3DLevelScanner II



Different Ways of Connecting to 3DLevelScanner II



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<u>Abstract</u>

This document describes different methods for connecting the 3DLevelScanner II (types S/M/MV and MVL) in variety of communication ways.



Note: All methods of connections are for recommendations only and the user may use more or other solutions to get connected to the 3DLevelScanner II.

1. Connection via 4...20mA.

a. The 4...20mA current output is available through ports 3 and 4 of the left green connector (as shown in the drawing below). Ports 3 and 4 are the negative and positive poles, respectively.



b. The 4...20mA line goes directly from the scanner mounted on the vessel to the PLC/device (as shown below).





- <u>This type of connection is active and not passive</u>, hence the 3DLevelScanner II is the active module and the PLC should be the passive module.
- This connection does not require the APM 3DLevel Manager Software tool.

- 2. Connection via Paperless Recorder (based on 4...20mA)
 - a. Each mounted scanner is connected directly to the recorder via ports 3 and 4 of the left green connector as shown below. Ports 3 and 4 are the negative and positive poles, respectively.



 b. The paperless recorder gathers all the 4...20mA inputs and displays the measurement on its screen (an example of connection of 7 scanners mounted on 7 silos is shown below):



🚺 Note:

- This connection does not require the APM 3DLevel Manager Software tool.
- This type of connection is active and not passive, hence the 3DLevelScanner II is the active module and the PLC should be the passive module.

3. Connection via HART

a. The HART connection is via ports 3,4 of the left green connector as shown below.



I Note:

- 1. The HART connection has no polarity (it is allowed to switch between ports 3 and 4).
- 2. The diagram below shows a combined connection of HART and 4...20mA.



- 1. RS-232/USB connection
- 2. 3DLevelScanner II
- 3. HART Adapter cable
- 4. Resistor of 250 ohm

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4. Multidrop ("daisy chain") Connection

- a. Physical Connections:
 - 1. All 3DLevelScanners should be connected in parallel mode in the RS485 ports. Hence, all the `+' positive ports of the RS485 should commonly be connected and all the `-' negative ports of the RS485 should commonly be connected.

Note: The multidrop ("daisy chain") connection is possible via RS485 interface only.



 The RS485 cable should be shielded and twisted pair. The shield of the cable should be connected to the ground screw on the back of the head of the 3DLevelScanner (as below):



b. At each end of the connection, a 120 Ohm termination resistor should be connected between the +' and the -' RS485 ports.



- c.Each Scanner should be configured with a different polling address. The configuration of the polling address is set in the LCD panel (as shown below).
- 1. In the main menu of the LCD click on 'E' and scroll down to the Output submenu.
- 2. Click on 'E'.
- 3. Configure the polling address number each scanner should have a different polling address (legal values 00...63).



IMPORTANT NOTE: When connecting a 3DLinkPro, one of the scanners must have a polling address 00 (does not matter which 3DLevelScanner in the bus)

Another example of a multiple / daisy chain connection:



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5. Connection via GSM Cellular Modem

a. In this method a GSM modem is connected to a PC and the 3DLinkPro is connected to the scanner (as shown below):



 b. The connection between the scanner and the 3DLinkPRo is via the RS485 ports in the electronic card, using ports 3 and 4 of the right connector (as shown below):



- c. The RS485 layer requires a parallel connection (all '+' connected together and all '-' connected together)
 - Note (1): The RS485 allows a multi drop connection of up to 64 scanners (as shown below):

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Note (2): There should be termination resistors of 120ohms between the RS485 lines inside the 3DLinkPro and at the end of the line in the last 3DLevelScanner (in the right scanner at the image above); hence, placed between the positive (+) and negative (-) lines of the RS485 (in the 3DLinkPro ports 11 and 12).

6. Connection via GPRS

- a. The physical connection of the scanners and the 3DLinkPro is done exactly the same as in GSM method (see clause 4)
- b. On the PC side, the communication to the scanner will be done via a local internet network.
- c. Pre steps Local Network Preparations:
 - i. In order to get connected from a local PC in a shared network, it is required to do the following configurations:
 - 1. Acquire the external IP of the shared network (e.g. browse to <u>www.whatismyip.com</u>)
 - 2. Find the IP address of the local PC running the APM 3DLevel Manager
 - 3. Set a port number which will be used for connection on the local PC.
 - 4. Configure the network's gateway for port forwarding ("NAT") so that any connection to the port chosen on clause 3 will be forwarded to the IP address of the local machine (from clause 2). It is advised that this task is done by the network administrator.
 - 5. Contact the cellular provider (the provider of the SIM card in the 3DLinkPro) and get the APN (Access Point Name) word for GPRS connection.
- d. Below is a configuration example. In this example we have:
 - 1.External IP is 212.235.113.27

- 2. There are 3 local machines with IP addresses:
 - a. 192.168.1.104
 - b. 192.168.1.105
 - c. 192.168.1.106
- 3. The gateway is configured so that port 7040 is forwarded to IP address 192.168.1.104; port 7050 is forwarded to IP address 192.168.1.105; port 7068 is forwarded to IP address 192.168.1.106.
- 4. The APN word of the cellular provider is "internet.tmobile".
- 5. The number of the SIM card in the 3DLinkPro is: +972-54-6488891



Network Connections Scheme

- 6. Operation of the APM 3DLevel Manager (PC side) in this example
 - a. Run the APM 3DLevel Manager and go to Device \rightarrow Manually Connect menu.
 - b. Select in the Manually Connect window the GPRS radio button (see image below).
 - c. In order to connect to PC with the local IP address 192.168.1.104, set the "Local IP Port" field to 7040.
 - d. Set the polling address of the scanner you wish to get connected to.

e. Then press the *Connect* button.

Manually Connect	×											
Manually Connect												
Please select your preferred connection method:												
Connection Method												
C HART	GPRS											
C RS485	C GPRS + SMS											
C GSM (Modem)	C TCP/IP											
Configuration												
Local IP Port:	7040											
Polling Address:	00 💌											
Communication Log:	Normal											
Connect	*											

Manually Connect Window

Note: Since this method involves TCP/IP communication, a Windows message might appear (see image below), in that case, select the <u>unblock</u> option.

🖗 Windows Security Alert 🛛 🔀
To help protect your computer, Windows Firewall has blocked some features of this program.
Do you want to keep blocking this program?
Name: APM 3DLevelManager Publisher: APM
Keep Blocking
Windows Firewall has blocked this program from accepting connections from the Internet or a network. If you recognize the program or trust the publisher, you can unblock it. <u>When should I unblock a program?</u>

Window Security Message

f. The 'Wait for Connection' window will pop up:

Wait for Connection	×
Listening on Port: 7040	
Cancel	

3DLevel Manager ready for connection

- g. The local PC is now ready to be connected via GPRS.
- h. Send the following SMS message to the number of SIM card in the 3DLinkPro:
- CALLAPM,212.235.27.113,7040,internet.t-mobile,

Important (1): the SMS message should be in the exact same format as above (case sensitive, no spaces and comma at the end).

(2): There should be a termination resistor of 120ohms between the RS485 lines; hence, placed between the positive (+) and negative (-) lines of the RS485 in both sides of the RS-485 bus.

(3): For a remote hardware modem reset (the modem in the 3DLinkPro) send the text message (case sensitive): *RESET MODEM*

7. Connection via TCP/IP (using TCP/IP Converter)

- b. The Communication between the scanner and the converter is via RS485.
- c. The Communication between the Converter and the PC / Laptop is via the TCP/IP networking.
- d. **Important:** A 120 ohm resistor must be connected in parallel to the RS485 line (as shown below).

Note: APM is recommending the CHIYU BF-430 as the RS485 to TCP/IP converter (as shown below)



e. For initial setup, the converter must be found in the network. Use the "*IP Search Software Tool"* (comes in the CD supplied with the converter) as shown below. After running the software click on the Refresh button to locate the convertor.

g in Sedicit Ver1.1							
Device Name	Location	Model Nam	e IP Addr	ess Subn	et mask	Gateway	MAC Address
I CHIYU]	BF430 232/	485 TC 192.168	.2.57 255.2	255.255.0	192.168.2.1	00 0E E3 02 04 08
_							
					,	B	efresh
Realtek PCIe GBE	Family Controller	âl	IP Address :	192 168	. 2 . !	57 Search	
		E	Subnet Mask	255 255	255	0 G Br	padcast
				J		C Sn	
Active Route :	•• · 192 168 2 42		.			[[] [] [] [] [] [] [] []	cific IP Address
Active Route : IP Addre: Subnet M	ss : 192.168.2.42 lask : 255.255.25	5.0	Gateway :	192 168	2	1 192.1	cific IP Address 68.2.0
Active Route : IP Addre: Subnet M Gateway	ss : 192.168.2.42 Iask : 255.255.25! : 192.168.2.1	5.0	Gateway : Mac Address :	192 168 00 0E E3 02 04	2 08	1 [192.1 PS:	cific IP Address 68.2.0
Active Route : IP Addre Subnet M Gateway	ss : 192.168.2.42 lask : 255.255.25 : 192.168.2.1	5.0	Gateway : Mac Address :	192 168 00 0E E3 02 04	08	1 [192.1 PS: IP 192.1 192.168	cific IP Address 68.2.0 68.0.0 scan 1.0.1~192.168.0.255
Active Route : IP Addre Subnet M Gateway TeamViewer VPN A	ss : 192.168.2.42 lask : 255.255.255 : 192.168.2.1 	5.0	Gateway : Mac Address :	192 168 00 0E E3 02 04	08	1 1 1 1 1 1 1 1 1 1 1 1 1 1	cific IP Address 68.2.0 68.0.0 scan (0.1~192.168.0.255 68.0.66 only scan 0.66
Active Route : IP Addre Subnet H Gateway TeamViewer VPN A	ss : 192.168.2.42 Aask : 255.255.25! : 192.168.2.1 \dapter	5.0	Gateway : Mac Address :	192 168 00 0E E3 02 04	08 Alter	1 1 1 1 1 1 1 1 1 1 1 1 1 1	cific IP Address 68.2.0 68.0.0 scan .0.1~192.168.0.255 68.0.66 only scan 0.66 F xit

f. Once the convertor is found, double click on the line where the convertor was found, will run an html (as shown below) with all the parameters to configure:

🔶 🔿 🧭 http://192.168.2.57/		×=0=
CHIYU Serial To Ethernet C ×		and the second se
Pr.	One Page Quick Setu	p (Fixed IP)
RF-//30	IP Address	192 . 168 . 2 . 57
Main Menu	Subnet mask	255 . 255 . 255 . 0
One Page Setup	Gateway	192 . 168 . 2 . 1
Advanced Setup	Primary DNS	168 .95 .1 .1
Operation Mode	Serial Port Mod	e
<u>Serial Type</u>	Serial Type	R\$485 •
<u>Dynamic DNS</u>	Baud Rate	115200 • 0 (User Defined)
Management	Operation Mode	2
<u>Device Admin</u>	Connection Mode	TCP SERVER -
<u>System Status</u>	Connection Port Number	50000
Backup & Restore	Remote Host IP Address (For Client Only)	0.0.0
Upgrade Firmware	L APPLY CANCEL BA	ICK
• Ping		

- g. Operation of the APM 3DLevel Manager (PC side)
 - i. Run the APM 3DLevel Manager and go to Device→ Manually Connect menu.
 - ii. Select in the Manually Connect window the TCP/IP radio button (see image below).
 - iii. Set the IP address of the CHIYU Converter (e.g. 192.168.2.124) in the "Server IP Address" field.
 - iv. Set the IP port of the CHIYU Converter (e.g. 7024) in the "Server IP Port" field.
 - v. Set the polling address of the scanner you wish to get connected to (or select *Multiple*).

	vi.	Then	press	the	Connect	button.
--	-----	------	-------	-----	---------	---------

👪 Manually Connect												
Manually Connect												
Please select your preferred connection method:												
Connection Method		Further Configuration -										
C HART	C GPRS	Site name:	HaifaChemicalsSol 💌									
C RS485	C GPRS + SMS	Server IP Address:	192.168.2.124									
C GSM (Modem)	TCP/IP	Server IP Port:	7024									
Configuration												
Serial Port:	3											
Polling Address:	00 🔹											
Audit Communication:	No											
Connect	 											

8. Connection via Modbus

- a. Initial Settings:
 - i. Comport settings
 - 1. Baud Rage = 115200
 - 2. Data Bits = 8
 - 3. Parity = None
 - 4. Stop Bits = 1
- b. In order to get the values from the Scanner, a Modbus RTU command with function code 3 should be executed.
- c. The address of the device equals its Polling Address + 1
- d. Registers The relevant parameters are stored in registers 40001-40026 (see table).

No.	Register Number	Parameter	Units	Туре
1	40001 & 40002	Avg. Distance	m	Floating Point
2	40003 & 40004	Min Distance	m	Floating Point
3	40005 & 40006	Max Distance	m	Floating Point
4	40007 & 40008	Volume	% (*1000)	Floating Point
5	40009 & 40010	4-20mA	mA	Floating Point
6	40011 & 40012	SNR	dB	Floating Point
7	40013 & 40014	Temperature	°C	Floating Point
8	40015 & 40016	Temperature	°F	Floating Point
9	40017 & 40018	Avg. Level	m	Floating Point
10	40019 & 40020	Bulk Density	g/cm^3	Floating Point
11	40021 & 40022	Mass	customer unit	Floating Point
12	40023 & 40024	S/N	number	Long Integer
13	40025 & 40026	Tag Name	First 4 chars	4 Characters Integer

e. All parameters are stored as IEEE754 floating point; hence each parameter is stored in two consecutive registers. The byte sending order is from high to low.

- f. Communication examples for a device with polling address 0:
 - i. Example A:
 - 1. To retrieve the average distance, we send: 01 03 00 00 02 C4 0B
 - 2. A sample reply would be: 01 03 04 3D 85 1E 20 EE 0E.

This means that Distance = 0x3D851E20, which represents a float value of "0.065".

- ii. Example B:
 - 1. to acquire all relevant parameters, we send: 01 03 00 00 00 1A C4 01

Note: Mass value is in the chosen configured units and relevant only if the scanner linearization is configured to mass.

9. Connection via RS485

- a. The physical layer is RS-485 as follows:
 - 1. Baud Rage = 115200
 - 2. Data Bits = 8
 - 3. Parity = None
 - 4. Stop Bits = 1
- b. The available parameters and their units are as follows:

Parameter	Units
Avg. Distance	m
Min Distance	m
Max Distance	m
Volume	%
4-20mA	mA
SNR	dB
Temperature	°C
Temperature	٥F
Avg. Level	m
Bulk Density	g/cm^3
Mass	Customer units
S/N	number
Tag Name	First 4 chars

To retrieve all thirteen parameters, the controller needs to transmit a single command. The Packet format of the request is as follows:

1 BYTE	1 BYTE	4 BYTES	2 BYTES
Polling Address +1	<mark>03</mark>	00 00 00 1A	CRC-16

- The above values are all in hexadecimal
- For CRC-16, see reference implementation in Appendix B
- The below table indicates the request string for retrieving data from 15 3DLevelScanners (polling addresses 00 to 15):

Polling Address	Request							Polling Address		Request									
00		01	<mark>03</mark>	00	00	00) 1A	C4	01	08		<mark>09</mark>	<mark>03</mark>	00	00	00	1A	C5	49
01		02	<mark>03</mark>	00	00	00) 1A	C4	32	09		0A	<mark>03</mark>	00	00	00	1A	C5	7A
02		03	<mark>03</mark>	00	00	00) 1A	C5	E3	10		<mark>0</mark> B	<mark>03</mark>	00	00	00	1A	C4	AB
03		04	<mark>03</mark>	00	00	00) 1A	C4	54	11		0C	<mark>03</mark>	00	00	00	1A	C5	1C
04		05	<mark>03</mark>	00	00	00) 1A	C5	85	12	()D	<mark>03</mark>	00	00	00	1A	C4	CD
05		06	<mark>03</mark>	00	00	00) 1A	C5	B6	13		0E	<mark>03</mark>	00	00	00	1A	C4	FE
06		07	<mark>03</mark>	00	00	00) 1A	C4	67	14		0F	<mark>03</mark>	00	00	00	1A	C5	2F
07		08	<mark>03</mark>	00	00	00) 1A	C4	98	15		10	<mark>03</mark>	00	00	00	1A	C7	40

1 BYTE	1 BYTE	1 BYTES	4 BYTES	4 BYTES	4 BYTES
Polling Address +1	03	34	Avg. Distance	Min Distance	Max Distance
4 BYTES	4 BYTES	4 BYTES	4 BYTES	4 BYTES	4 BYTES
Volume	4-20mA	SNR	Temp (°C)	Temp (°F)	Avg. Level
	_				
4 BYTES	4 BYTES	4 BYTES	4 BYTES	2 BYTES	_
Bulk Density Mass S/N Tag Name CRC-16					
 Each of the eight 4-byte block represents a floating point 					
value according to the IEEE-754 standard.					

c. Then, the packet format of the reply is as follows:

We refer the reader to:

http://en.wikipedia.org/wiki/IEEE 754-1985

- Example:
 - i. Suppose the reply starts as follows (in this example we show only the first 4 bytes of payload):

Byte Number	Value
00	01
01	03
02	34
03	3D
04	85
05	1E
06	20

ii. Then the average distance is represented by a 4bytes-block of 0x3D851E20 which corresponds to floating point value of 0.065m.

To verify, enter "3d851e20" in the *hexadecimal representation* text box at the following webpage:

http://babbage.cs.qc.cuny.edu/IEEE-754/32bit.html

To Calculate CRC-16, it is possible to use the following website:

http://www.lammertbies.nl/comm/info/crc-calculation.html

Select input type HEX, type in the string to convert and press the 'Calculate CRC' button, look for the 'CRC-16 (Modbus)' value in the table.

Output result is flipped, for example, if the result is 0x01C4, the two bytes to be transmitted are C401.

10.Appendix A – Example using InTouch System

1. This example uses TOP Server with version:

About T	OP Server	×
	Software Toolbox OPC Power Server V4.270.416.0 - U Copyright © 1996-2007	
	Versions	

- 2. Create a new file.
- 3. Create a new channel with the following definitions:

Channel Properties					
Network	Interface	Write O	ptimizations		
General	Communicati	ions R1	S Line Control		
₹,	<u>I</u> D:	DM 1	•		
	Baud rate: 1	15200	•		
	<u>D</u> ata bits: 8		•		
	Parity: N	one	•		
	Stop bits:	• 1	2		
Elow control: None					
☐ Use <u>m</u> odem ☑ <u>R</u> eport comm. errors ☐ Use <u>E</u> thernet encapsulation					
ОК	Cancel	Apply	Help		

- 3. Add a new device (MODBUS serial) and set the following properties:
 - 3.1 ID = polling address + 1

Device Properties				
Variable Import Settings Framing Database Creation Settings General Ethernet Encapsulation Timir	Error Handling Block Sizes ng Auto-Demotion			
Channel Assignment				
Name: MODBUS				
Driver: Modbus Serial				
Device <u>N</u> ame: APMScanner				
Model: Modbus	-			
ID: 1 - Decimal	•			
✓ Enable data collection				
OK Cancel App	ly Help			

3.2

Device Properties	K		
General Ethernet Encapsulation Timing Auto-Demotion Variable Import Settings Framing Error Handling Database Creation Settings Block Sizes			
Data Access ✓ Use zero based addressing ✓ Use zero based bit addressing within registers ✓ Use holding register bit mask writes ✓ Use Modbus function 06 for single register writes ✓ Use Modbus function 05 for single coil writes			
Data Encoding ✓ Use default Modbus byte order First word low in 32 bit data types ✓ First Dword low in 64 bit data types ✓ Use Modicon bit ordering (bit 0 is MSB)			
OK Cancel Apply Help			

4. Create tag Properties according to the table in page 2 / clause 4

General Scaling		
Identification		
<u>N</u> ame: distant	ce	i <u>e</u> <u> </u>
Addr <u>e</u> ss: 40000	1	
Description:		
– Data properties Data	type: Float 💌	
<u>C</u> lient acc	cess: Read/Write	
<u>S</u> can	rate: 100 🛨 milliseconds	\$
		the second second second second

5. The TOP Server will then present all the registers as follows:

🖷 TOP Server - [C:\Program Files\Software Toolbox\TOP Server\Projects\mod_scanner.opf]											
Elle Edit View Users Iools Help											
D 🖻 🔒 🖗	D 🗳 🔒 🛜 🛅 🛅 🗁 📽 🗠 🗼 🛍 💼 🗙 🌽 🌺 🍔										
E 🖗 MODBUS			Tag Name	Address	Data Type	Scan Rate	Scaling	Description			
APMS	canner		distance	400001	Float	100	None				
			M indistance	400003	Float	100	None				
			maxdistance	400005	Float	100	None				
			Ø percent	400007	Float	100	None				
			1 ² ™ A	400009	Float	100	None				
				400011	Float	100	None				
			temperatureC	400013	Float	100	None				
				400015	Float	100	None				
			<								>
Date	Time	User Name	Source	Event							^
12/8/2008	11:17:49 AM	Default User	TOP Server	Yaskawa Memobu	is Plus device driv	er loaded succes	sfully.				
12/8/2008	11:17:49 AM	Default User	TOP Server	User Configurable	e Driver device dri	ver loaded succe	ssfully.				
12/8/2008	11:17:49 AM	Default User	TOP Server	Uni-Telway device	e driver loaded su	ccessfully.					
12/8/2008	11:17:49 AM	Default User	TOP Server	Triconex Ethernel	t device driver loa	ded successfully.					
12/8/2008	11:17:49 AM	Default User	TOP Server	TIWAY Host Adap	ter device driver	loaded successfu	illy.				
12/8/2008	11:17:49 AM	Default User	TOP Server	SIXNET UDR devi	ce driver loaded s	uccessfully.					
1 2/8/2008	11:17:49 AM	Default User	TOP Server	Simulator device (driver loaded succ	essfullv.					
A 12/8/2008	11-17-40 AM	Default Licer	TOD Sarvar	Siemens TCD/TD I	Incolicited Etherne	st davica drivar la	adad successfully				×
<											>
Ready								C	lients: 0 Active	etags: 0 of 0	11.

In the InTouch configure the following:

1. Create a new access name with topic name = alias name from TOP Server:

Modify Access Name		
Access MODBUS	6	ОК
Node Name:		
		Cancel
Application Name:		Failover
servermain		
<u>T</u> opic Name:		
MODBUS_APMScanner		
Which protocol to use-		
💿 DDE 🛛 🔘	SuiteLink OMessage Excha	ange
<u>∼W</u> hen to advise server		
 Advise all items 	🔘 Advise only active items	
Enable Secondary So	urce	

 Topic name should be the same as the alias name in TOP Server (in this example connecting to *APMScanner* device in MODBUS channel, this means the access name should be *MODBUS_APMScanner*) see image below:

🛥 Alias Map		
	🔽 Show alias	es for system generated groups
Alias	Mapped To	Scan Rate
T MODBUS_System	MODBUSSystem	0
Image: MODBUS_APMScanner	MODBUS.APMScanner	0
Image: Model of Model and Model a	MODBUS.APMScannerSystem	0
		Close <u>H</u> elp

3. Define tags according to your tag names definitions in TOP Server. Put your created access name

Tagname Dictionary					
◯ Main ⊙ Details ◯ Alarms ◯ Details & Al	Alarms 🔿 Members				
New Restore Delete Save <<	Cancel Close				
Tagname: distance	Type: I/O Integer				
Group: \$System	○ Read only				
Comment: AccessLevel					
Log Data Log Events	Retentive Value 🔲 Retentive Para <u>m</u> eters				
Initial Value: 100	Min EU: -32768 Max EU: 32767				
Deadband: 0	Min Raw: -32768 Max Raw: 32767				
Eng Units:	Log Deadband: 0 Conversion Square Root				
Access Name: MODBUS					
Item: distance	Use Tagname as Item Name				

4. Create a new screen with some texts that will display analog value:

C Touch Links	Line Color	Fill Color	Text Color
User Inputs	Discrete	Discrete	Discrete
Discrete	Analog	Analog	Analog
Analog	Discrete Alarm	Discrete Alarm	Discrete Alarm
String	Analog Alarm	Analog Alarm	Analog Alarm
Sliders	Object Size	Location	Percent Fill
Vertical	Height	Vertical	Vertical
Horizontal	Width	Horizontal	Horizontal
Touch Pushbuttons	Miscellaneous	Value Display	
Discrete Value	Visibility	Discrete	
Action	Blink	Analog	
Show Window	Orientation	String	
Hide Window	Disable		
	Tooltip		

5. In the expression put the tag name:

Output -> Analog Expression	
E <u>x</u> pression:	ОК
distance	Cancel
	Clear

6. The WindowViewer of InTouch will present the outcome:

😵 InTouch - WindowViewer - C:\D	OCUMENTS AND SETTIN 🔳 🗖 🔀
<u>File Logic Special</u>	Development <u>!</u>
modbusapm_present	
Distance	4.65 m
Minimum Distance	3.15 m
Maximum Distance	6.15 m
SNR	48.3 dB
Volume	62.7%
Temperature (Celsius)	32.6 ⁰ C
Temperature (Fahrenhein)	90.7 ⁰ F
Analog Output	14.03 mA

11.Appendix B – CRC-16 Reference implementation

```
11
// code for computing crc-16
// The polynomial is
// X^16+X^15+X^2+X^0 (8005)
/* Table of CRC values for high-order byte */
unsigned char crc16tableHI[256] = {
0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,
0x40,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,
0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,
0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,
0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,
0x40,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,
0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,
0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,
0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,
0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x01,0xC0,
0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,
0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,
0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x01,0xC0,
0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,
0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,
0x40
};
/* Table of CRC values for low-order byte */
unsigned char crc16tableLO[256] = {
0x00,0xC0,0xC1,0x01,0xC3,0x03,0x02,0xC2,0xC6,0x06,0x07,0xC7,0x05,0xC5,0xC4,
0x04,0xCC,0x0C,0x0D,0xCD,0x0F,0xCF,0xCE,0x0E,0x0A,0xCA,0xCB,0x0B,0xC9,0x09,
0x08,0xC8,0xD8,0x18,0x19,0xD9,0x1B,0xDB,0xDA,0x1A,0x1E,0xDE,0xDF,0x1F,0xDD,
0x1D,0x1C,0xDC,0x14,0xD4,0xD5,0x15,0xD7,0x17,0x16,0xD6,0xD2,0x12,0x13,0xD3,
0x11,0xD1,0xD0,0x10,0xF0,0x30,0x31,0xF1,0x33,0xF3,0xF2,0x32,0x36,0xF6,0xF7,
0x37,0xF5,0x35,0x34,0xF4,0x3C,0xFC,0xFD,0x3D,0xFF,0x3F,0x3E,0xFE,0xFA,0x3A,
0x3B,0xFB,0x39,0xF9,0xF8,0x38,0x28,0xE8,0xE9,0x29,0xEB,0x2B,0x2A,0xEA,0xEE,
0x2E,0x2F,0xEF,0x2D,0xED,0xEC,0x2C,0xE4,0x24,0x25,0xE5,0x27,0xE7,0xE6,0x26,
0x22,0xE2,0xE3,0x23,0xE1,0x21,0x20,0xE0,0xA0,0x60,0x61,0xA1,0x63,0xA3,0xA2,
0x62,0x66,0xA6,0xA7,0x67,0xA5,0x65,0x64,0xA4,0x6C,0xAC,0xAD,0x6D,0xAF,0x6F,
0x6E,0xAE,0xAA,0x6A,0x6B,0xAB,0x69,0xA9,0xA8,0x68,0x78,0xB8,0xB9,0x79,0xBB,
0x7B,0x7A,0xBA,0xBE,0x7E,0x7F,0xBF,0x7D,0xBD,0xBC,0x7C,0xB4,0x74,0x75,0xB5,
0x77,0xB7,0xB6,0x76,0x72,0xB2,0xB3,0x73,0xB1,0x71,0x70,0xB0,0x50,0x90,0x91,
0x51,0x93,0x53,0x52,0x92,0x96,0x56,0x57,0x97,0x55,0x95,0x94,0x54,0x9C,0x5C,
0x5D,0x9D,0x5F,0x9F,0x9E,0x5E,0x5A,0x9A,0x9B,0x5B,0x99,0x59,0x58,0x98,0x88,
0x48,0x49,0x89,0x4B,0x8B,0x8A,0x4A,0x4E,0x8E,0x8F,0x4F,0x8D,0x4D,0x4C,0x8C,
0x44,0x84,0x85,0x45,0x87,0x47,0x46,0x86,0x82,0x42,0x43,0x83,0x41,0x81,0x80,
0x40
};
unsigned short DoCrc16Block( unsigned char *s, unsigned short length )
   unsigned char HI = 0xFF ; /* high byte of CRC initialized */
   unsigned char LO = 0xFF ; /* low byte of CRC initialized
                                                             */
   unsigned i ;
                                 /* index into CRC lookup table
                                                                 */
   while (length--)
   {
         i = LO ^ *s++;
         LO = crc16tableHI[i] ^ HI;
         HI = crc16tableLO[i];
   }
   return (HI << 8 | LO) ;
}
```

