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Document Revision

Version	Date	Description of changes
Rev1.0	2019-04-09	First release for tWF-DA1PD2R1
Rev1.1	2020-02-13	Add Modbus connection idle timeout

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1. Introduction

The tWF-DA1PD2R1 Multi Function controller have WLAN connection complies with the IEEE802.11b/g/n standards. With the popularity of 802.11 network infrastructure, the tWF-DA1PD2R1 make an easy way to incorporate wireless connectivity into monitoring and control systems. They also support Modbus TCP protocol and the network encryption configuration, which makes perfect integration to SCADA software and offer easy and safe access for users from anytime and anywhere.



Figure 1-1: Application architecture for the tWF series

1.1 Wireless connection mode

tWF-DA1PD2R1 support both AP(Access Point) & STA(Station) wireless connection modes of WLAN.

1.2 Features

- Wi-Fi communication remote I/O controller
- Compatible with IEEE 802.11b/g/n standards
- Support Station(STA) and Access Point(Limited-AP, 1 Client) modes for wireless networks
- Support WEP, WPA and WPA2 wireless encryption
- Support Modbus TCP protocols
- Support DHCP Server(AP), DHCP Client or Static IP(STA) network configuration
- Wide operating temperature range & Power supply range
- Software Digital Input with 32-bit counter
- Simplify Light control function
- Photo couple Isolation input, Relay Isolation output, 0~10V 12-bit resolution DA output

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1.2.2 Features Description

The tWF-DA1PD2R1 offers the most comprehensive configuration to meet specific application requirements. The following list shows the features designed to simplify installation, configuration and application.

Compatible with IEEE 802.11b/g/n standards

tWF controller complied with IEEE 802.11b/g/n standard from 2.4~2.5 GHz, and it can be used to connect your wireless LAN.

Support STA(Station) and AP(Access Point) modes for wireless networks

AP mode lets you create a Limited AP(1 Client access allow) network with the specified SSID to communicate directly with each other without the need for a wireless access point.

STA mode is the more common network configuration where all wireless hosts (clients) connect to the wireless network via a WAP (Wireless Access Point).

Support WEP, WPA and WPA2 wireless encryption

WEP and WPA are common types of security that are used to protect wireless networks. When WEP or WPA is turned on, tWF controller uses a special security key combination to allow only devices that know this key to connect to its wireless network. This applies to laptops, smart device, or any other wireless device.

Support Modbus TCP protocols

The Modbus TCP server function on tWF-DA1PD2R1 can be used to provide data remote with HMI/SCADA software built with Modbus TCP driver.

Also there is some other HMI Modbus App in Android Google Play you can use.

Built-in Software counter for Digital Input

Each of the Digital Input port have a 32-bit (4294967295) software counter, use to count the input triggered, it can be reset from utility or Web browser.

Built-in Multi-function I/O

Various I/O components are mixed with multiple channels in a single controller, which provides the most cost effective DA output, I/O usage and enhances performance of the I/O operations.

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Built-in Simplify Light control function

Light control can be config by Utility, WEB, APP, using DI pin to trigger DO output and DA output with timing operations.

1.3 Specifications

Table 1-1: System Specifications

Controller	tWF-DA1PD2R1
Wi-Fi Interface	
Antenna	Chip Antenna
Output Power	18.0 dBm @ 1 DSSS / 14.5 dBm @ 54 OFDM
Receive Sensitivity	–95.7 dBm @ 1 DSSS /–74.0 dBm @ 54 OFDM
Standard Supported	IEEE 802.11b/g/n
Wireless Mode	Station & AP(1 Client)
Encryption	WEP, WPA and WPA2
Power	
Input Voltage Range	DC 9V ~ 48V
Power Consumption	0.86W
Mechanism	
Installation	DIN-Rail
Dimensions (W x L x H)	52 mm x 97 mm x 27 mm
Environment	
Operating Temperature	-25℃ ~ +75℃
Storage Temperature	-30℃ ~ +80℃
Humidity	10% ~ 95%

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Table 1-2: I/O Specification

Controller		tWF-DA1PD2R1
Digital Input		
Channels		2
Input Type		Dry Contact: Sink
Dry Contact Level		Off Voltage Level: Open On Voltage Level: Close to GND-
Counters	Channels	2
	Max. Counts	32-bit (4294967295)
	Max. Input Frequency	20 HZ
Photo-Isolation		3750 VDC
Relay Output		
Channels		1
Output Type		Form A
Contact Rating (Resistive Load)		DC30V/5A, AC250V/5A
Relay/SSD Operate Time		5ms (max.)
Relay/SSD Release Time		5ms (max.)
DA Output (Vout0, Iout0)		
Channels		1
Type		0 ~ 10 V, 0 ~ 20 mA, 4 ~ 20 mA
Resolution		12-bit
Accuracy		+/-0.1% of FSR
DA Output Response Time		10 ms
Voltage Output Capability		20 mA
Current Load Resistance		500 Ω

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2. Hardware

2.1 Front Panel

The tWF-DA1PD2R1 controller front panel contains I/O connectors and LEDs.

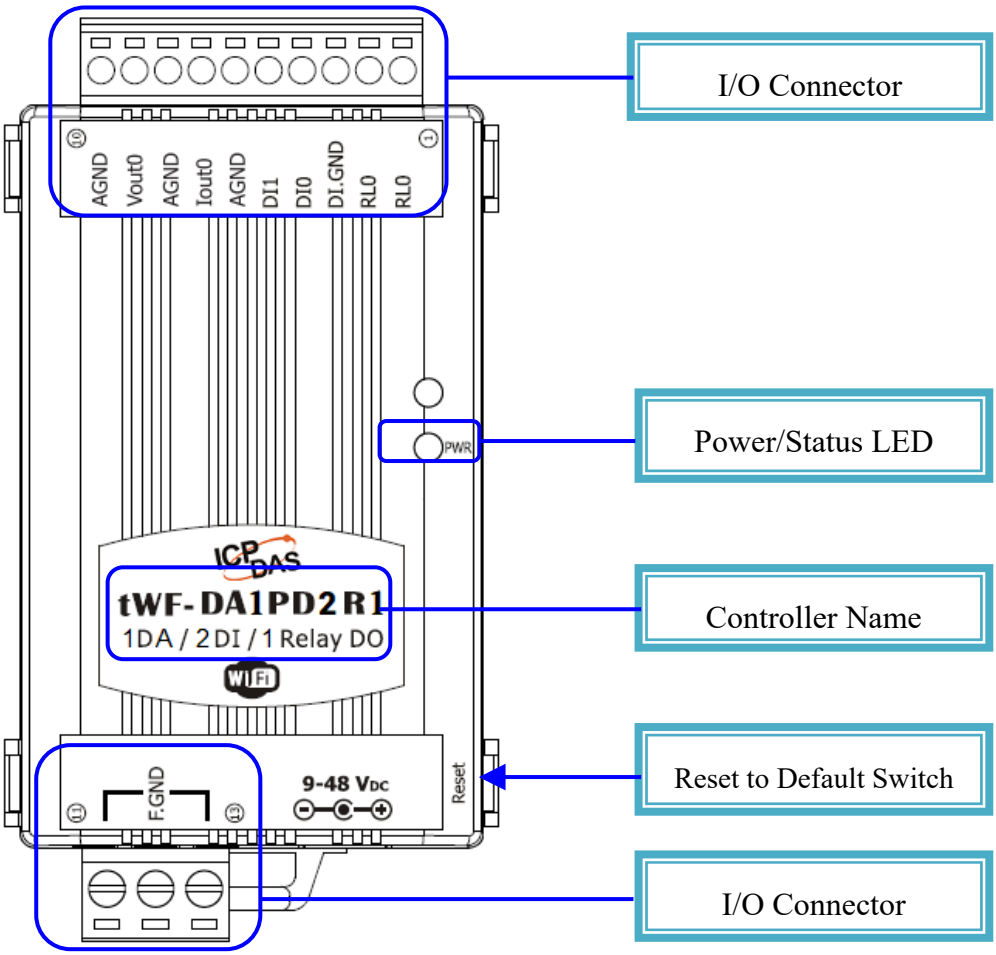


Figure 2-1: Front Panel of the tWF-DA1PD2R1 controller

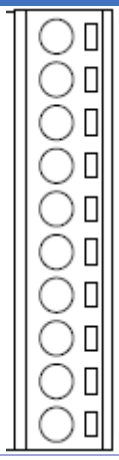
2.1.2 LED Indicator

Table 2-1: System Status Indicator

System Status Indicator		
LED	**Controller Status**	**LED Status**
PWR	Wi-Fi get Link	Red LED ON
	Power On	Blue LED ON
	Locator	Red LED Blinking
	Process reset to default	Blue LED Blinking(Fast)

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2.1.3 tWF-DA1PD2R1 Connector Pin Define

Terminal NO	Pin	Assignment Name
	10	AGND
	9	Vout0
	8	AGND
	7	Iout0
	6	AGND
	5	DI1
	4	DI0
	3	DI.GND
	2	RL0
	1	RL0

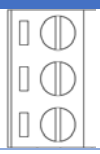
Terminal NO	Pin	Assignment Name
	11	F.GND
	12	F.GND
	13	F.GND

Figure 2-2: I/O Connector of tWF-DA1PD2R1

2.2 Reset to default

Press & hold the reset button in right side over 6 Sec until the Red LED quick flash then release to restore tWF default setting, default is set in AP mode.

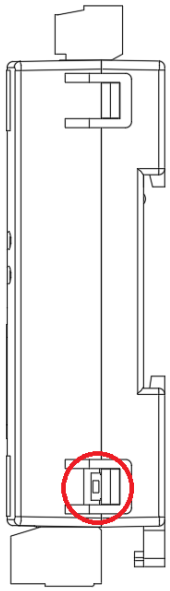


Figure 2-7: Reset button locate in the right side of tWF Controller

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2.3 Dimensions

The diagrams below provide the dimensions of the tWF series Controller to use in defining your enclosure specifications. All dimensions are in millimeters.

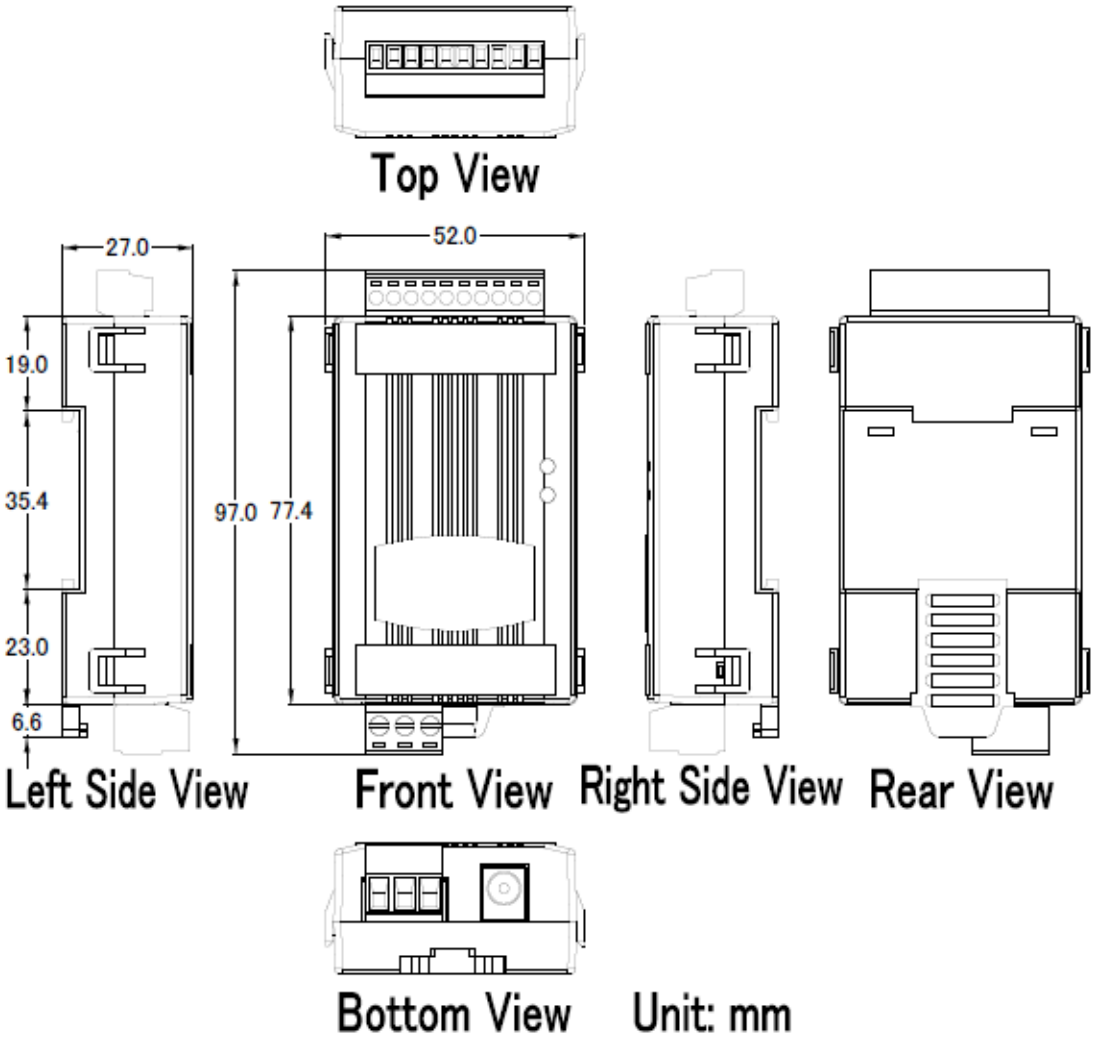


Figure 2-8: Dimension of the tWF I/O Controller

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2.4 Hardware Connection

2.4.2 Power connection

The following figures describe the Power

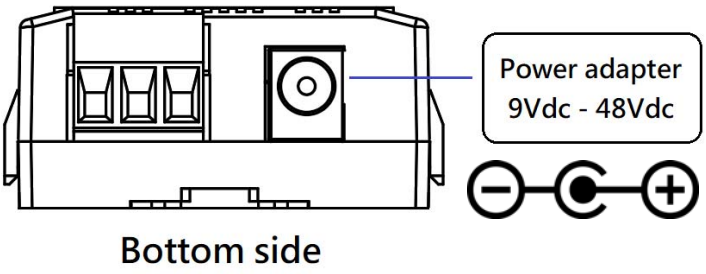


Figure 2-9: Power connection

2.4.3 I/O connection

2.4.3.1 Digital Input wiring

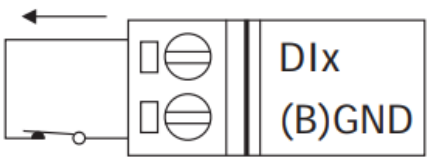
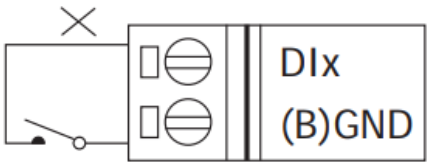
Digital Input wiring		
Digital Input/ Counter	ON State	OFF State
Dry Contact	Close to GND	OPEN
		

Figure 2-10: DI Dry contact wiring

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2.4.3.2 Relay Output wiring

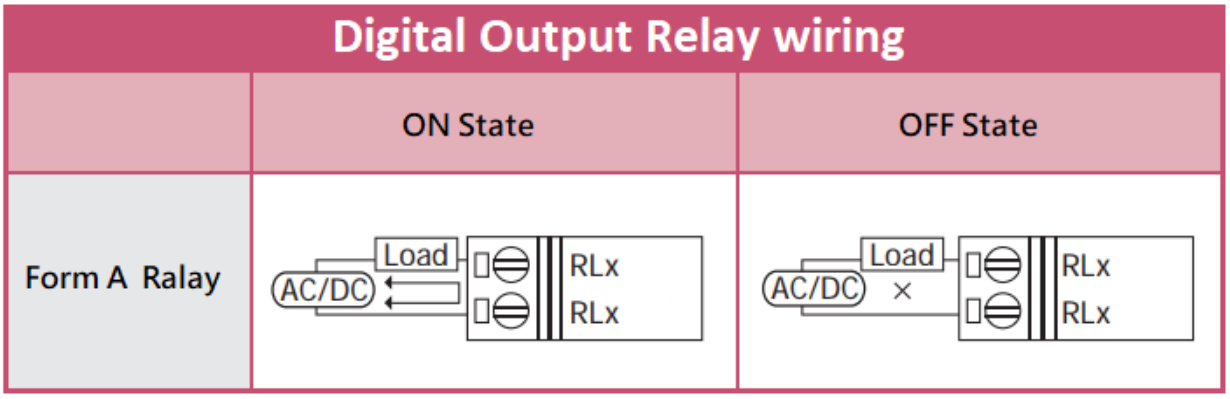


Figure 2-11: Relay Output wiring

2.4.3.3 Analog Voltage Output wiring

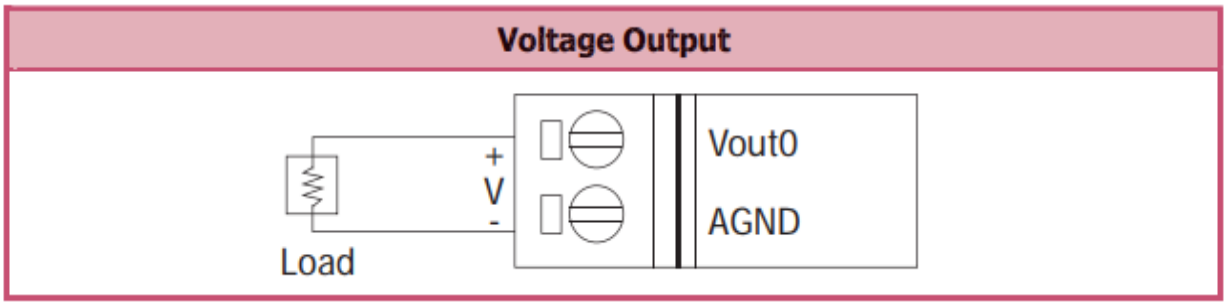


Figure 2-12: Analog Vout wiring

2.4.3.4 Analog Current Output wiring

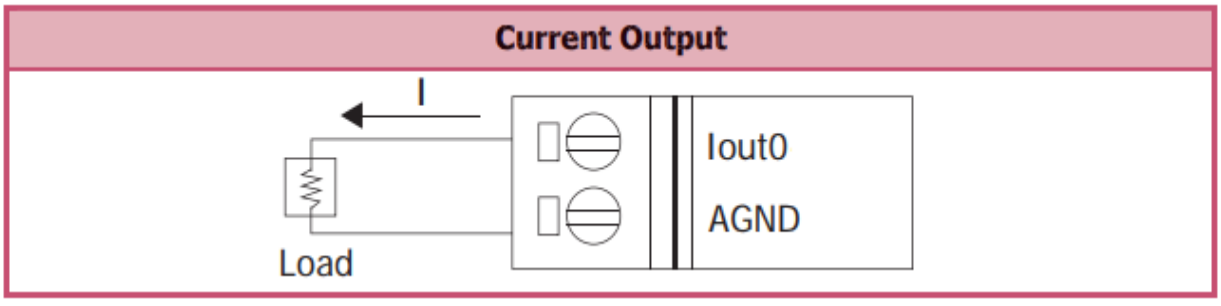


Figure 2-13: Analog Iout wiring

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3. Software

The tWF DA Multi Utility provides the simple way to operating and acquire I/O status. It used the wireless network interface to configure. Provide AP(Access Point) & STA(Station) mode to connect the tWF-DA1PD2R1 Controller.

tWF DA Multi Utility available on both Windows & Android application, also it can work in Web browser to operating and configure the tWF-DA1PD2R1 Controller,

Utility Support Windows 7 (or later versions) and Android 6.0 (or later versions).

3.1 tWF DA Multi Utility

The following is the main screens provided by tWF DA Multi Utility, these utility tools can be thought as a useful tool for I/O control and monitoring on the tWF DA Controller. It supplies several functions, such as I/O operating, Controller connection, Wi-Fi configuration setting and F/W upgrade, etc.

3.1.2 Main Screen/ Calibration

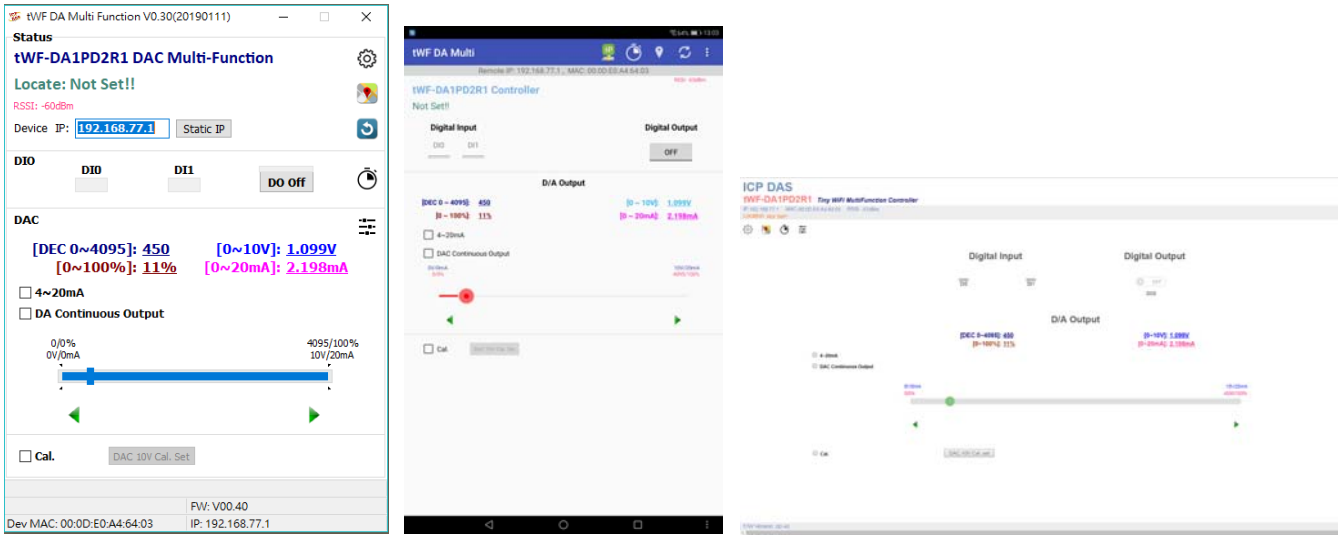


Figure 3-1: tWF DA Multi Utility main screen
(From left to right is Windows Utility , Android App & Web browser)

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3.1.2.1 Controller Status

Show the connected controller information, user define Locate string, RSSI strength, Device IP & Static IP button for changing device IP in STA mode.



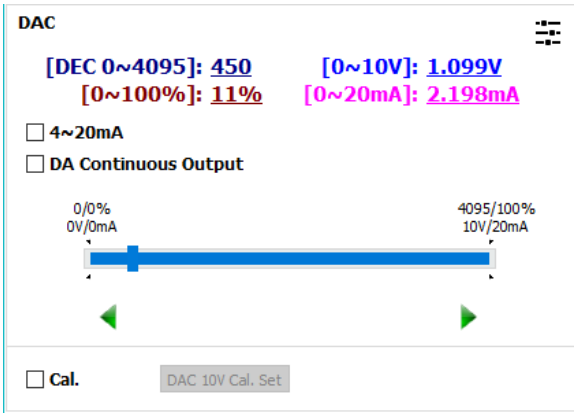
3.1.2.2 DI/DO Status & Control

Show the DI/DO status, If channel not support, utility will disable those unused channel. The value can be read(DI) or write(DO) in this area.
Counter icon show each DI input triggered times(On edge) .



3.1.2.3 DA Status & Control

Show the DA status/value, the Track Bar and fine tune button control the DA output, include 4mA(2V)~20mA(10V) checkbox, DA continuous output checkbox & Function mode config ICON.



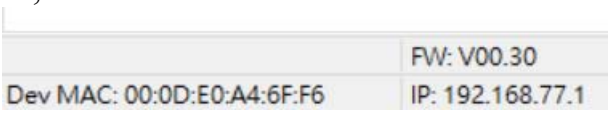
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3.1.2.4 Calibration

Checked the "Cal." checkbox, use Track Bar & fine tune button adjust the DA output voltage, make Vout-AGND pin as near as 10.00V, clicked the button "DAC 10V Cal. Set" to save the setting, then unclick the "Cal." checkbox for normal use.
(Device have been calibration when shipping)

3.1.2.5 Status Bar

Show the F/W Version, Device's MAC address and Device's IP address.



3.1.2.6 ICON

ICON	function	
	**Setup**	Open the Setup page (Android versions Setup function under the  icon)
	**Find Controller**	Red Led blinking, use to find the connected Controller
	**Refresh**	Refresh status Web operating please use F5 or Refresh
	**Menu**	Only Android Device, Include setup, Function config, FW Version & About.
	**DI Counter**	Show the DI trigger counter page
	**Function Mode**	Open the Standalone Function config page

Table 3-1: icon Indicator

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3.1.3 Configuration/Setup

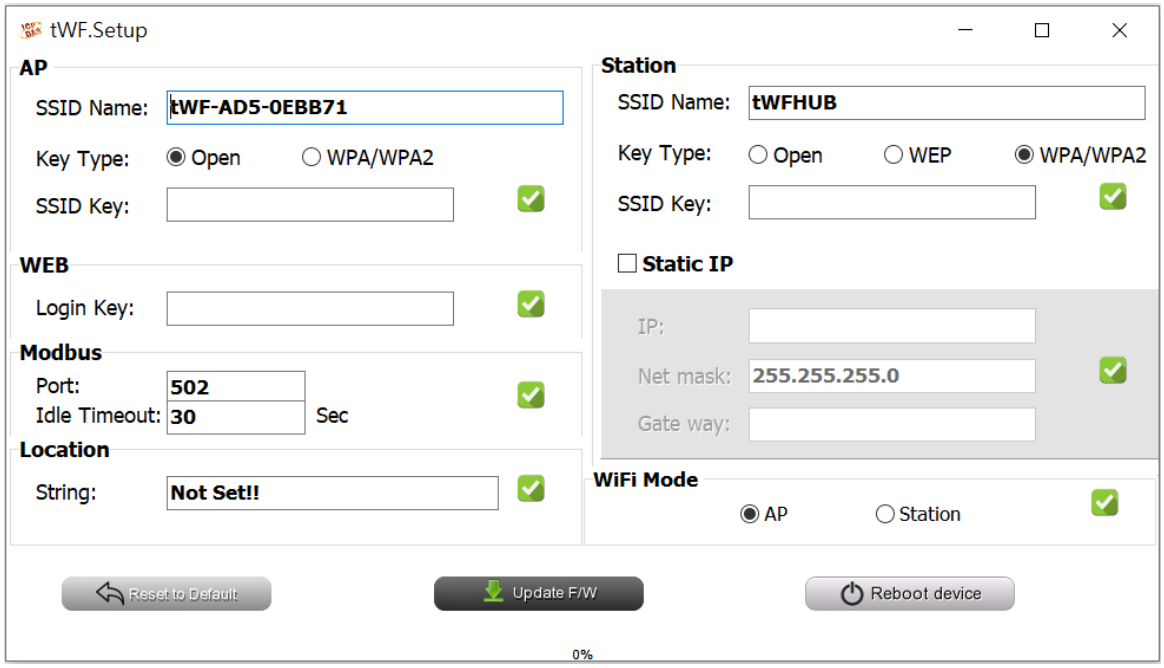


Figure 3-2**:** tWF DA Multi Utility setup page

Click apply icon  to save each subject's setting, after finish all setting click 

to make device take effect on new setting

AP：

SSID Name

1. Controller's SSID in Wi-Fi AP mode, (default will be tWF-[Controller Name]-xxxxxx , show as below,
   a. tWF-DA1PD2R1-xxxxxx

   Note: xxxxxx is the last 6 character MAC address of your device.

Key Type

AP mode SSID Key type,(default is **Open**)

SSID Key

AP mode SSID Key, (default is **None**)

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STA：

SSID Name

Wi-Fi AP's SSID intent to connect,(default is **tWFHUB**)

Key Type

Wi-Fi AP's SSID Key Type,(default is **WPA/WPA2**)

SSID Key

Wi-Fi AP's SSID Key,(default is **00000000**)

Static IP:

IP: Specific an IP that is not been used.

Mask: Default will be **255.255.255.0**.

Gateway: Basically define in the AP you are going to connect.

SSID	Service Set Identifier: Connected devices must be the same SSID, SSID length must not exceed 31 characters.
Key Type	Key of Encryption, connected devices must with the same Key. Open ：No Key request. WEP(Shared) ：Key length must be 31 characters. WPA/WPA2-PSK ：Key length must between 8~15 characters.

Table 3-2**:** Station SSID & Key type configure

WiFi Mode：

tWF Controller working mode, (default is in **AP**)

AP (Access Point**)：**

PC or Android Device connect to tWF Controller directly through AP(Fixed IP:**192.168.77.1**), AP mode support only one connection, If Multiple devices connect at a same time, only first connected devices can access.

STA(Station**):**

tWF Controller will auto connect to specific WiFi AP, PC or Android Device also need to connect to the same AP, then they can use those tWF Controller in same domain.

*. Please check specific WiFi AP is active and SSID/key is same as the setting before use.

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WEB:

Open your Web Browser, fill the URL with the IP that been arrange to the device and enter. A while you will get a dialog for Account & Password, both Account & Password are "**admin**" for default.

- Modify Web password need 5 characters (max).
- In AP mode, the IP default will be **192.168.77.1**.
- In STA mode, use the IP scanner utility to discovery tWF device, found your device & enter the IP you intent to access.

Location information:

Set the information for you to identify & locate those controller easily, length must under 31 characters.

Modbus Port:

Modify Modbus TCP Port (default is **502**)

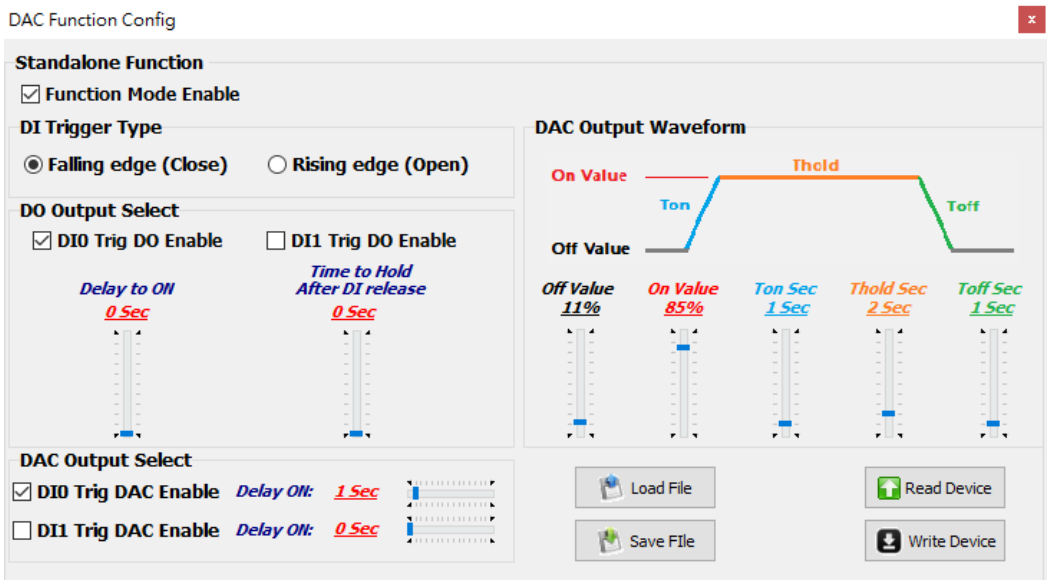
Modbus Idle Timeout:

Set Idle Timeout for Modbus TCP connection (default is **120 Sec**) in STA(Station) mode, recommend 30 Sec. when device in STA mode connect to an AP, Host device break connect with AP and lost connection, the device will hang in a dead connection. To prevent this happen, set a timeout, the device will close the connection and wait for next connect.

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3.1.4 Standalone Function mode Configuration

Timing control is a standalone function in tWF-DA1PD2R1, it can enable by PC utility, Android APP and Web, it can be trigger by both DI pin, and follow the setting to operate the DO and AO, the prefer application is Simplify Light Control system.



Function Mode Enable: Enable or Disable the global function.
DI Trigger Type: Define the DI trigger mode, DI close to GND or DI open from GND.
DO output select: Define which DI or both can be trigger DO, when both DI been trigger, DO will release until the last DI release.
Delay to ON: The track bar set the delay time to turn on the DO.
Time to Hold: Set the time to hold DO "ON" after the last DI release.
DAC output select: Define which DI or both can be trigger DA, when both DI been trigger, DA will release until the last DI release.
Delay to ON: Set the delay time to start the DA output.
Off value: Set the DA value for idle "OFF".
On value: Set the DA value for turn "ON".
Ton value: Set the time from "OFF" rising to "ON".
Thold value: Set the time to hold when turn "ON".
Toff value: Set the time from "ON" falling to "OFF".
Load/Save File button: Load/Save config file(*.tcf) from/to local storage.
Read/Write Device button: Read/Write config from/to target device.

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3.2 IP scanner

There are lot of Free IP scanner tools in both Windows & Android OS, for example "Advanced IP Scanner" for Windows, "Network Analyzer" for Android, those are high performance scanner tools on each OS.

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4. Application

Users can use a Computer or Smart Device to communicate with the tWF devices in the application. It can complete the purpose of I/O control to wireless network by this way.



Figure 4-1: tWF + PC/Laptop/Smart Device application architecture

4.1 Connection with Modbus TCP utility

a. Open Modbus TCP utility and key in the IP address , Port as "502". Finally, click the "Connect" button.
b. If the network settings are correct, this will immediately establish a connection.
c. Use the function code "0x02", and set the Reference Number as "0x00", Bit Count as "0x08" to get the 8 CHs DI value.

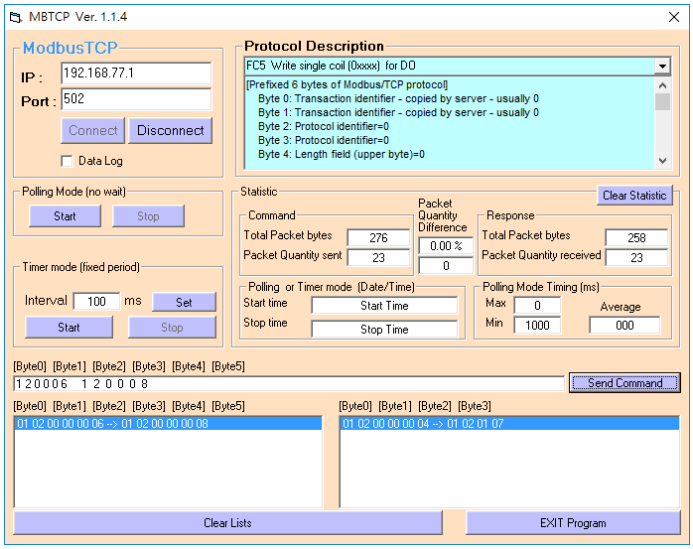


Figure 4-2: Digital Input reading

d. Use the function code "0x01", and set the Reference Number as "0x00", Bit Count as "0x08" to get the 8 CHs DO value.

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e.

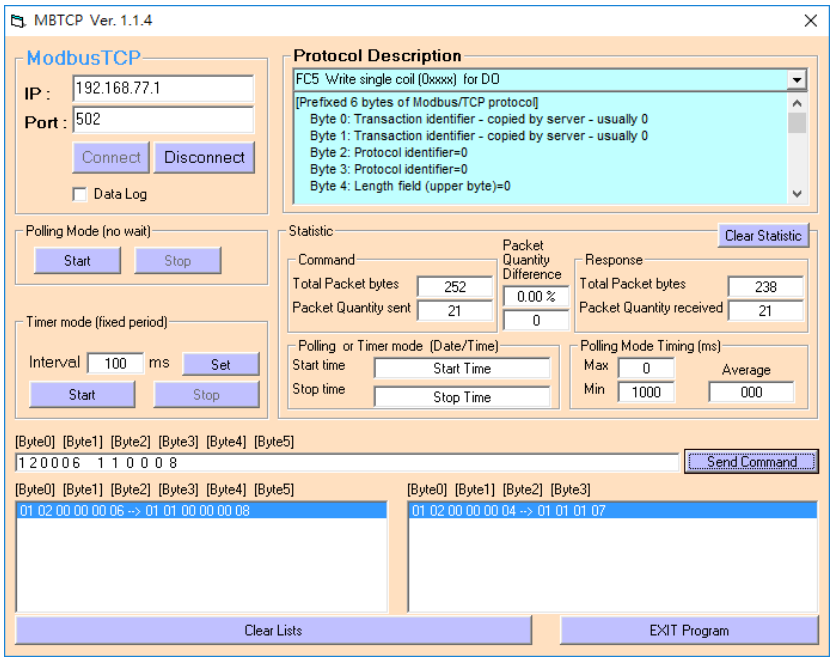


Figure 4-3: Digital output reading

f. Use the function code "0x05", and set the Reference Number as "0x00", Bit Count as "0xFF" to turn on the CH0 DO, & 0x00 to turn off.

g.

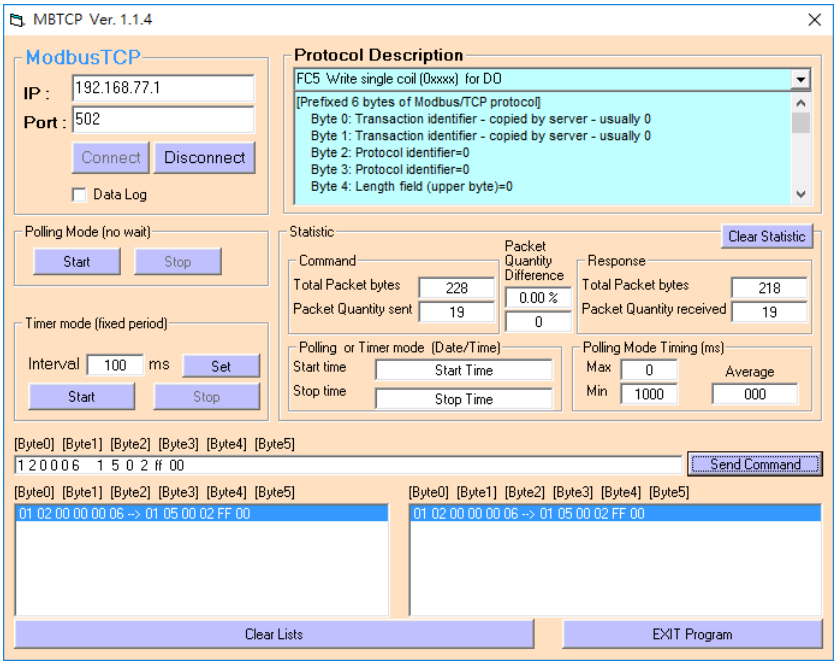


Figure 4-4: Digital output turn on

h. Use the function code "0x06", and set the Reference Number as "0x00", Register value 7 FF as "0x07FF" to set the DA output value to 4.999V/10mA.

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i.

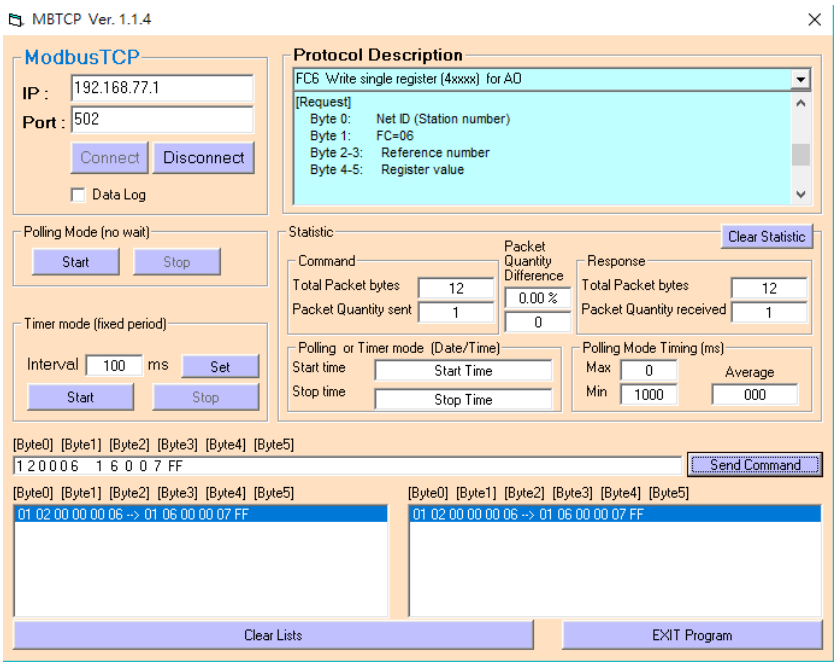


Figure 4-4**:** Setting DA output

j. Use the function code "0x03", and set the Reference Number as "0x00", word count as "1" to read the DA value holding in register 07 FF(0x07FF) 4.999V/10mA.

k.

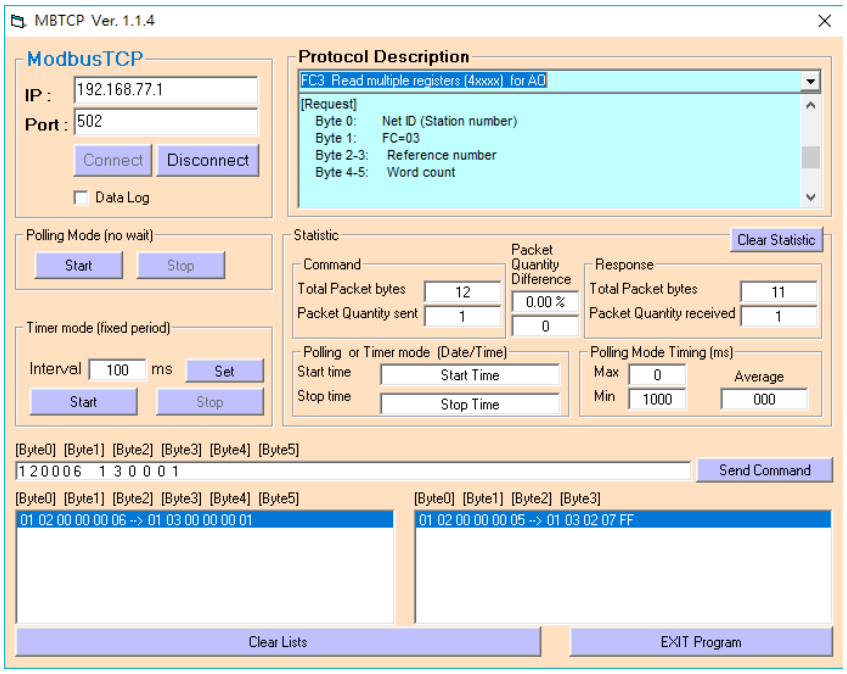


Figure 4-4**:** Reading DA register

l. Use the function code "0x04", and set the Reference Number as "0x00", word count as "4" to read the 32bit(4 byte) 2 channel Counter or AI value, to return 8 byte, CH0 counter is 00 31 00 00 is 0x00000031 as 49, CH1 is 00 08 00 00 is 0x00000008 as 8.

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m.

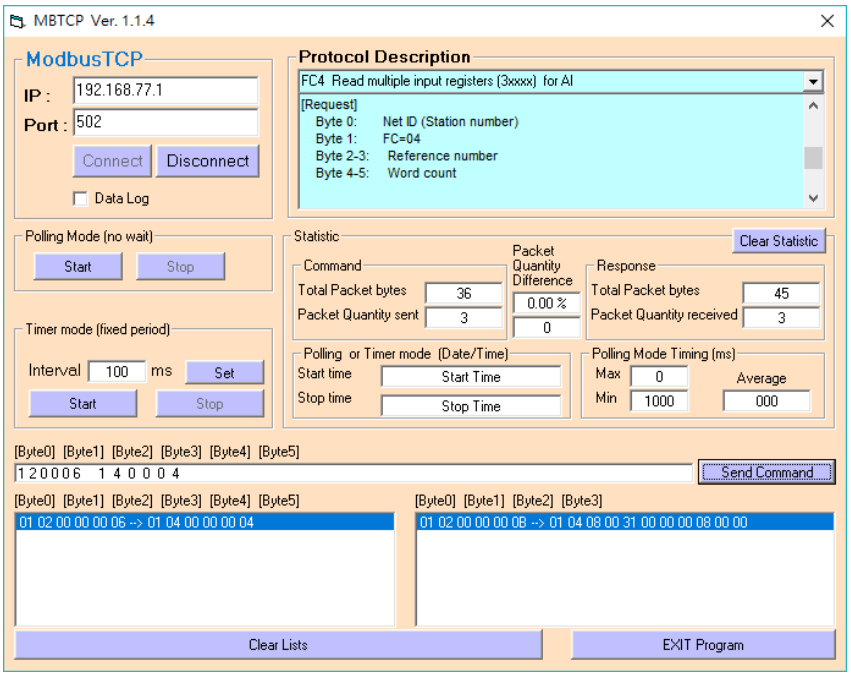


Figure 4-4: Reading Counter or AI

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5. Modbus Applications

The tWF include a Modbus port that allows you to access terminals data via Wi-Fi and communicates using a master-slave technique in which only one device (the master) can initiate transactions (called queries). The other devices (slaves) respond by supplying the requested data to the master, or by taking the action requested in the query.

Most SCADA (Supervisor Control And Data Acquisition) and HMI software can easily integrate serial devices via the Modbus protocol, such as Citect, ICONICS, iFIX, InduSoft, Intouch, Entivity Studio, Entivity Live, Entivity VLC, Trace Mode, Wizcon, Wonderware, etc.

For Android Device, a freeware HMI Modbus is easy to use.

5.1 What is Modbus TCP/IP?

Modbus is a communication protocol developed by Modicon in 1979.

Different versions of Modbus used today include Modbus RTU (based on serial communication like RS485 and RS232), Modbus ASCII and Modbus TCP, which is the Modbus RTU protocol embedded into TCP packets.

Modbus TCP is an internet protocol. The protocol embeds a Modbus frame into a TCP frame so that a connection oriented approach is obtained thereby making it reliable. The master query's the slave and the slave responds with the reply. The protocol is open and hence highly scalable.

5.2 Protocol Description

The Modbus protocol defines a simple protocol data unit independent of the underlying communication layers. The mapping of Modbus protocol on network can introduce some additional fields on the application data unit.

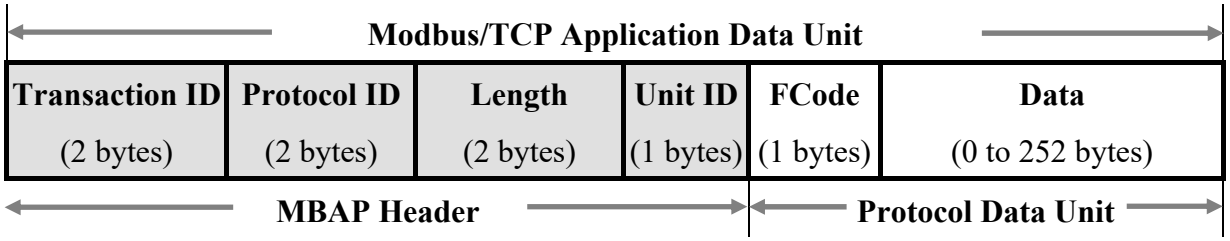


Figure 5-1: Modbus/TCP Application Data Unit

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5.2.1 MBAP

The Modbus/TCP extension includes 7 additional bytes to the original Modbus protocol, which allows for transport over the TCP/IP layers.

A dedicated header is used on TCP/IP to identify the Modbus Application Data Unit. It is called the MBAP Header (MODBUS Application Protocol Header). The MBAP Header consists of 7 bytes of information:

Fields	Length	Description
Transaction Identifier	2 bytes	Identification of Request/Response transaction – Copied from request to response
Protocol Identifier	2 bytes	0 = Modbus protocol
Length	2 bytes	Number of following bytes - Includes the Unit Identifier
Unit Identifier	1 byte	Identification of remote slave

Table 5-1: MODBUS Application Protocol Header

5.2.2 Function Code

The function code field of a Modbus data unit is coded in one byte. Valid codes are in the range of 1 ... 255 decimal (the range 128 - 255 is reserved and used or exception responses). When a Modbus request is sent from a Modbus Client to a Server device the function code field tells the Server what kind of action to perform.

The Modbus/TCP feature of tWF-DA1PD2R1 controller supports 6 function codes, which allows the reading and writing of data contents of registers.

Function Code	Descriptions
01 (0x01)	Read Coil Status
02 (0x02)	Read Input Status
03 (0x03)	Read multiple AO Registers
04 (0x04)	Read analog Input Registers/Read counter
05 (0x05)	Write Single Coil/Clear Counter/Force Function mode
06 (0x06)	Write Single AO

Table 5-2: Supports Function Codes of tWF series

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Any other function code request will be returned with an error response indicating the function code is not supported, as well as a request for too much data or data at a register address that not present.

5.2.3 Data

The data field of Modbus request sent from a client to server devices contains additional information that the server uses to take the action defined by the function code. This can include items like discrete and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field.

The data field may be nonexistent (of zero length) in certain kinds of requests, in this case the server does not require any additional information. The function code alone specifies the action.

5.2.4 Response

If no error occurs related to the Modbus function requested in a properly received Modbus PDU (Protocol Data Unit) the data field of a Modbus response from a server to a client contains the data requested. If an error related to the Modbus function requested occurs, the field contains an exception code that the server application can use to determine the next action to be taken.

For example a client can read the ON/OFF states of a group of digital input or output or it can read/write the data contents of a group of registers.

When the server responds to the client, it uses the function code field to indicate either a normal response or that some kind of error occurred (called an exception response). For a normal response, the server simply echoes to the request the original function code.

For an exception response, the server returns a code that is equivalent to the original function code from the request PDU with its most significant bit set to logic 1.

5.2.5 Data Encoding

Modbus uses a "big-endian" representation for address and data items. This means that when a numerical quantity larger than single byte is transmitted, the most significant byte (MSB, also called the high-order byte) is send first. The following sub-topics

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describe the different byte of encoding and show how the data is encoded as it is within the Modbus/TCP packet.

5.2.5.1 Binary

A binary item is represented as a single bit within a data word. All binary is packed into 16-bits data words, which are accessed using function code 01 and 02. Therefore, a single register contains 16 bits of binary data, each having a specific meaning.

Value	1st	2nd
0xAA55 (1010101001010101)	0xAA (10101010)	0x55 (01010101)

Table 5-3: A single register contains 16 bits of binary data

5.2.5.2 16-bits Word

A 16-bits word item is transmitted with the most significant byte first. Function code 03 and 04 read 16-bits items at a time; therefore, each of these data items will fit within one register that is read.

Value	1st	2nd
0x1234	0x12	0x34

Table 5-4: A 16-bits word item

5.2.5.3 32-bits Double Word

A 32-bits word item is transmitted with the most significant byte first. Function 04 read 32-bits items at a time; therefore, each of these data items will fit within 2 register that is read.

Value	1st Word	2nd Word
0x12345678	0x5678	0x1234

Table 5-5: A 32-bits double word item

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5.3 Address Mapping

5.3.1 tWF-DA1PD2R1 I/O Address Mapping

Address	CH	Descriptions	Range	Access Type
00001	1	Digital Output	0=OFF, 1=ON	R
00009~00010	2	Clear DI Trigger Counter	Always 0	R
00015	1	Function mode Enable/Disable	0=OFF, 1=ON	R

Table 5-6: FC01 Read DO address (0xxxx)

Address	CH	Descriptions	Range	Access Type
10001~10002	2	Digital Input	0=OFF, 1=ON	R

Table 5-7: FC02 Read DI address (1xxxx)

Address	CH	Descriptions	Range	Access Type
00001	1	Digital Output	0x00=OFF, 0xFF=ON	W
00009~00010	2	Clear DI Trigger Counter	0xFF=Clear	W
00015	1	Function mode Enable/Disable	0=OFF, 1=ON	W

Table 5-8: FC05 Write DO address (0xxxx)

Address	CH	Descriptions	Range	Access Type
30001~30008	2	DI Counter 2 Word/CH	16bit Word	R

Table 5-9: FC04 Read Counter address (3xxxx)

Address	CH/Length	Descriptions	Range	Access Type
40001	1	AO output	16bit Word	R
40011	Always 1	Read Idle Timeout value	16bit Word	R

Table 5-10: FC03 Read AO address (4xxxx)

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Address	Reg	Descriptions	Range	Access Type
40001	1	AO output	16bit Word	R
40011	-	Write Idle Timeout value	16bit Word(1~65000)	W

Table 5-10: FC06 write AO address (4xxxx)

Technical Support

If you have problems about using the tWF series I/O controller, please contact ICP DAS Product Support.
Email: service@icpdas.com

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