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Document Revision

Version	Date	Description of changes
Rev1.0	2018-08-19	First release for tWF series
Rev1.1	2020-02-13	Add Modbus connection idle timeout

Table of Contents

1. Introduction

The tWF series I/O controller have WLAN connection complies with the IEEE802.11b/g/n standards. With the popularity of 802.11 network infrastructure, the tWF series I/O controller 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 series 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
- Wide power supply range
- Software Digital Input wit 32-bit counter
- Photo couple Isolation input, Relay or SSR Isolation output

1.2.2 Features Description

The tWF controller 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 slave function on the tWF controller can be used to provide data to remote 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 I/O usage and enhances performance of the I/O operations.

1.3 Specifications

Table 1-1: System Specifications

Controller	tWF-PD4R3	tWF-PD4SR2A/D	tWF-PD8	tWF-R6
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	0.84W	0.83W	0.82W	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%			

Table 1-2: tWF I/O Specification

Controller		tWF-PD4R3	tWF-PD4SR2A/D		tWF-PD8	tWF-R6
Digital Input						
Channels		4-	4		8	-
Input Type		Dry Contact: Sink				-
Dry Contact Level		Off Voltage Level: Open On Voltage Level: Close to GND				-
Counters	Channels	4	4		8-	-
	Max. Counts	32-bit (4294967295)				-
	Max. Input Frequency	20 HZ				-
Photo-Isolation		3750 VDC				-
Digital Output			AC	DC		
Channels		3	2		-	6
Output Type		Form A	SSR	SSR	-	Form A
Contact Rating (Resistive Load)		DC30V/5A AC250V/5A	AC240V 1.5A	DC3~30V 1A	-	DC30V/5A AC250V/5A
Relay/SSD Operate Time		5ms (max.)	2 ms (max.)		-	5ms (max.)
Relay/SSD Release Time		5ms (max.)	2 ms (max.)		-	5ms (max.)

2. Hardware

2.1 Front Panel

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

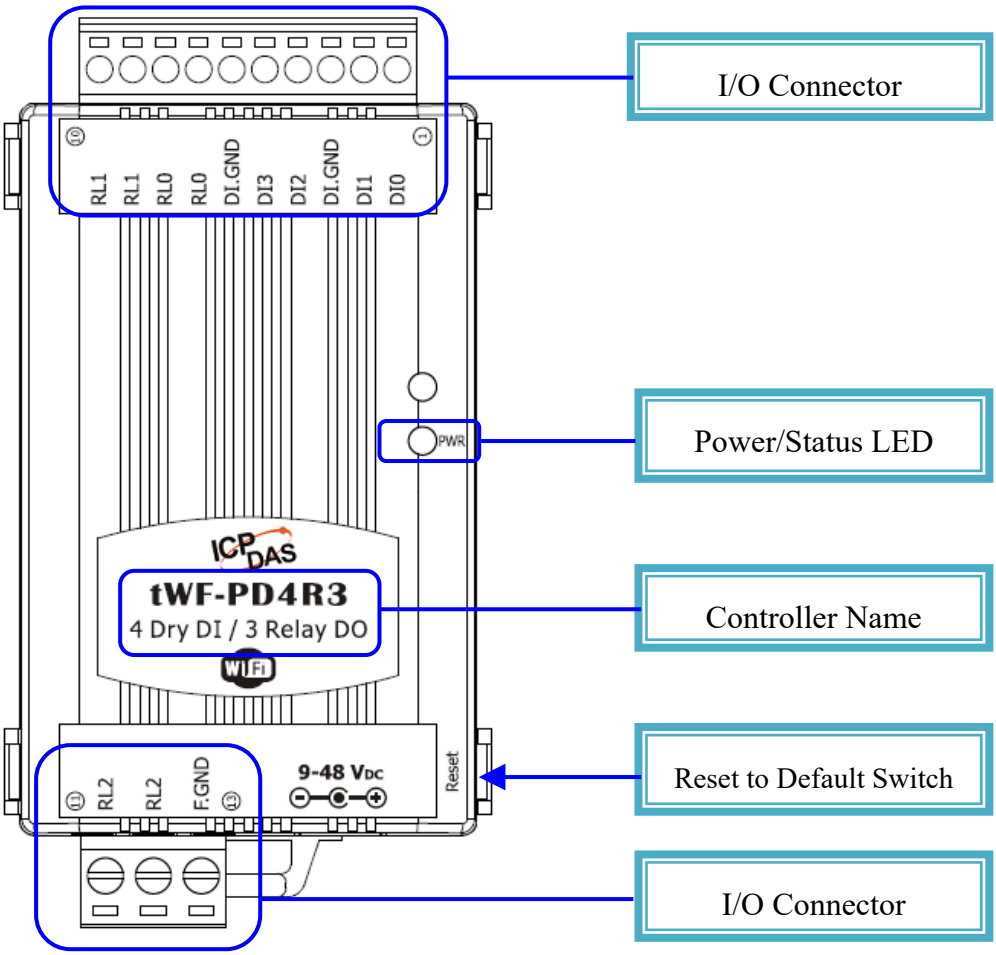


Figure 2-1: Front Panel of the tWF DIO controller

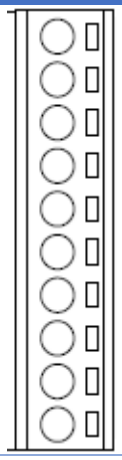
2.1.2 LED Indicator

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)

2.1.3 I/O Connector Pin Define

2.1.3.1 tWF-PD4R3

Terminal NO	Pin Assignment Name
	10 RL1
	9 RL1
	8 RL0
	7 RL0
	6 DI.GND
	5 DI3
	4 DI2
	3 DI.GND
	2 DI1
	1 DI0

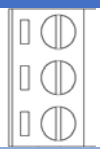
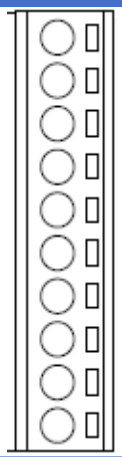
Terminal NO	Pin Assignment Name
	11 RL2
	12 RL2
	13 F.GND

Figure 2-2: I/O Connector of tWF-PD4R3

2.1.3.2 tWF-PD8

Terminal NO	Pin Assignment Name
	10 DI7
	9 DI6
	8 DI.GND
	7 DI5
	6 DI4
	5 DI3
	4 DI2
	3 DI.GND
	2 DI1
	1 DI0

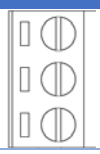
Terminal NO	Pin Assignment Name
	11 F.GND
	12 F.GND
	13 F.GND

Figure 2-3: I/O Connector of tWF-PD8

2.1.3.3 tWF-R6

Terminal NO	Pin Assignment Name
10	RL4
9	RL4
8	RL3
7	RL3
6	RL2
5	RL2
4	RL1
3	RL1
2	RL0
1	RL0

Terminal NO	Pin Assignment Name
11	RL5
12	RL5
13	F.GND

Figure 2-4: I/O Connector of tWF-R6

2.1.3.4 tWF-PD4SR2A

Terminal NO	Pin Assignment Name
10	SSR1
9	SSR1
8	DI.GND
7	DI3
6	DI2
5	DI1
4	DI0
3	DI.GND
2	SSR0
1	SSR0

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

Figure 2-5: I/O Connector of tWF-PD4SR2A

2.1.3.5 tWF-PD4SR2D

Terminal NO	Pin Assignment Name
10	SSR1-
9	SSR1+
8	DI.GND
7	DI3
6	DI2
5	DI1
4	DI0
3	DI.GND
2	SSR0-
1	SSR0+

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

Figure 2-6: I/O Connector of tWF-PD4SR2D

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.

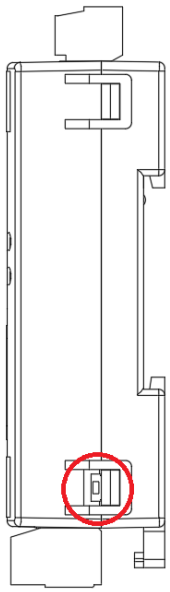


Figure 2-7: Reset button locate in the right side of tWF Controller

2.3 Dimensions

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

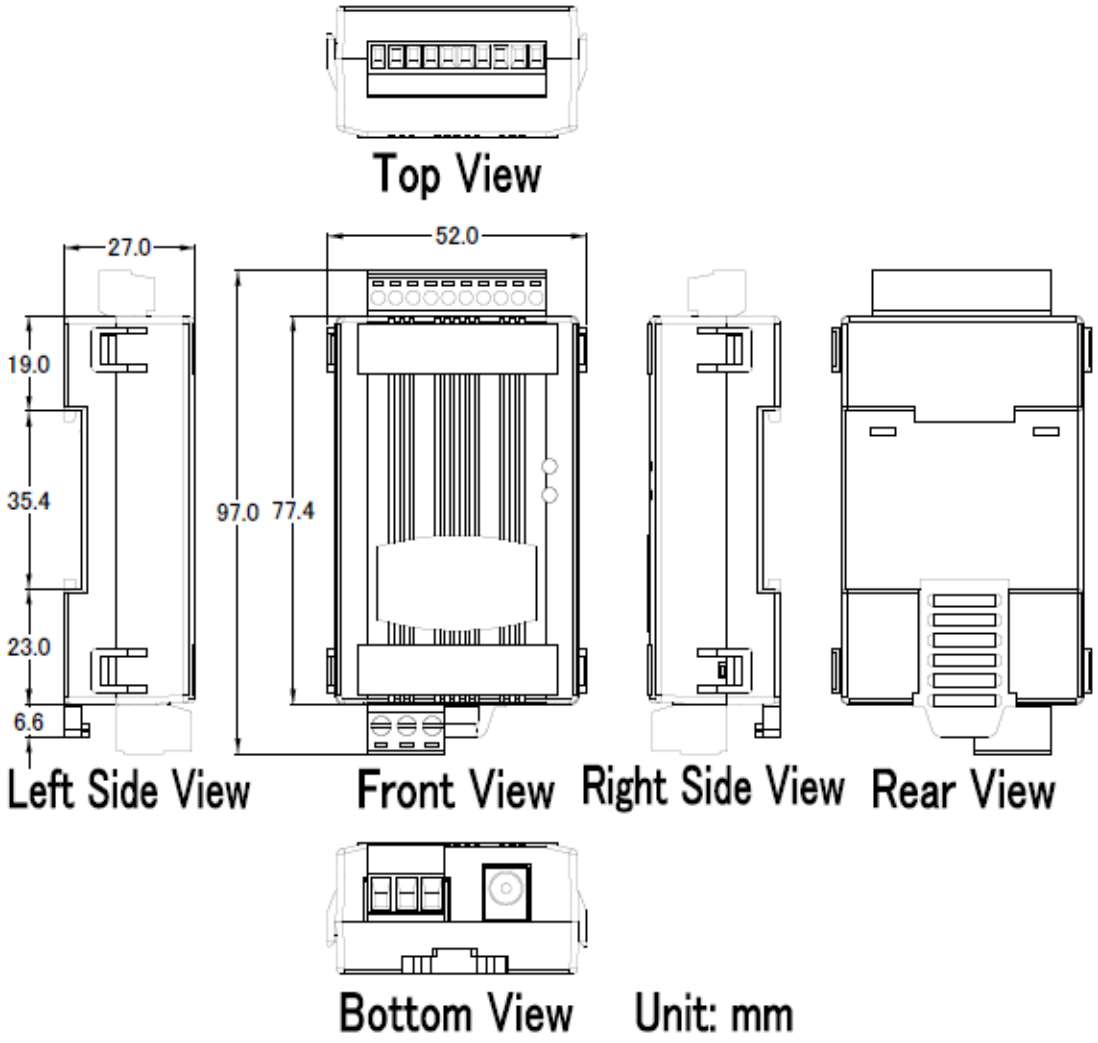


Figure 2-8: Dimension of the tWF I/O Controller

2.4 Hardware Connection

2.4.2 Power connection

The following figures describe the Power

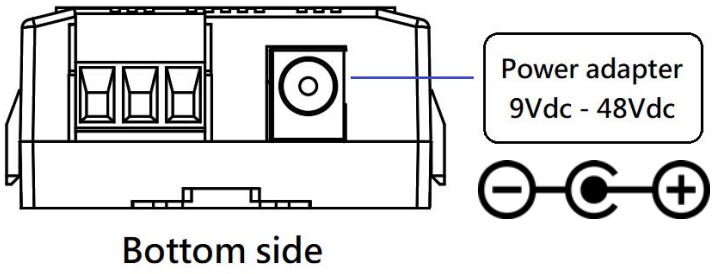


Figure 2-9: Power connection

2.4.3 I/O connection

2.4.3.1 Digital Input(DI) wiring

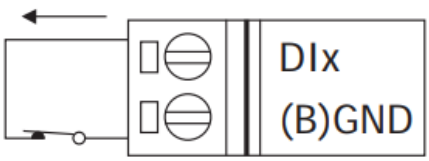
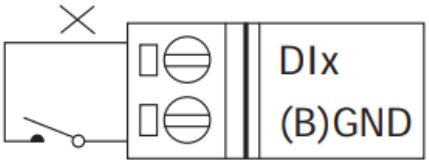
Digital Input wiring		
Digital Input/ Counter	ON State	OFF State
Dry Contact	Close to GND	OPEN
		

Figure 2-10: DI Dry contact wiring

2.4.3.2 Digital Output(DO) Relay wiring

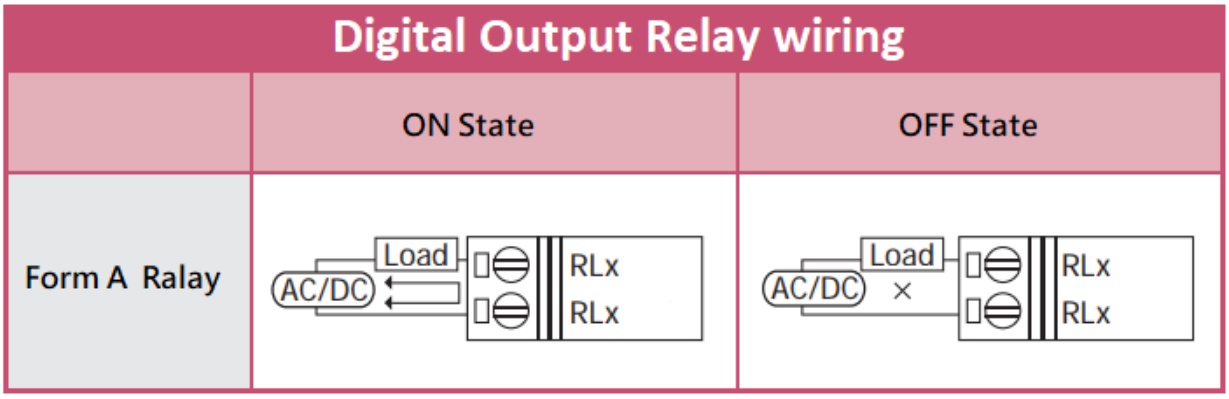


Figure 2-11: Relay DO wiring

2.4.3.3 Digital Output(DO) SSR AC wiring

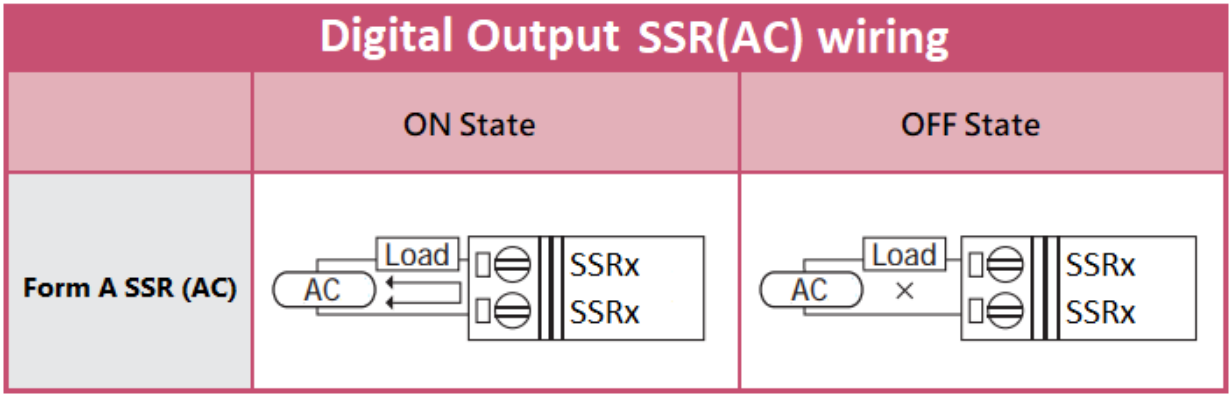


Figure 2-12: SSR(AC) DO wiring

2.4.3.4 Digital Output(DO) SSR DC wiring

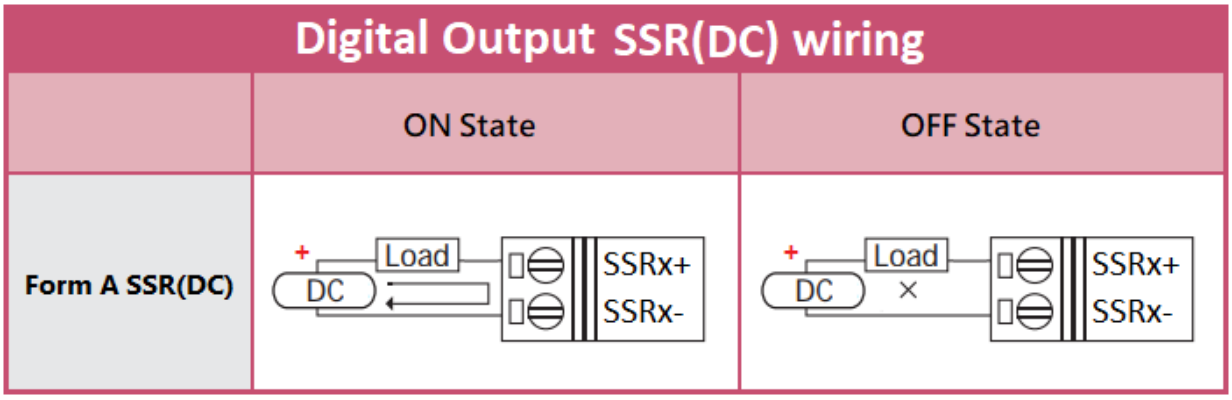


Figure 2-13: SSR(DC) DO wiring

3. Software

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

tWF Utility available on both Windows & Android application, also it can work in Web browser to operating and configure the tWF I/O Controller,

Utility Support Windows 7 (or later versions) and Android 5.0 (or later versions).

3.1 tWF Utility(AP Mode)

The following is the main screens provided by tWF Utility, these utility tools can be thought as a useful tool for I/O control and monitoring on the tWF series 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

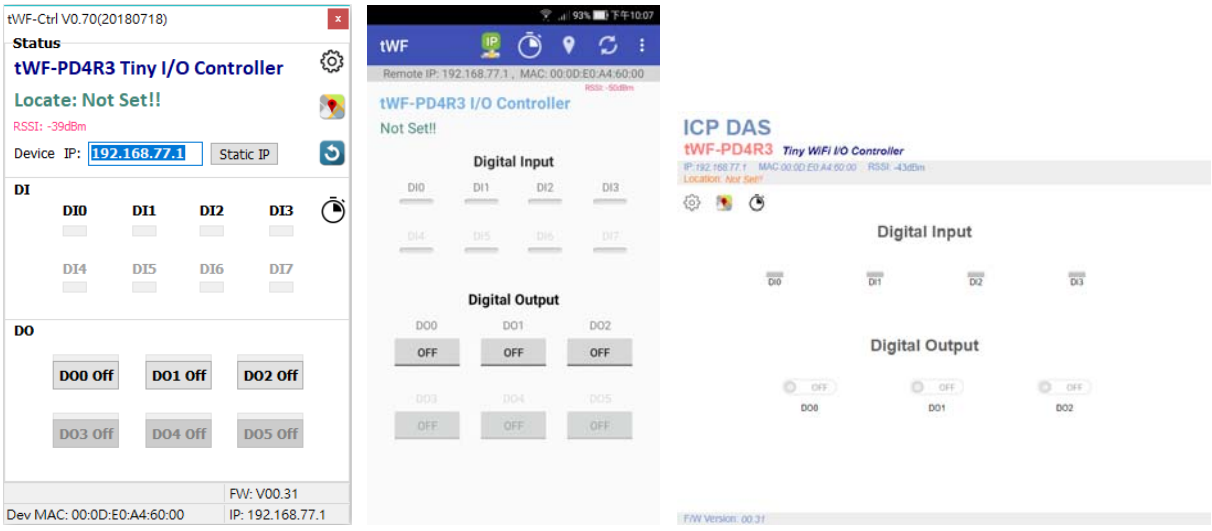


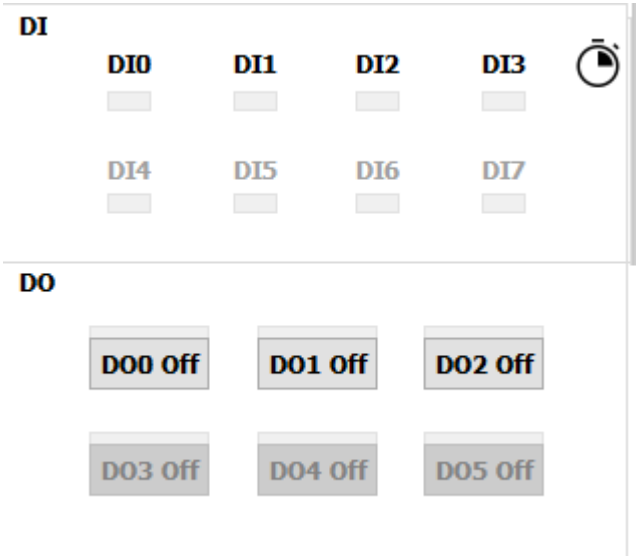
Figure 3-1: tWF Utility main screen
(From left to right is Windows Utility , Android App & Web browser)

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 Status Bar

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

3.1.2.4 ICON

ICON	function	
	Setup	Open the Setup Screen(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, FW Version & About.
	DI Counter	Show the DI trigger counter page

Table 3-1: icon Indicator

3.1.3 Configuration/Setup

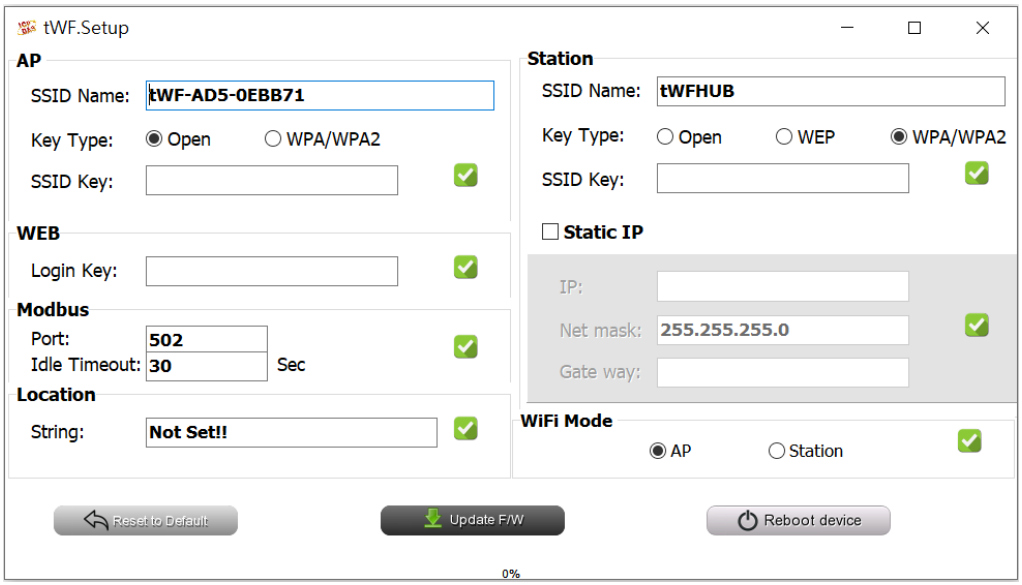


Figure 3-2: tWF Utility setup page

Click apply icon to save each subject's setting, after finish all setting click Reboot device 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-PD4R3-xxxxxx
   b. tWF-PD4SR2A-xxxxxx
   c. tWF-PD4SR2D-xxxxxx
   d. tWF-PD8-xxxxxx
   e. tWF-R6-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**)

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 8~31 characters. Characters of key should be in range of: [0 ~ 9_-] or [A ~ F] or [a ~ f].

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.

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 will always 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.

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.

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.

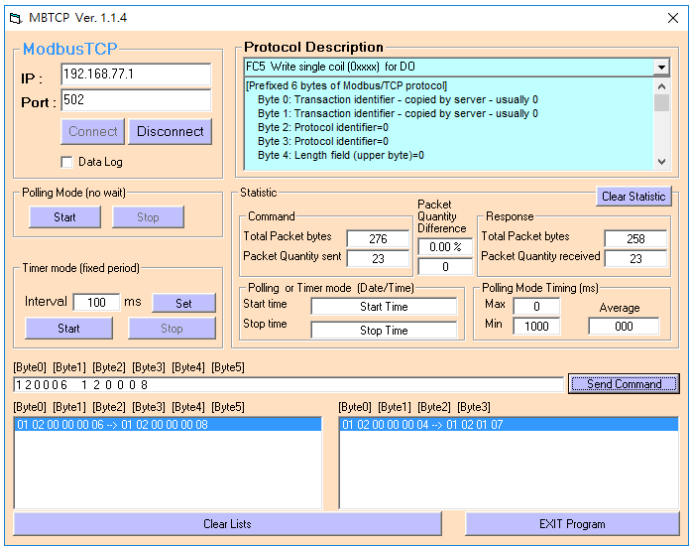


Figure 4-2: Digital Input reading screen

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

e.

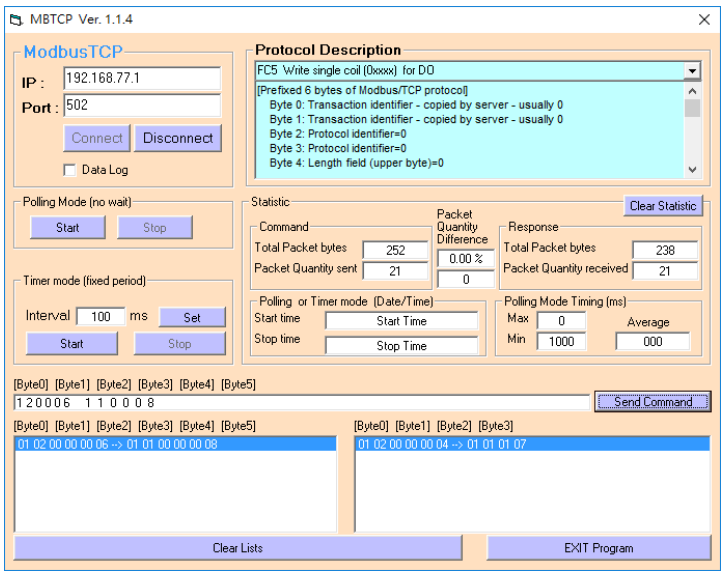


Figure 4-3**:** Digital output reading screen

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.

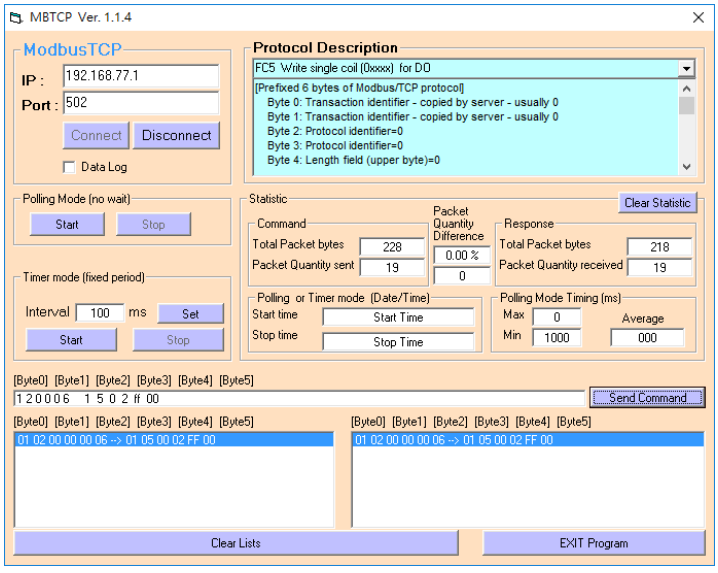


Figure 4-4**:** Digital output turn on

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.

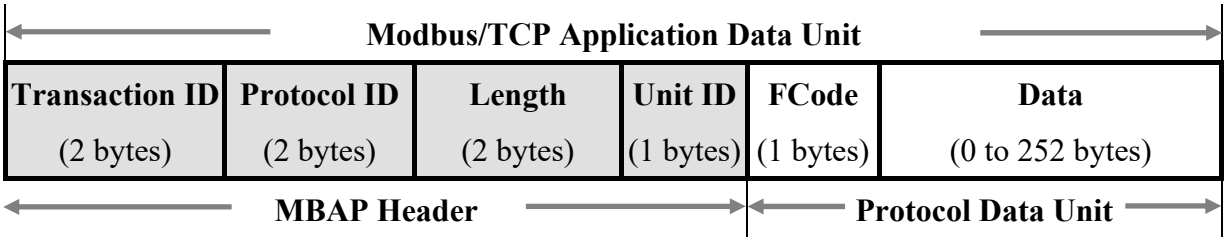


Figure 5-1: Modbus/TCP Application Data Unit

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 series controller supports 7 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)	Force Single Coil
06 (0x06)	Write Single AO
15 (0x0F)	Force Multiple Coils

Table 5-2: Supports Function Codes of tWF series

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 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

5.3 Address Mapping

5.3.1 tWF-PD4R3 I/O Address Mapping

Address	CH	Descriptions	Range	Access Type
00001~00003	3	Digital Output	0=OFF, 1=ON	R
00009~00012	4	Undefined	Always 0	R

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

Address	CH	Descriptions	Range	Access Type
10001~10004	4	Digital Input	0=OFF, 1=ON	R

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

Address	CH	Descriptions	Range	Access Type
00001~00003	3	Digital Output	0x00=OFF, 0xFF=ON	W
00009~00012	4	Clear DI Trigger Counter	0xFF=Clear	W

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

Address	Reg	Descriptions	Range	Access Type
30001~30008	8	DI Counter Value, 2 Word/CH	16bit Word	R

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

5.3.2 tWF-PD4SR2A/D I/O Address Mapping

Address	CH	Descriptions	Range	Access Type
00001~00002	2	Digital Output	0=OFF, 1=ON	R
00009~00012	4	Undefined	Always 0	R

Table 5-10: FC01 Read DO address (0xxxx)

Address	CH	Descriptions	Range	Access Type
10001~10004	4	Digital Input	0=OFF, 1=ON	R

Table 5-11: FC02 Read DI address (1xxxx)

Address	CH	Descriptions	Range	Access Type
00001~00002	2	Digital Output	0x00=OFF, 0xFF=ON	W
00009~00012	4	Clear DI Trigger Counter	0xFF=Clear	W

Table 5-12: FC05 Write DO address (0xxxx)

Address	Reg	Descriptions	Range	Access Type
30001~30008	8	DI Counter Value, 2 Word/CH	16bit Word	R

Table 5-13: FC04 Read AI/Counter address (3xxxx)

5.3.3 tWF-PD8 I/O Address Mapping

Address	CH	Descriptions	Range	Access Type
00009~00016	8	Undefined	Always 0	R

Table 5-14: FC01 Read DO address (0xxxx)

Address	CH	Descriptions	Range	Access Type
10001~10008	8	Digital Input	0=OFF, 1=ON	R

Table 5-15: FC02 Read DI address (1xxxx)

Address	CH	Descriptions	Range	Access Type
00009~00016	8	Clear DI Trigger Counter	0xFF=Clear	W

Table 5-16: FC05 Write DO address (0xxxx)

Address	Reg	Descriptions	Range	Access Type
30001~30016	16	DI Counter Value, 2 Word/CH	16bit Word	R

Table 5-17: FC04 Read AI/Counter address (3xxxx)

5.3.4 tWF-R6 I/O Address Mapping

Address	CH	Descriptions	Range	Access Type
00001~00006	6	Digital Output	0=OFF, 1=ON	R

Table 5-18: FC01 Read DO address (0xxxx)

Address	CH	Descriptions	Range	Access Type
00001~00006	6	Digital Output	0x00=OFF,0xFF=ON	W

Table 5-19: FC05 Write DO address (0xxxx)

5.3.5 MODBUS Idle Timeout Address Mapping

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

Table 5-20: FC03 Read multiple AO address (4xxxx)

Address	CH/Length	Descriptions	Range/Value	Access Type
40011	-	Write Idle Timeout value	16bit Word(1~65000)	W

Table 5-21: FC06 Write Single 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