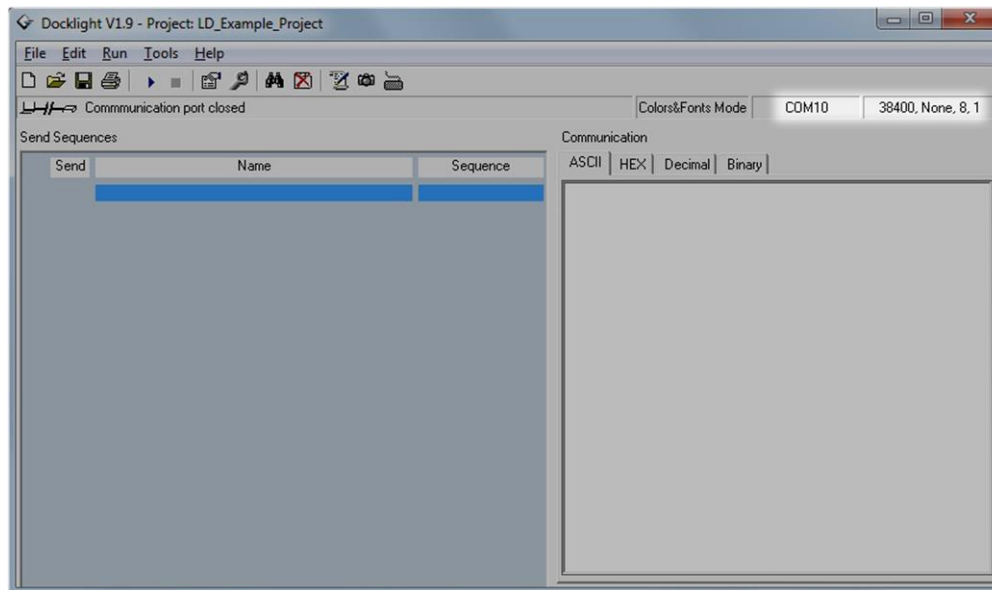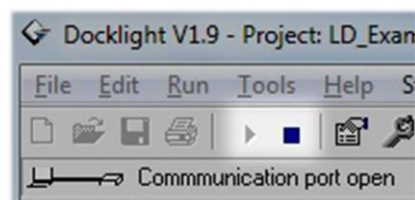

You can then change the COM channel (port number) to match the value determined in step 2.
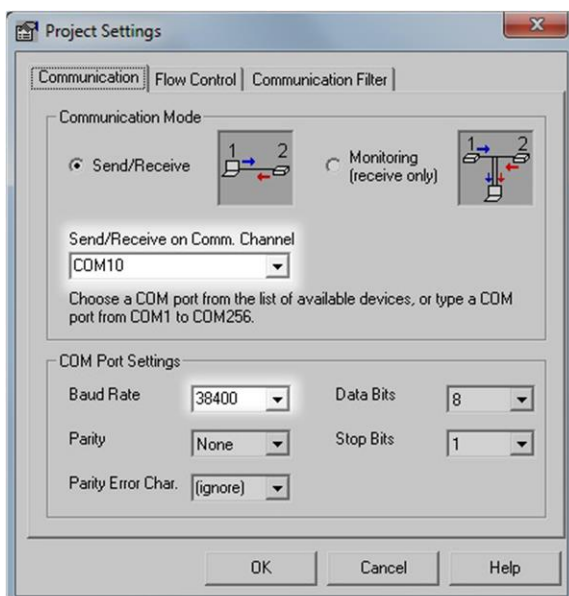
The default baud setting for all SOLAR sensors is 38400, with 8 data bits, 1 stop bit and no parity.

Click OK then open the port by clicking on the ▶ button:

Once the port is open, the ■ button should be visible as shown below:

The ■ button can then be used to close the port if required. (Note: the port can only be open in 1 application at a time).

You can now begin to create the commands to send to the Inclinometer. To do this go to Edit, Edit Send Sequence List…

A First Use Guide for Solar Inclinometers Using RS485 &ModBus RTU.
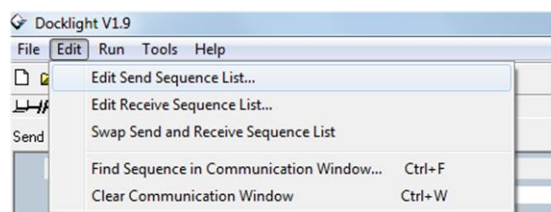
This will open the "Edit Send Sequence" window where we can enter the hexadecimal commands to send to the Inclinometer. Before we continue, here's a breakdown of the first ModBus command we will be sending:

Command

```
address (0x64 = 100 decimal)
|  function code
|  |  starting reg. to read (0x0000)
|  |  |      number of reg. to read (0x0002)
|  |  |      |
|  |  |      |       CRC-16
|  |  |      |      |
64 03 00 00 00 02 cd fe
```

	Byte Data	No Of Bytes	Description
	0x64	1	Slave address 100
	0x03	1	Function code for read register
Command	0x0000	2	Starting register (0x0000 is X axis angle)
	0x0002	2	Number of registers to read
	0xCDFE	2	CRC-16 of all bytes

By default the slave (inclinometer) device **Address** is set to 100 (decimal) which is the same as 0x64 (hexadecimal) so "64" will formulate the first byte of our command.

The next byte is the **Function Code** & as we want to read from the device (rather then set a parameter) the next part of the command must be "03".

The following 2 bytes of information should contain the **Starting Register** we want to read from; which in this case is "00" & "00" (as it's where the X Axis angle is stored, Y Axis would be "00" & "02" for example).

The next 2 bytes should contain the **Number** (or span) **of registers** to read. The X Axis angle is stored in 2 registers so these 2 bytes must be "00" & "02".

The final 2 bytes of every ModBus command is the **CRC** (cyclic redundancy check sum) which on receipt will run the sequence (excluding the CRC itself) through an algorithm and compare the CRC code it has generated with the one it has received. This is used for error checking the transmission. Each identical command will have an identical CRC code, but if any of the command is changed the CRC code changes too.

You can download the CRC code generator from www.simplymodbus.ca/crc.xls when making your own commands. The "Simply Modbus" website is also a useful knowledge base for the ModBus Protocol but you can find many of the required commands (pre-calculated) on our product datasheet.

Switch to "HEX" view & type the command into the "Edit Send Sequence" window. You can see as you start typing that the "command" itself becomes highlighted but the address and CRC bytes do not.
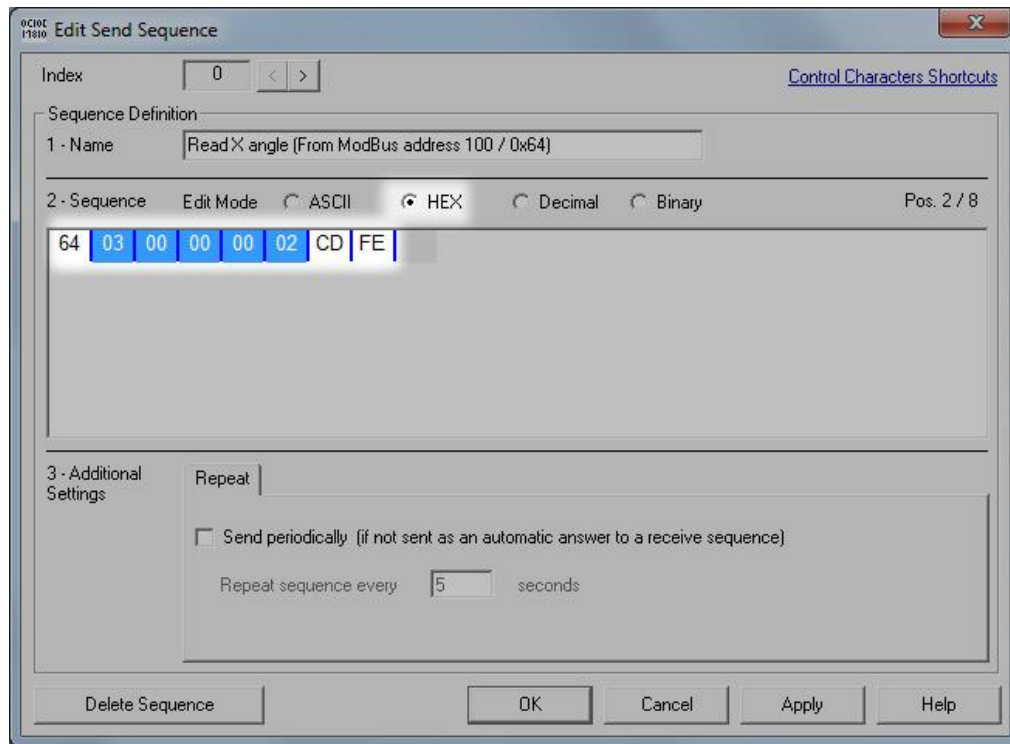
(If you are using a SOLAR-360-X-RS485M use the command "64 03 00 04 00 02 8c 3f" instead)

Once you have filled in the send sequence press OK.

This will save the new command into the sequence list as shown below. You can now send the command to the Inclinometer by clicking on the "—>" button. This will print the command "64 03 00 00 00 02 CD FE" (Tx) into the monitor window & and the inclinometer should respond (Rx) with a 9 byte string.
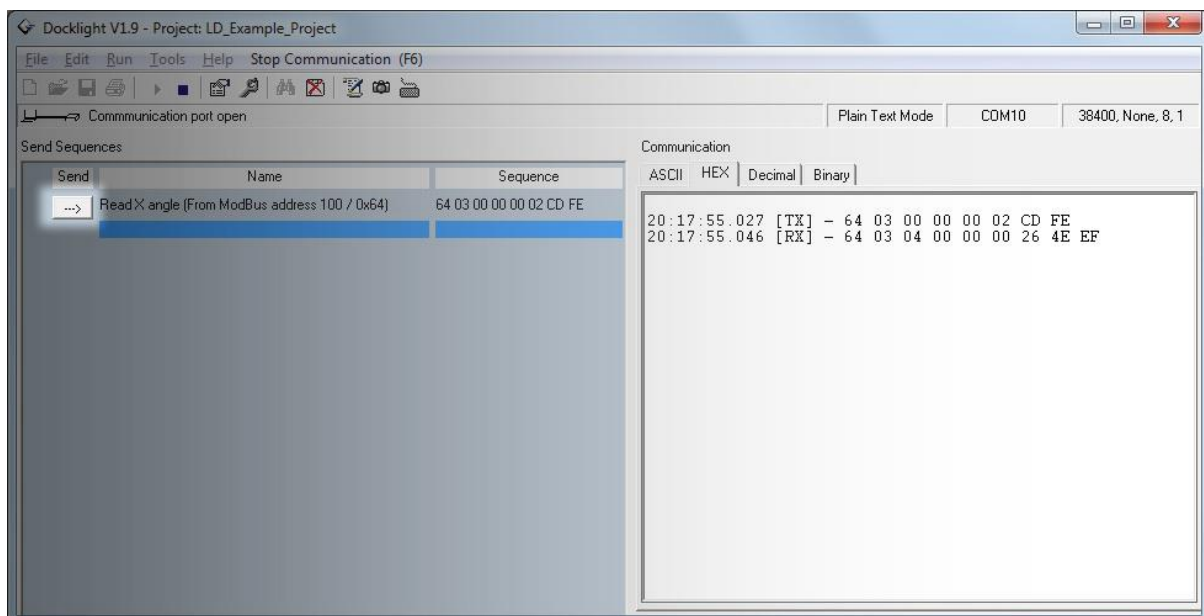
The 9 byte response can be converted into a positive or negative angle as shown below:

Response (positive angle)

```
address (0x64 = 100 decimal)
|  function code
|  |  byte count
|  |  |  angle (0x00005ba3 = 23459 decimal (23.459 degrees)
|  |  |  |           CRC-16
|  |  |  |              |
64 03 04 00 00 5b a3 b4 7c
```

Response (negative angle)

```
address (0x64 = 100 decimal)
|  function code
|  |  byte count
|  |  |  angle (0xffffa54d = -23219 decimal (-23.219 degrees)
|  |  |  |           CRC-16
|  |  |  |              |
64 03 04 ff ff a5 4d 74 74
```

(The same conversion applies to SOLAR-360-X-RS485M products also).

You can now use these techniques to build on your collection of send sequences using the full list of commands as described on the product datasheet.

Step 7: **Connecting multiple Inclinometers in a daisy chain topology:**

The ModBus RTU Protocol is address based; meaning that up to 128 Inclinometers can be connected and used by a PC or PLC using only one COM port as shown in this functional drawing of a 6 piece inclinometer network:
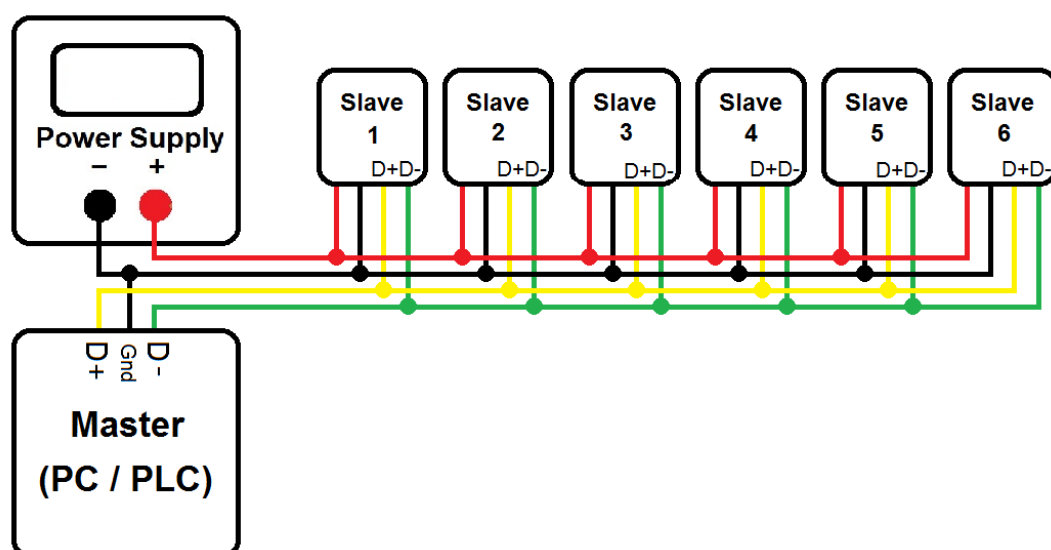
All of our ModBus type inclinometers are shipped with 100 (0x64) as the default address, to communicate with multiple units you must first give the units unique addresses; these can be between 1 and 246.
To do this **first connect only one unit to a host PC or PLC** then change to another address using the special function code 110 (0x6E) and the LD command for change address which is 0x91. For example, the command "64 6E 91 65 D3 72" would change the address from 100 (0x64) to 101 (0x65). Refer to the Inclinometer datasheet/Step 6 for more information on ModBus commands and structure. We recommend assigning addresses sequentially as this is optimal when used with our free Multi-Node app

Once the units have unique addresses, they can then be communicated with individually on the network.

Devices on the network will respond first with their address, followed by the response to the specific command that was sent and finally the 2 byte CRC code.

To send an instruction to all units on the network you can use the Modbus broadcast address which is 0. Note that when sending any command using the broadcast address the unit(s) will not respond.

& That's It!

If you need more information or have a query relating to the use of your SOLAR inclinometer, please get in touch with tech@leveldevelopments.com, we'll be happy to assist you.