DG21E5A

KC certification

R-R-Diu-DGE5A
Company name: Ilpum Corporation
Model name: DG21E5A

Operating environment

Normal operating temperature range = -25 ~ 70 [°C]
No dew, no dust.

Power

Rated voltage = DC 24 [V] (operable range 20 ~ 27 [V])
Maximum current consumption = 300 [mA]

Communication

Physical standard: TIA/EIA-485A (RS485)
Maximum number of devices on the track = 64 node
ESD protection = up to 15 [kV]
Data protocol: MODBUS RTU protocol

Rating of DI terminal

Points can be connected without any external power
Have direct connection with external DO (includes power for DI detection inside the device)

DI detection indication

LED lights up when ON is detected

Rating of DO terminal

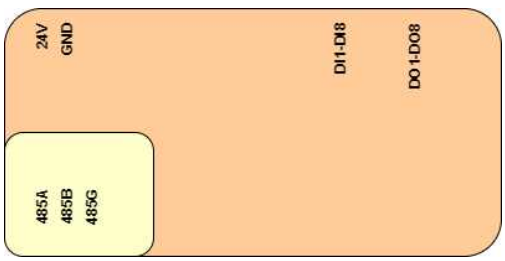
Transistor output: Sink type
Current: 0~0.5 [A], Voltage: 0~50 [V]

DO operation indication

Setting OFF: LED OFF, contact open
Setting ON: LED ON, contact short circuit

Isolation

Photo Coupler. Maximum isolation voltage = 3.75 [kV rms]
Isolation group 1: RS485 terminal
Isolation group 2: power terminal, all input/output (DI, DO) terminals



[Figure 1] Internal isolation of E5A

Dimensions

Width 145 [mm], Depth 90 [mm], Height 41 [mm]

Fastening method

Can be mounted on DIN rail
Can be fixed with 4 screws on the wall (hole distance: x axis = 135 [mm], y axis = 70 [mm])

1. Summary

DG21E5A is a CPU (Central Processing Unit) module of DiBA PLC (Programmable Logic Controller). The product name of the model name DG21E5A is CPU type 2. The model name consists of Ilpum Corporation mark (DG), the year of release, and the representative model name (E5A).

Users can use DST (Diurnal Standard Text) files to instruct the E5A what to do. DST files are written in a unique PLC programming language designed based on ST (Standard Text) among PLC programming language standards (IEC 61131-3). The format of the DST file is a WindowsTM text document, so it can be created and modified with a basic text editor such as “Notepad”. For the DST programming method, please refer to the DST grammar manual.

E5aLoader can read the completed DST file and save it in E5A (Run) or test it in E5A (Debug). Jobs stored on the E5A are maintained even when the power is turned off, and will be executed as soon as power is applied again. However, if the E5A encounters an unrecoverable problem during task execution, it restarts after 30 seconds and disables the stored task to prevent system malfunction. When testing the E5A, the work is only valid until the E5A is powered off.

E5A can perform general functions of PLC and has 1 RS485 (2 wire) and 1 WiFi (802.11 b/g/n). With RS485, MODBUS RTU master/slave, user defined communication can be performed. WiFi can be set as an AP (Access Point, 802.11 b/g) or station, and can be operated safely by applying various security protocols. With WiFi, MODBUS TCP server/client, user defined server/client communication can be performed over TCP/IP.

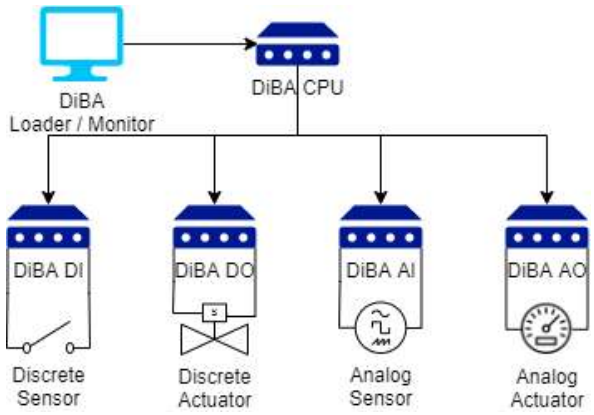
E5A has 8 DI (Digital Input, self-supplying power for measurement) and 8 DO (Digital Output, transistor sink type ~0.5A). A small number of devices can be controlled without a separate I/O module.

(Warning) E5A can operate and manage systems and networks. For safe and stable operation of the automatic control system, the user should consider safety and conduct sufficient tests before applying E5A to the actual automatic control system.

2. DiBA system

2.1. Basic configuration of DiBA system

DiBA is a brand name for a class of PLC products. Although the types of automatic control systems to which PLC is applied are different, the basic structure for building the system is almost the same.



[Figure 2] Configuration of automatic control system

[Figure 2] briefly expresses DI (Digital Input: A device that detects only match/mismatch for a specific condition and converts it into an electrical signal, such as a full water sensor or door open sensor, etc.), DO (Digital Output: A device that controls ON/OFF with electrical signals such as fans and lights, etc.), AI (Analog Input: A device that converts the size of voltage/current/resistance according to a range of conditions, such as a thermometer, salinity meter, etc.) or AO (Analog Output: A device that controls the size of voltage/current such as a flow control valve, DC motor, etc.) that users encounter in their daily life. It also expresses that information can be exchanged between the DiBA CPU module and the DiBA I/O (Input/Output) module.

Install and use applications such as E5aLoader and SCADA (Supervisory Control And Data Acquisition) on your computer.

Ilpum Corporation's automatic control product line (DiBA-21) consists of the following products.

Form	Model name	Product name	Explanation
	DG21E5A	CPU type 2	DiBA CPU. 1 WiFi, 1 RS485, 8 DI, 8 DO Operate the system according to the stored task history.
	E5aLoader	CPU loader	Application for Windows™ PC Assign tasks to CPU modules.
	DG21E4H	MODBUS RTU DO	1 RS485, 40 DO Controlled by CPU or PC with SCADA installed.
	DG21E4I	MODBUS RTU DI	1 RS485, 40 DI Controlled by CPU or PC with SCADA installed.
	DG21E4J	MODBUS RTU IO	1 RS485, 8 DI, 8 DO, 8 AI, 8 AO, 8 UI Controlled by CPU or PC with SCADA installed.

The model name of the hardware type product is [Ilpum Corporation mark]+[release year]+[representative model name]. Therefore, when CPU type 2 is generally referred to, it is denoted as E5A. All hardware-type products use the same case, and the dimensions are 145 x 90 x 41 [mm] (W x D x H).

2.2. E5A Scalability

The pyramid structure as shown in [Figure 2] is convenient and efficient to apply to a simple system. In addition, when operating a system using SCADA, it can be efficiently applied to a slightly more complex system by placing multiple CPUs under the SCADA. However, considering both stability against risk situations and scalability in irregular directions, it is recommended to configure a distributed system to properly distribute control.

Dangerous situations can be caused by power outages, PC lifespan, bottlenecks of system resources, etc. When the PC is restarted due to a power outage, it takes more time than PLC CPU to return to a normal state and give proper control to the system. This delay becomes a blank period for system administration. And since PC requires more resources compared to PLC CPU, the lifespan of some resources limits the operating time of the PC as a whole, and the PC cannot be used until the problematic resource is repaired. In addition, the pyramid structure has a characteristic in which data is concentrated at the top of the system. If the data collection plan is not optimized according to the size of the system, the system operation may be hindered due to the bottleneck of the communication network.

The direction of expansion of the system is difficult to predict. It is a better choice to be prepared to respond flexibly and quickly to changing circumstances than to have a solid expansion plan. For this, the product must be selected by examining how excellent the scalability of the PLC system is.

E5A, like a typical PLC CPU, has significantly higher stability against power and lifespan risk compared to PC. To prepare for a dangerous situation, the system's top controller should be the PLC CPU. In addition, E5A can perform both the role of controller (CPU) and controlee (I/O) for all communication protocols supported by E5A for easy distributed system configuration. Through RS485 interface, E5A can control lower I/O modules or can be controlled by upper CPU or SCADA. With WiFi, both server interface and client interface can be operated at the same time. That is, it can be controlled by other CPUs or SCADA through the server interface, and can also control lower I/O modules through the client interface. Therefore, various types of interworking between E5A are possible using the interface combination, and the scope of the distributed system can be infinitely expanded.

3. Ready to use E5A

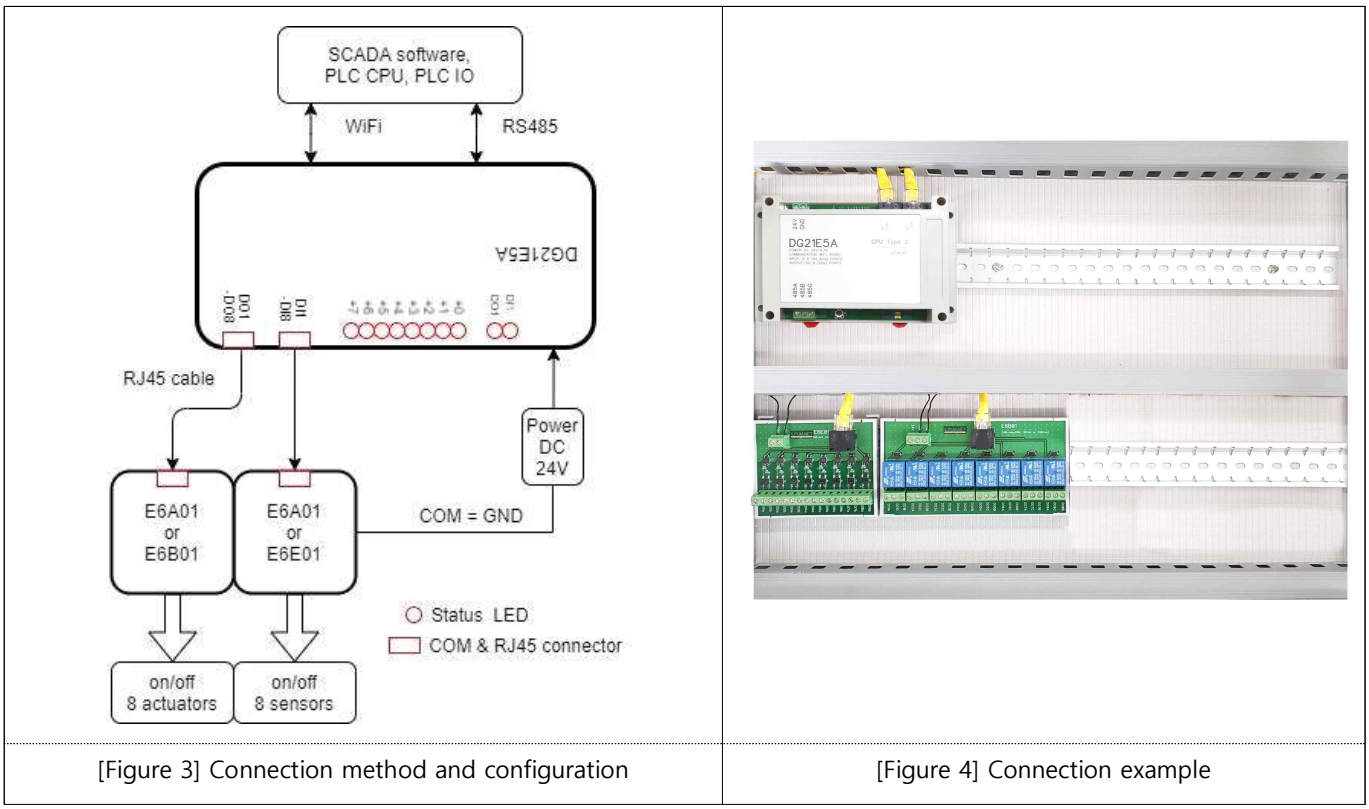
3.1. Power and signal line connection

The range of power supply voltage for all functions of E5A to operate normally is 20 ~ 29[Vdc]. If a voltage of 30[Vdc] or higher is applied to the power supply, parts may be damaged. It is recommended to use a 24[Vdc] SMPS (Switching Mode Power Supply).

Most automatic control systems include switches that shut off the power in their configuration. This is necessary to prevent damage caused by electric shock or malfunction of the system during wire work. The operator must de-energize the system while connecting/disconnecting wires.

RS485 is connected with 3 wires. 485A and 485B are sometimes denoted as + and - depending on the device. Since RS485 uses a multi-drop method (a communication line connection method in which several devices are continuously connected to one line), the devices must be arranged in a line along the line. If you branch the line and extend it in multiple directions, a communication error will occur.

E5A can be connected to terminal board E6A01 (Direct connection type 8 terminals), E6B01 (Relay type 8 terminals, Max 10[A], Max 30[Vdc] or 250[Vac]), and E6E01 (Individual isolation type 8 terminals, Outer power voltage 10~30[Vdc], No polarity).

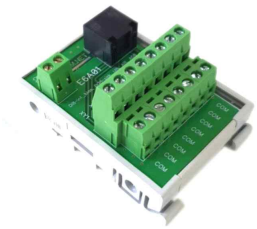


[Figure 3] Connection method and configuration

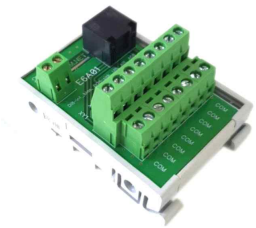
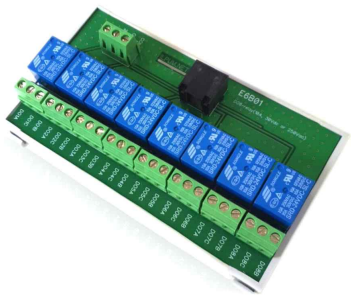
[Figure 4] Connection example

DI is paired with a normal DO to read ON/OFF state. Power to operate the line is supplied by DI, so external power should not be supplied. Since the DI terminal uses RJ45, it is connected to a general external device through a terminal board (RJ45 uses a direct cable). By separating the terminal board, the number of terminals can be increased and a terminal board suitable for the various output characteristics of the DI terminal can be selected. If you connect DI directly to the DO terminal of E4H (digital output module) or the

DO terminal of E4J (integrated input/output module), you can use it by connecting only with an RJ45 direct cable without a terminal board. This interface is protected by Patent No. 10-2214702. Terminal boards applicable to DI are E6A01 and E6E01.

Terminal board	E6A01	E6E01
Photograph		
Characteristics	Direct connection type 8 terminals	Individual isolation type 8 terminals, Outer power voltage 10~30[Vdc], No polarity

DO outputs ON/OFF. When DO1 is OFF, the circuit between DO1 and GND is open, and when ON, the circuit between DO1 and GND is shorted. The maximum current is 0.5[A]. The voltage is DC only, and the maximum is 50[V]. Since the DO terminal uses RJ45, it is connected to a general external device through the terminal board. By separating the terminal board, the number of terminals can be increased and a terminal board suitable for the various output characteristics of the DO terminal can be selected. This interface is protected by Patent No. 10-2214702. If DO is directly connected to the DI terminal of E4I (digital input module) or the DI or UI terminal of E4J (integrated input/output module), it can be used by connecting only with an RJ45 direct cable without a terminal board. There are E6A01 and E6B01 terminal boards applicable to DO.

Terminal board	E6A01	E6B01
Photograph		
Characteristics	Direct connection type 8 terminals	Relay type 8 terminals, Max 10[A], Max 30[Vdc] or 250[Vac]

The status LED of E5A consists of 2 group LEDs and 8 terminal LEDs, and displays the status of terminals grouped by RJ45 modular jack unit. The 8 terminal LEDs from +0 to +7 indicate the terminal status of the lit group among the 2 LEDs indicating the group. That is, when the DI1 LED is on, the +0~+7 LEDs indicate the status of the DI1~DI8 terminals, and when the DO1 LED is on, the +0~+7 LEDs indicate the DO1~DO8 terminal status. The group LED lights up in sequence for 2 seconds to indicate the status of the terminals (8) belonging to the unit of the RJ45 modular jack for 2 seconds each, showing the status of all 16 terminals in turn for 4 seconds.

Terminal LED / Group LED	+0	+1	+2	+3	+4	+5	+6	+7
DI1	DI1	DI2	DI3	DI4	DI5	DI6	DI7	DI8
DO1	DO1	DO2	DO3	DO4	DO5	DO6	DO7	DO8

3.2. Reset settings

E5A needs to know the password to change WiFi-related settings and to load DST. If the user forgets the password or sets the wrong password by mistake, press the INIT button on the E5A for 3 seconds, the E5A will clear the stored work and change the WiFi settings and password to default values. The following is the default setting for E5A.

Mode of WiFi	AP
AP SSID	E5A-XXXXXX (X is different for each E5A)
AP Password	ilpum.net
Domain Name, IP Address (Address to access E5A from web browser of PC)	e5a.net, 10.123.45.1
User Name (Login Name)	Admin
User Password (Login Password)	ilpum.net
Registered Network Information	-
Stored Work (DST)	-

3.3. E5aLoader connection

In order to run E5aLoader on a PC and do a new job, the PC must be able to connect to E5A via Ethernet. If the E5A is set to AP mode, connect the PC by designating the network to join the E5A's wireless network.

[Figure 5] shows the network connection in Windows™. Connect to E5A with SSID "E5A-AC6BCD". When connecting for the first time, you must enter a password. Enter "ilpum.net".

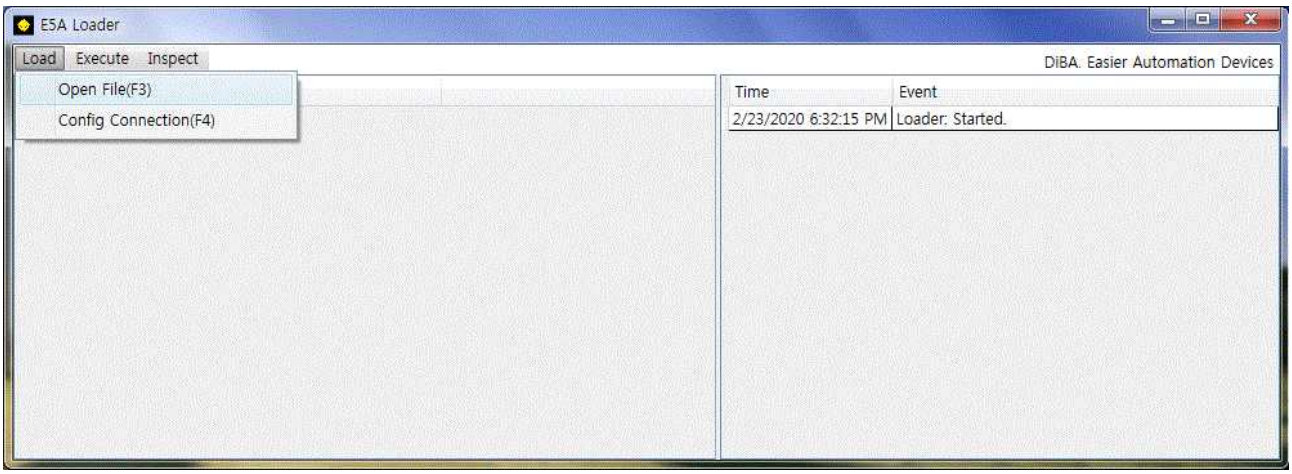
[Figure 5] Connection to E5A in AP mode

```
CONFIGURATION nameOfConf
  TYPE T_UDF: (* User-defined variable type declaration *)
    STRUCT (* Struct type declaration *)
      length : BYTE;
      buffer : STRING(100);
    END_STRUCT
  END_TYPE
  VAR_GLOBAL
    gUsrSend : T_UDF;
    gCount : SINT;
  END_VAR

  RESOURCE extLine1 ON SER_1 (* SER_1 is interface name of RS485 *)
    VAR_GLOBAL
      gConf : CONF_SER1;
      gCommUsr : COMM_SERUSR;
    END_VAR
    (* Executed only once for the first time during bootup. Priority 1 is the highest. *)
    TASK taskInit (SINGLE := TRUE, PRIORITY := 1);
    (* Run every 1 second *)
    TASK taskSync (INTERVAL := t#1s, PRIORITY := 2);
    PROGRAM pgm1Init WITH taskInit : Prog1Init();
    PROGRAM WITH taskSync : Prog1Sync();
  END_RESOURCE
END_CONFIGURATION

PROGRAM Prog1Init
  (* Communication settings: SET, user defined mode, 9600/N/8/1 *)
  extLine1.gConf.DATABITS := 8;
  extLine1.gConf.STOPBIT := 1;
  extLine1.gConf(GET_SET := 1, MODE := 3, RATE := 9600, PARITY := 0);
  extLine1.gCommUsr.EC := 0; (* Initialize communication result *)

  (* Task initialization *)
  gCount := 0; (* 0:IP, 1:SSID, 2:mode, 3:domain_name *)
END_PROGRAM

PROGRAM Prog1Sync
  (* Outputs network information as ser1/user-defined one by one every second. *)
  (* Wait for the communication request to finish processing *)
  IF extLine1.gCommUsr.EC = 1 THEN
    RETURN;
```

```
  END_IF;

  CASE gCount OF
    0: gUsrSend.buffer := CONCAT(SEE_NW_IP(), ', ');
    1: gUsrSend.buffer := CONCAT(SEE_NW_SSID(), ', ');
    2: gUsrSend.buffer := CONCAT(SEE_NW_MODE(), ', ');
    3: gUsrSend.buffer := CONCAT(SEE_NW_DOMAIN(), '$l$r');
  ELSE gUsrSend.buffer := 'Undefined$l$r';
  END_CASE;

  (* Use counters for periodic tasks *)
  gCount := gCount + 1;

  (* Cycle every 4 *)
  IF gCount >= 4 THEN
    gCount := 0;
  END_IF;

  (* Communication request: SEND *)
  extLine1.gCommUsr.SEND_LEN := LEN(gUsrSend.buffer);
  extLine1.gCommUsr(RECV_SEND := 1, SEND_ADDR := ADDROF(gUsrSend));
END_PROGRAM
```

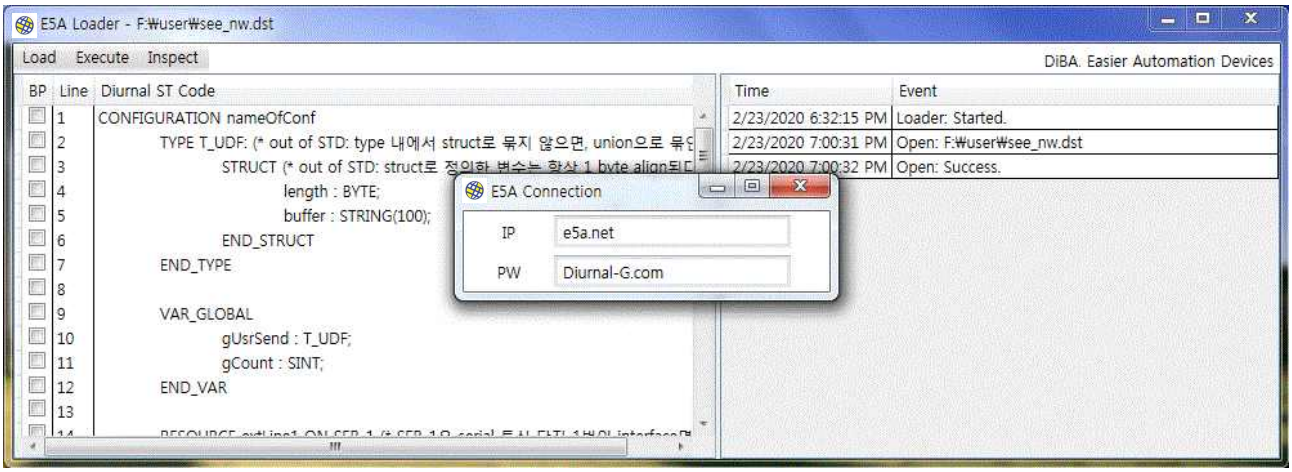
[DST 1] see_nw.dst

[DST 1] is the task of outputting the IP address, SSID, mode, and domain name currently used by E5A sequentially through RS485 interface. Copy this content as it is, paste it into a regular text editor, name it and save it with the extension “dst”. (For convenience, it is called “see_nw.dst”.)



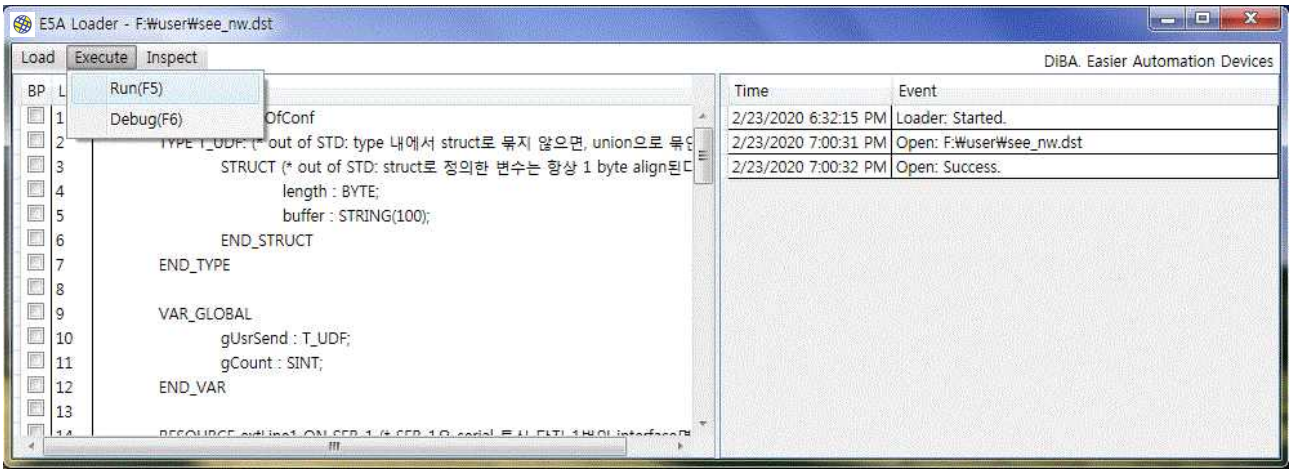
[Figure 6] Load menu of E5aLoader

Execute E5aLoader referring to [Figure 6], and open the “see_nw.dst” file with “Open File(F3)”.



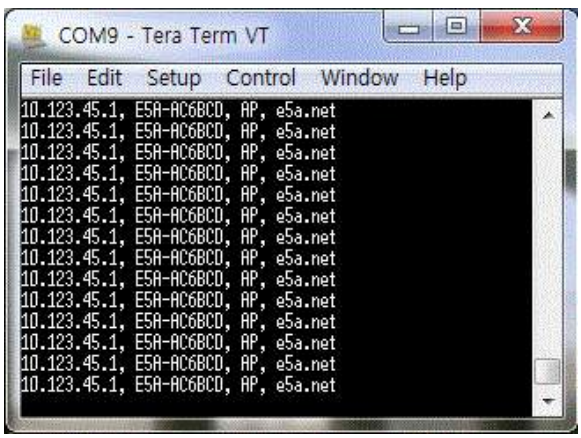
[Figure 7] Enter the connection information of E5A

When E5A is in AP mode, you can connect with the domain name "e5a.net". Make all necessary corrections and press Enter. (If you press "Enter" key in PW, the change is saved and the dialog window is closed.)



[Figure 8] Saving and executing tasks

Press "Run(F5)" to save the task to E5A and run it.

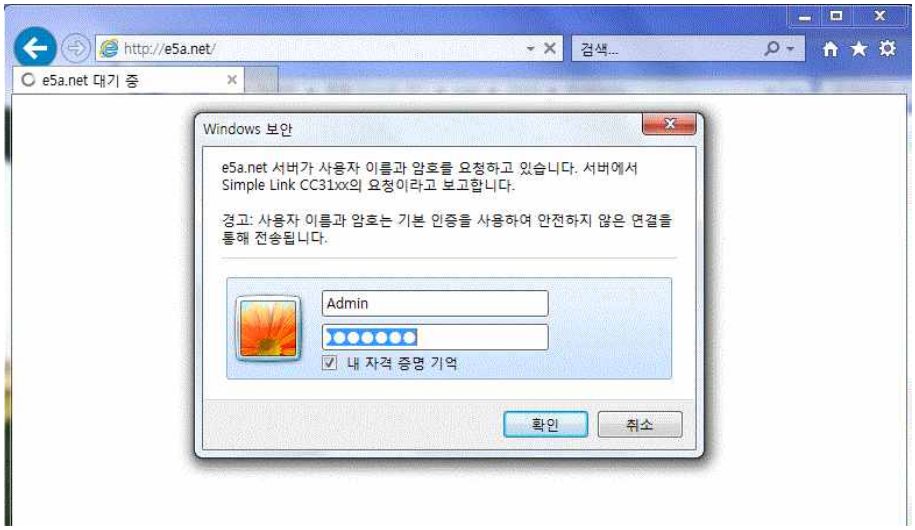


[Figure 9] RS485 output contents

Connect RS485 terminal of E5A and RS485 interface of PC and execute Tera Term™. There are very few PCs equipped with RS485 interface as standard. RS485 interface module must be purchased separately. Tera Term™ is a free terminal program created by the Open Source Project. You can download and use it for Windows™. You need to select "Serial port..." in "Setup" of Tera Term™ to set the communication settings. In [Figure 9], Port: COM9, Baud rate: 9600, Data: 8 bit, Parity: none, Stop: 1 bit, Flow control: none, Transmit delay: 0 & 0 are set.

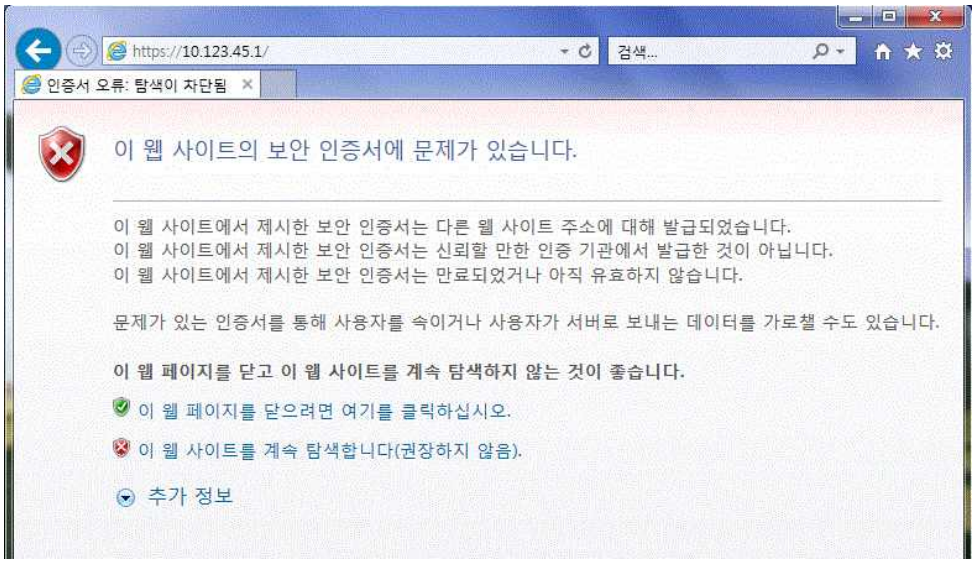
3.4. Change WiFi settings

E5A can be linked with other devices by participating in an existing network. To do this, change the WiFi mode to station.



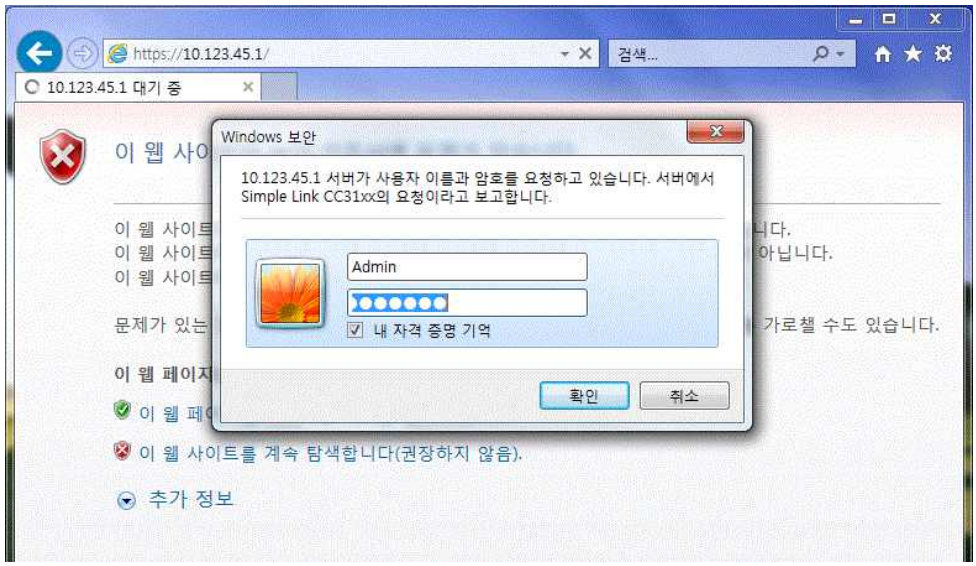
[Figure 10] Connect to E5A with Web Browser

Enter the domain name as “e5a.net” in the address bar. It will ask for your username and password. Enter “Admin” and “ilpum.net” respectively.



[Figure 11] Certificate problem notification

The web browser informs you that there is a problem with the certificate. The certificate used by E5A is a normal result because it is not certified by a certification authority. This private certificate is essential to keep E5A's network secure. Ignore the report and proceed. Tap “Continue browsing this website (not recommended).” The window and content to report the certificate error may differ depending on the web browser.

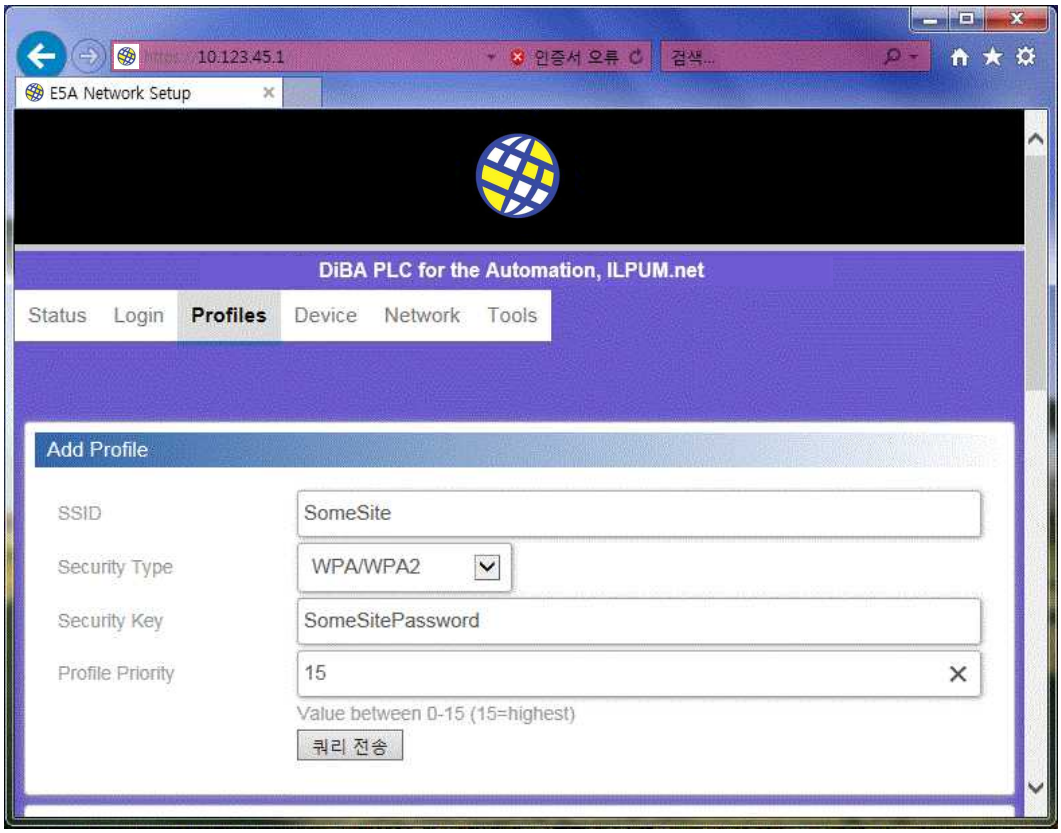


[Figure 12] Ignore the certificate problem and proceed

You will be asked for your username and password again. Enter the same as before.

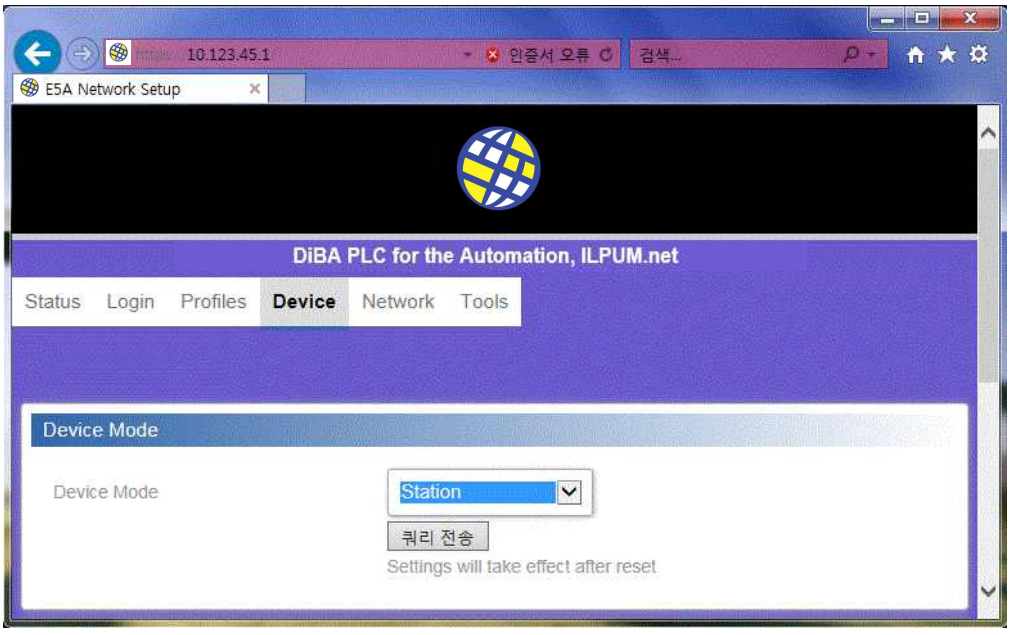
[Figure 13] First screen of E5A network setting

You are on the first screen. You can see it is set to AP mode.



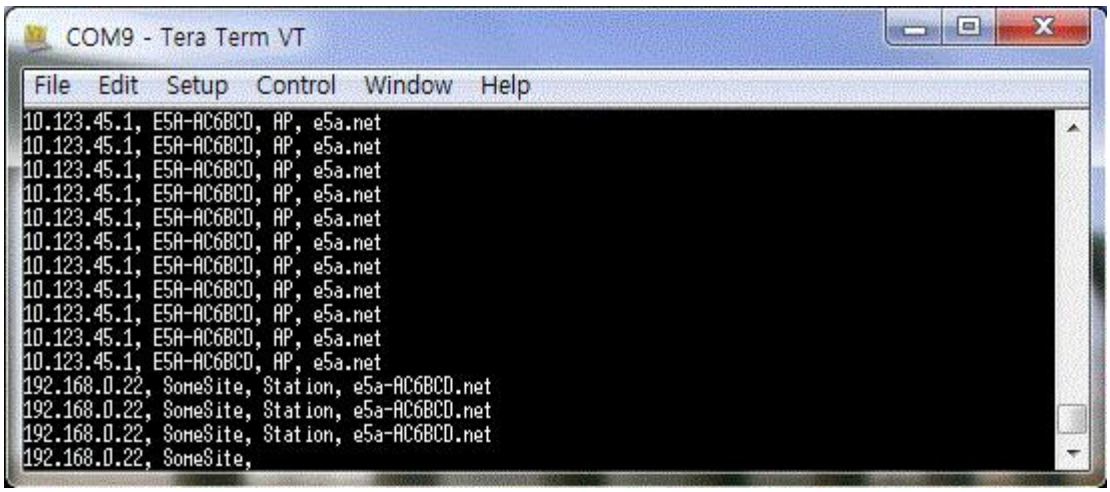
[Figure 14] Profiles setting

Select the Profiles tab. Enter the previously established network information. [Figure 14] shows the information connected to the AP called “SomeSite”. In SSID, Security Type, and Security Key, enter the connected AP information, and in Profile Priority, enter the connection priority among the registered profiles. E5A tries to connect sequentially according to priority. After entering all the values, press the button. (The button says “Submit Query”. This is the case when using Internet Explorer, and “Add” in Chrome.)



[Figure 15] Device setting

Select the Device tab. Select Device Mode as Station, and press the button. After powering it off and on again after a while, the E5A connects to SomeSite. (Turn off the E5A and wait until all the accumulated current is exhausted. Wait about 1 second.)



[Figure 16] RS485 output after changing to Station

E5A is connected to the “SomeSite” network. Now you can easily access the E5A from any PC in the “SomeSite” network to change tasks, monitor state and take control.

4. User monitoring and control

Most PLC CPUs, including the E5A, come with a HMI (Human Machine Interface) separated from the device. SCADA is usually installed to view the current state of the system, intervene in the control process, and record important control actions or changes in state whenever the user wants to.

SCADA can be built in many different forms. The most common form is a PC application. SCADA software is installed on a PC. It runs and connects to the PLC CPU (E5A, etc.) through the communication interface, and performs system control, monitoring and logging.

E5A provides two paths for SCADA: RS485 and WiFi. Users can use both paths at the same time, but it is recommended to choose only one, as the controls may overlap and cause different behavior than expected. If RS485 interface is selected, other devices connected to RS485 must also be directly controlled and monitored by SCADA. In this case, SCADA takes the role of MODBUS RTU master on RS485 line, and all other devices on RS485 line become MODBUS RTU slaves. If you select the WiFi server interface, SCADA acts as a MODBUS TCP client. In this case, E5A can also act as MODBUS RTU master for other devices on RS485 line.

4.1. A simple way to monitor

Design a task that maintains a temperature between 0 and 10 degrees using a heater and a cooler. There is no need to prepare an actual cooler and heater, and you can experiment with only a variable resistor that can adjust the range of 960 to 1070[Ω]. It is assumed that a heater is connected to DO1 and a cooler is connected to DO2. When E5A controls DO1 and turns it ON, DO1 LED turns ON, so it is judged that the heater is ON.

```
CONFIGURATION nameOfConf
  TYPE T_UDF:
    STRUCT
      length : BYTE;
      buffer : STRING;
    END_STRUCT
  END_TYPE

  VAR_GLOBAL
    gUsrSend0, gUsrSend1 : T_UDF;
    gTemp1 AT %IW16 : INT;
    gTemp2 AT %IW17 : INT;
    gTemp3 AT %IW18 : INT;
    gTemp4 AT %IW19 : INT;
    gOhm1 AT %IW32 : WORD;
    gOhm2 AT %IW33 : WORD;
    gOhm3 AT %IW34 : WORD;
    gOhm4 AT %IW35 : WORD;
```

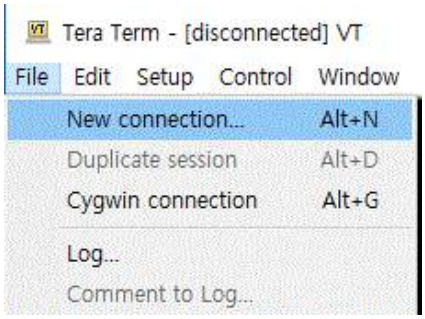
```
    gDscGet AT %IW47 : WORD;
    gDsc1 AT %IW48 : WORD;
    gDsc2 AT %IW49 : WORD;
    gDsc3 AT %IW50 : WORD;
    gDsc4 AT %IW51 : WORD;
    gDscSet AT %QW47 : WORD;
  END_VAR

  RESOURCE extLine1 ON ETH_1
    VAR_GLOBAL
      gConf : CONF_ETH1;
      gCommUsr : COMM_ETHUSR;
    END_VAR

    TASK taskInit (SINGLE := TRUE, PRIORITY := 1);
    TASK taskSync (INTERVAL := t#3s, PRIORITY := 2);

    PROGRAM pgm1Init WITH taskInit : Prog1Init();
    PROGRAM WITH taskSync : Prog1Sync();
  END_RESOURCE
END_CONFIGURATION

PROGRAM Prog1Init
  (* Communication settings: SET, user defined server mode, IPv4/23 *)
  extLine1.gConf(GET_SET := 1, MODE := 2, IPV4_6 := 0, PORT := 23);
  extLine1.gCommUsr.EC := 0; (* Initialize communication result *)
END_PROGRAM

PROGRAM Prog1Sync
  VAR
    vIdx, vDsc : INT := 0;
    vTemp, vOhm : REAL;
    vStr : STRING;
  END_VAR

  (* Wait for the communication request to finish processing *)
  IF extLine1.gCommUsr.EC = 1 THEN RETURN; END_IF;

  (* Temperature check *)
  IF %IX0 THEN
    vIdx := 1;
    vTemp := gTemp1 / 10;
```

```
    vDsc := gDsc1;
    vOhm := gOhm1 / 10;
  ELSIF %IX1 THEN
    vIdx := 2;
    vTemp := gTemp2 / 10;
    vDsc := gDsc2;
    vOhm := gOhm2 / 10;
  ELSIF %IX2 THEN
    vIdx := 3;
    vTemp := gTemp3 / 10;
    vDsc := gDsc3;
    vOhm := gOhm3 / 10;
   ELSIF %IX3 THEN
    vIdx := 4;
    vTemp := gTemp4 / 10;
    vDsc := gDsc4;
    vOhm := gOhm4 / 10;
  END_IF;

  (* Heater/cooler control *)
  IF vIdx <> 0 THEN
    vStr := CONCAT('Temp', STR_FROM_INT(vIdx), ' = ', STR_FROM_REAL(vTemp), '
[degC], Heater = ');
    IF vTemp < 0 THEN
      %QX0 := 1;
      vStr := CONCAT(vStr, 'ON');
    ELSE
      %QX0 := 0;
      vStr := CONCAT(vStr, 'OFF');
    END_IF;
    vStr := CONCAT(vStr, ', Cooler = ');
    IF vTemp > 10 THEN
      %QX1 := 1;
      vStr := CONCAT(vStr, 'ON');
    ELSE
      %QX1 := 0;
      vStr := CONCAT(vStr, 'OFF');
    END_IF;
    vStr := CONCAT(vStr, '$l$r');
  ELSE
    %QX0 := 0;
    %QX1 := 0;
```

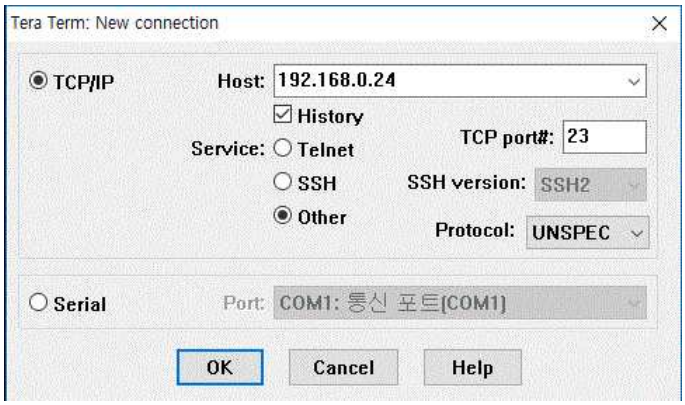
```
    vStr := 'Heater = OFF, Cooler = OFF$l$r';
  END_IF;

  (* Communication request: SEND *)
  gUsrSend0.buffer := vStr;
  extLine1.gCommUsr(RECV_SEND := 1, SEND_ADDR := ADDROF(gUsrSend0), SEND_LEN
:= LEN(gUsrSend0.buffer));
  IF vIdx = 0 THEN RETURN; END_IF;

  vStr := CONCAT('DSC=', STR_FROM_INT(vDsc), ', set=', STR_FROM_INT(gDscSet), ',
now=', STR_FROM_INT(gDscGet));
  vStr := CONCAT(vStr, ', R=', STR_FROM_REAL(vOhm), ' [Ohm]$l$r');
  gUsrSend1.buffer := vStr;
  extLine1.gCommUsr(RECV_SEND := 1, SEND_ADDR := ADDROF(gUsrSend1), SEND_LEN
:= LEN(gUsrSend1.buffer));
END_PROGRAM
```

[DST 2] text_scada0.dst

Execute the above task and connect to E5A using Tera Term™. You need to know E5A's IP in advance.



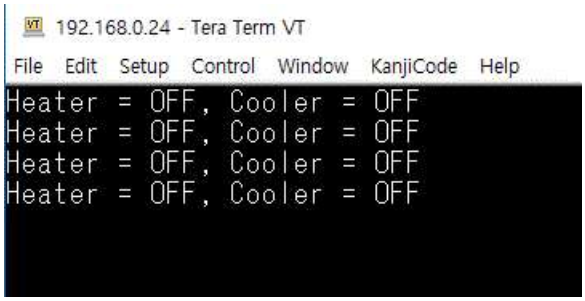
[Figure 17] Opening a new connection



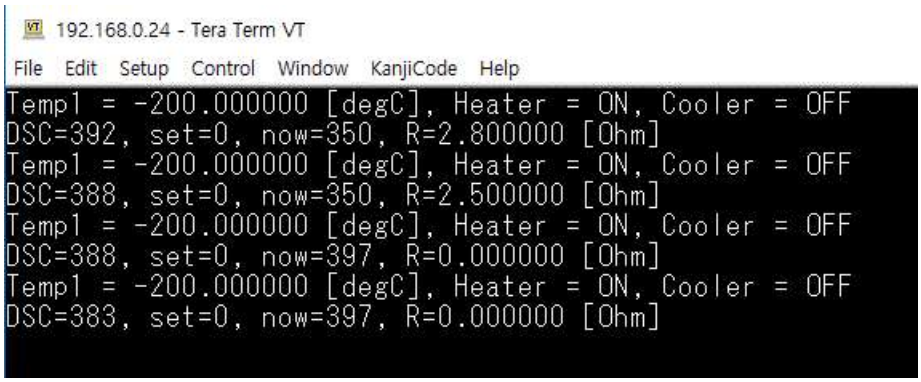
[Figure 18] Connection settings

Enter 23 for port as set in the task. If Tera Term™ is connected successfully, you can see the output according to the resistance value connected to the UI terminal.

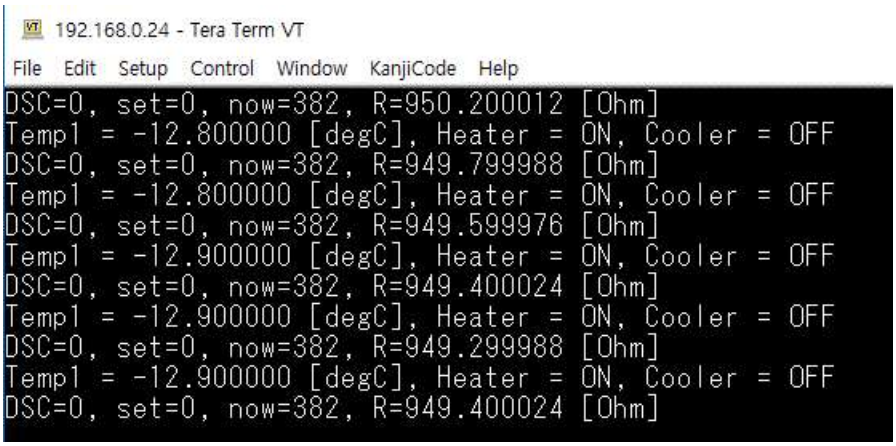
The example shown below is the output for each of no-load (when no resistance is connected), short circuit (when directly connected with a line, resistance value is 0), low temperature (less than 0℃, resistance value less than 1000Ω, heater ON condition), constant temperature (between 0~10℃, resistance value between 1000~1039Ω, heater and cooler OFF condition), and high temperature (over 10℃, resistance value exceeding 1039Ω, cooler ON condition).



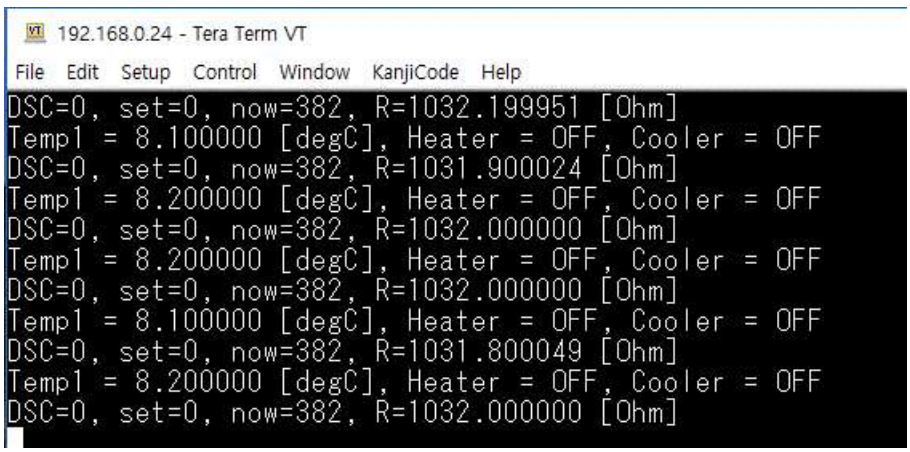
[Figure 19] No-load



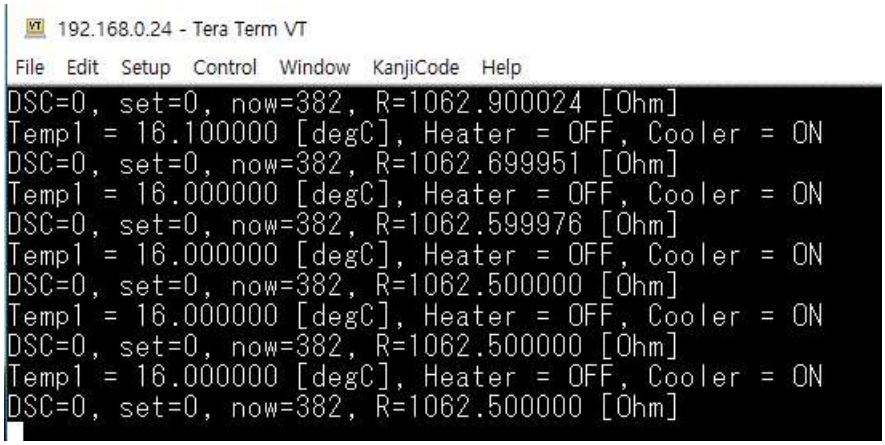
[Figure 20] Short circuit



[Figure 21] Low temperature



[Figure 22] Constant temperature



[Figure 23] High temperature

4.2. A simple way to control and monitor

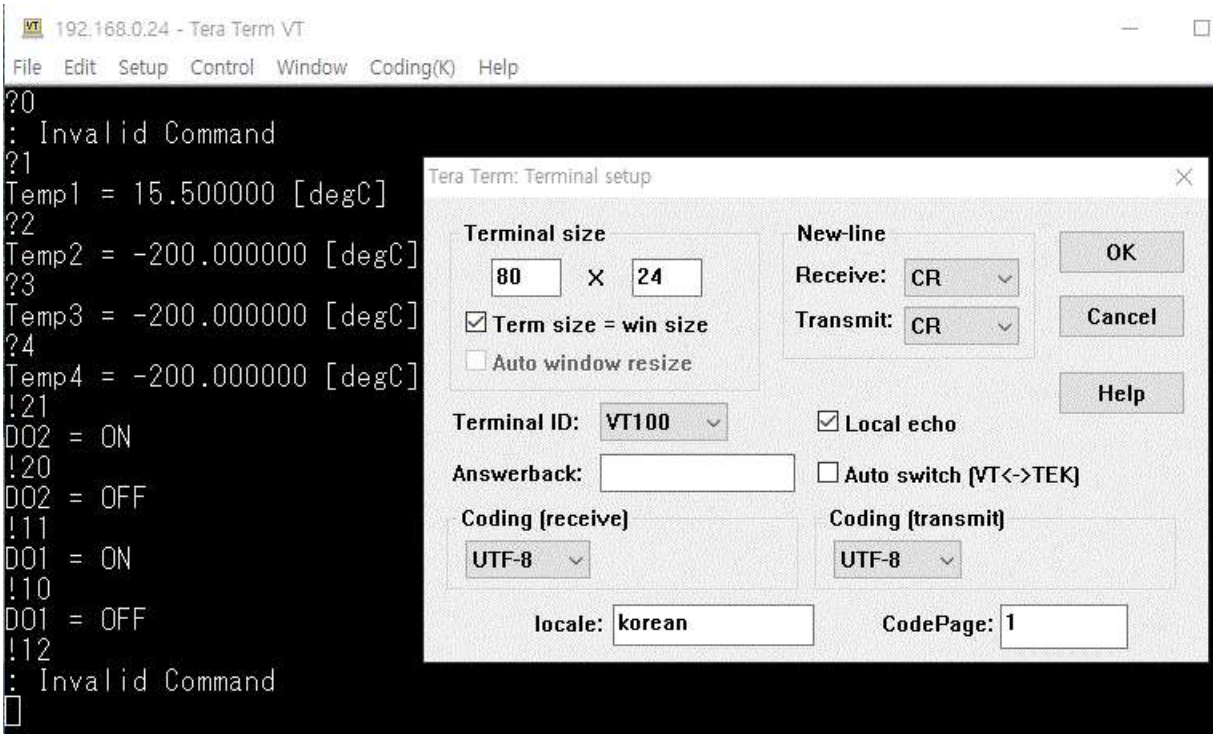
```
CONFIGURATION nameOfConf
  TYPE T_UDF:
    STRUCT
      length : BYTE;
      buffer : STRING;
    END_STRUCT
  END_TYPE

  VAR_GLOBAL
    gUsrSend, gUsrRecv : T_UDF;
    gTemp1 AT %IW16 : INT;
    gTemp2 AT %IW17 : INT;
    gTemp3 AT %IW18 : INT;
    gTemp4 AT %IW19 : INT;
  END_VAR

  RESOURCE extLine1 ON ETH_1
    VAR_GLOBAL
      gConf : CONF_ETH1;
      gCommUsr : COMM_ETHUSR;
    END_VAR

    TASK taskInit (SINGLE := TRUE, PRIORITY := 1);
    TASK taskSync (INTERVAL := t#1s, PRIORITY := 2);

    PROGRAM pgm1Init WITH taskInit : Prog1Init();
    PROGRAM WITH taskSync : Prog1Sync();
  END_RESOURCE
```

```
END_CONFIGURATION

PROGRAM Prog1Init
  (* Communication settings: SET, user defined server mode, IPv4/23 *)
  extLine1.gConf(GET_SET := 1, MODE := 2, IPV4_6 := 0, PORT := 23);
  extLine1.gCommUsr.RECV_ADDR := ADDROF(gUsrRecv);
  extLine1.gCommUsr.RECV_LEN := SIZEOF(gUsrRecv.buffer) / 8;
  extLine1.gCommUsr(RECV_SEND := 0);
END_PROGRAM

PROGRAM Prog1Sync
  VAR
    vLen, vPosL, vPosR : INT;
    vTemp : REAL;
    vStr0, vStr1 : STRING;
  END_VAR

  (* Command confirmation *)
  vLen := gUsrRecv.length;
  IF vLen < 3 THEN RETURN; END_IF;
  vStr0 := gUsrRecv.buffer;
  vPosL := FIND(vStr0, '$l');
  vPosR := FIND(vStr0, '$r');
  IF vLen < 10 THEN
    IF (vPosL < 0) & (vPosR < 0) THEN RETURN; END_IF;
  END_IF;

  vStr1 := vStr0;
  vStr0 := LEFT(vStr0, 1);
  vStr1 := DELETE(vStr1, 0, 1);
  vPosL := STR_TO_INT(vStr1);
  IF vStr0 = '?' THEN
    CASE vPosL OF
      1: (* Status output of UI1 *)
        vStr1 := CONCAT('Temp1 = ', STR_FROM_REAL(gTemp1 / 10), ' [degC]');
      2: (* Status output of UI2 *)
        vStr1 := CONCAT('Temp2 = ', STR_FROM_REAL(gTemp2 / 10), ' [degC]');
      3: (* Status output of UI3 *)
        vStr1 := CONCAT('Temp3 = ', STR_FROM_REAL(gTemp3 / 10), ' [degC]');
      4: (* Status output of UI4 *)
        vStr1 := CONCAT('Temp4 = ', STR_FROM_REAL(gTemp4 / 10), ' [degC]');
      ELSE
```

```
            vStr1 := ': Invalid Command';
        END_CASE;
    ELSIF vStr0 = '!' THEN
        CASE vPosL OF
            10: (* DO1 OFF *)
                %QX0 := 0;
                vStr1 := 'DO1 = OFF';
            11: (* DO1 ON *)
                %QX0 := 1;
                vStr1 := 'DO1 = ON';
            20: (* DO2 OFF *)
                %QX1 := 0;
                vStr1 := 'DO2 = OFF';
            21: (* DO2 ON *)
                %QX1 := 1;
                vStr1 := 'DO2 = ON';
            ELSE
                vStr1 := ': Invalid Command';
        END_CASE;
    ELSE
        vStr1 := ': Invalid Command';
    END_IF;

    (* Communication request: SEND & RECV *)
    gUsrSend.buffer := CONCAT('$l$r', vStr1, '$l$r');
    extLine1.gCommUsr.SEND_ADDR := ADDROF(gUsrSend);
    extLine1.gCommUsr.SEND_LEN := LEN(gUsrSend.buffer);
    extLine1.gCommUsr(RECV_SEND := 2);
END_PROGRAM
```

[DST 3] text_scada1.dst

Connect to E5A with Tera Term™ and enter commands. As shown in [Figure 24], you need to turn ON Local echo in Terminal setup to see the commands you enter on the screen.



[Figure 24] text_scada1 connection screen and terminal setup

5. Specification

5.1. Power

The power circuit of the E5A is designed based on the use of SMPS. It is recommended to use output 24[Vdc], 20[W].

(1) Threshold

The power supply voltage must be less than 30[Vdc].

(2) Rating

The power supply voltage operates normally from 20 to 27[Vdc].

The instantaneous maximum current is 0.3[A]. On average, the maximum is 0.2[A].

(3) Isolation

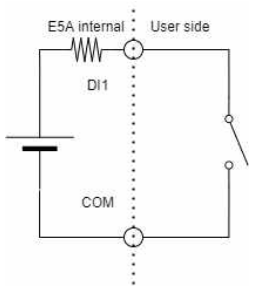
Isolated group 1	Power, DI, DO
Isolated group 2	RS485

Isolation refers to the electrical separation between circuit elements. Since the devices in the system are connected by wires, which are conductors, when lightning or a power shock wave is transmitted to the wire, the isolated group connected to the wire (a group of circuits that can directly transmit and receive current through the circuit) is affected until the shock wave is exhausted. Usually, the part of the circuit that is closest to the shock wave and has the lowest resistance is destroyed first. Therefore, when designing an automatic control system, if the appropriate isolated group is not considered, the shock wave may also be transmitted to the user. E5A has two isolated groups inside for the safety of users and systems.

5.2. I/O and communication

5.2.1. DI

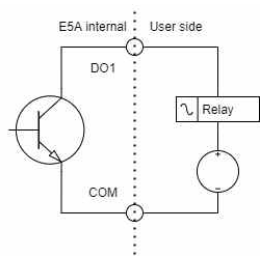
E5A has 8 DIs. [Figure 25] is an easy-to-understand representation of the internal circuit of DI1. The rest of the DIs have the same shape. DI provides power to measure the state of the external DO. [Figure 25] is an example of connecting a switch as an external DO. The current state of [Figure 25] is that the switch is off (open), and DI1 is recognized as OFF. When the circuit is connected (shorted) by pressing the switch, DI1 is recognized as ON.



[Figure 25] DI internal circuit model and usage example

5.2.2. DO

E5A has 8 DOs. [Figure 26] is an easy-to-understand representation of DO1's internal circuit. The rest of the DOs have the same shape. In [Figure 26], DO1 and COM terminals are open (disconnected) or shorted (connected) according to the set value. When the power of E5A is initially supplied, the state of DO is OFF, and DO1 and COM terminals are open (power-on default).



[Figure 26] DO internal circuit model and usage example

5.2.3. RS485

RS485 of E5A can connect up to 64 nodes. Baudrate can be set from 300 to 3,000,000[bps].

Users can operate the E5A by selecting one of the following settings or none.

(1) MODBUS RTU master/slave connection

If E5A is set as MODBUS RTU master, you can read or write the values of other E5A or devices operating MODBUS RTU slave.

When E5A is set as MODBUS RTU slave, SCADA used as master or other E5A can read or write values in its internal memory. At this time, to limit the external control range, E5A has a write-protect function for the internal memory. Users can control the write-protect area with the contents of task.

(2) User-defined protocol serial connection

The user-defined protocol serial used in [DST 2] for the introduction of E5A. At this time, it was Tera Term™ that played the role of the counterpart user-defined protocol serial.

5.2.4. WiFi

E5A's WiFi can be operated as an 802.11b/g/n standard station and can also be operated as an 802.11b/g standard AP (Access Point). The initial state of E5A is to operate in AP mode. The initial SSID is in the form of E5A-XXXXXX, where the X is configured based on the MAC address of E5A. The initial password is “ilpum.net” and the login ID is “Admin”. SSL (Secure Socket Layer) is used to prevent unauthorized access. Because the security certificate used for this purpose is a self-made certificate that is not registered with a certification authority, a certificate error occurs in general web browsers. The use of a private certificate was chosen because of the specificity of E5A, so the user should ignore the certificate error of the web browser and use it.

(Note 1) E5A can be used in IPv4 or IPv6 environment. (However, most of the tests were conducted only on IPv4.)

(Note 2) The reset button (INIT) exists to restore the security settings set by the user in the past when they are forgotten. If the user presses the reset button for more than 3 seconds, the E5A restarts with all settings changed to the initial state.

(Warning 1) Web browser and E5aLoader cannot be connected to the same E5A at the same time. Even two or more web browsers cannot be connected to the same E5A at the same time. The E5A may malfunction.

(Warning 2) E5A can operate only one server. Users must operate either MODBUS TCP server or user-defined TCP server. This property applies equally to the client.

(1) Web browser connection (network setting)

In case of operating as an AP, E5A operates DNS and users can get E5A's IP with “e5a.net”. Security-related information can be changed by accessing E5A with a web browser. (Login ID cannot be changed.)

You can register/delete information about the AP to be connected to operate as a station by accessing the web browser. The operation mode can be selected as AP or Station, and these setting changes are reflected in actual operation through the process of turning the E5A power off and on again.

(2) E5aLoader connection

The E5aLoader, which runs on your PC, is used to test/save new tasks to E5A. E5A and E5aLoader are connected via E5A WiFi. Since E5aLoader requests a connection to E5A, you need to check E5A's operating mode (AP or Station), IP (or hostname), password, etc. before connecting.

(3) MODBUS TCP server/client connection

If E5A is set as MODBUS TCP server, SCADA or other E5A can connect as a client and read or write values in E5A's internal memory. However, the maximum number of devices that can be connected as a client is one. When a new device is connected, the old one is disconnected.

If E5A is set as MODBUS TCP client, E5A can read or write values by connecting to other E5A or devices operating MODBUS TCP server. The maximum number of servers that E5A can connect to is one. To connect to another server, you must disconnect the existing connection and reconnect.

Security protocols do not apply to MODBUS TCP server/client connections. In other words, the transmitted content is not encrypted and there is no process of checking access rights such as password. For security purposes, the E5A has write protection for the internal memory and can control the write protection area based on the work saved by the user.

(4) User-defined protocol TCP server/client connection

For the introduction of E5A, the user-defined protocol TCP server was used in [DST 3]. It was TeraTerm™ that served as the user-defined protocol TCP client. Similarly, E5A can also be set up as a user-defined protocol TCP client. Whether E5A is a server or a client, the maximum number of connections is 1.

5.3. Memory

The E5A has 3 memory areas. These are the input memory area to which the input terminals (UI) are mapped, the output memory area to which the output terminals (AO, DO) are mapped, and the internal memory area where general variables exist. The input memory area is mapped to the input status and input register area of MODBUS, the output memory area is mapped to the coil status and holding register area of the MODBUS, and the internal memory area is mapped to the general register area of the MODBUS.

Within the memory area, addresses start from 0, and the actual location is determined by the size of the variable. If the variable type is BOOL, the size is 1 bit, so the interval between consecutive variables is 1 bit. If the variable type is DWORD, the size of the variable is 32 bits (or 4 bytes), so the interval between consecutive variables is 4 bytes.

There are 13 basic variable types supported by E5A.

Variable type	Byte size	Bit size	Minimum	Maximum
BOOL	-	1	0	1
BYTE USINT	1	8	0	255
SINT	1	8	-128	127
WORD UINT	2	16	0	65,535
INT	2	16	-32,768	32,767

Variable type	Byte size	Bit size	Minimum	Maximum
DWORD UDINT	4	32	0	4,294,967,295
DINT	4	32	-2,147,483,648	2,147,483,647
REAL	4	32	-3.4e38	3.4e38
TIME	8	64	-	-
TOD	8	64	tod#0:0:0.0	tod#23:59:59.999
DATE	8	64	d#1900-1-1	-
DT	8	64	dt#1900-1-1-0:0:0.0	-
STRING	64(can be specified)	-	-	-

Address expression is written like %IX0, where % is an address indicator and I is an input memory area. The output memory area uses Q, and the internal memory area uses M. X stands for BOOL as a variable type. Other variable type indicators available for address expression are B(BYTE, size of 1 byte), W(WORD, size of 2 byte), D(DWORD, size of 4 byte), and L(LWORD, size of 8 byte).

For better understanding, we show an example of applying each address representation to one address.

Address value = 64	Apply ADDROF()	Apply SIZEOF()
%MX64	64 ← ADDROF(%MX64)	1 ← SIZEOF(%MX64)
%MB8	64 ← ADDROF(%MB8)	8 ← SIZEOF(%MB8)
%MW4	64 ← ADDROF(%MW4)	16 ← SIZEOF(%MW4)
%MD2	64 ← ADDROF(%MD2)	32 ← SIZEOF(%MD2)
%ML1	64 ← ADDROF(%ML1)	64 ← SIZEOF(%ML1)

The entire internal memory area is a general area (0 ~ 8191 [byte]). Variables declared by the user in E5A are placed in internal memory if the location is not specified. Some of the functions of E5A designate memory addresses, and the address passed to the function must belong to the memory area specified by the function.

The input memory area consists of a general area (0 to 2047 [byte]), a restricted area (2048 to 8191 [byte]), and a system information area (18000 to 1999). General and restricted areas can be read and written in user's work. The System Information area can only be read from the user's actions. The restricted area is the area allocated for the write protection feature of the E5A, so if the user changes the value, the write protection feature may change for a specific address.

Address expression	Byte address	Bit address	Variable type	Input memory area description
%IX0	-	0	BOOL	DI1의 값. 0 = OFF, 1 = ON
%IX1	-	1	BOOL	DI2의 값. 0 = OFF, 1 = ON
%IX2	-	2	BOOL	DI3의 값. 0 = OFF, 1 = ON
%IX3	-	3	BOOL	DI4의 값. 0 = OFF, 1 = ON
%IX4	-	4	BOOL	DI5의 값. 0 = OFF, 1 = ON

Address expression	Byte address	Bit address	Variable type	Input memory area description
%IX5	-	5	BOOL	DI6의 값. 0 = OFF, 1 = ON
%IX6	-	6	BOOL	DI7의 값. 0 = OFF, 1 = ON
%IX7	-	7	BOOL	DI8의 값. 0 = OFF, 1 = ON
%IW9900	19800	-	UINT	Design Year
%IW9901	19802	-	UINT	Family Number
%IW9902	19804	-	UINT	Product Number
%IW9903	19806	-	UINT	Compatibility Number
%IW9910	19820	-	WORD	MAC 1, 2
%IW9911	19822	-	WORD	MAC 3, 4
%IW9912	19824	-	WORD	MAC 5, 6
%IW9990	19980	-	UINT	Version
%IW9991	19982	-	UINT	Lot

The output memory area consists of a general area (0 to 2047 [byte]), an open area (2048 to 4095 [byte]), and a restricted area (4096 to 8191 [byte]). All areas can be read and written in user's work. The open area is always writable even in the access of external users via MODBUS. Because the open area does not have write protection, it can be used to receive commands from the outside without considering control over write protection. The rstricted area is allocated for E5A's write protection, so if the user changes the value, the write protection feature may change for a specific address.

Address expression	Byte address	Bit address	Variable type	Output memory area description
%QX0	-	0	BOOL	Value of DO1. 0 = OFF, 1 = ON
%QX1	-	1	BOOL	Value of DO2. 0 = OFF, 1 = ON
%QX2	-	2	BOOL	Value of DO3. 0 = OFF, 1 = ON
%QX3	-	3	BOOL	Value of DO4. 0 = OFF, 1 = ON
%QX4	-	4	BOOL	Value of DO5. 0 = OFF, 1 = ON
%QX5	-	5	BOOL	Value of DO6. 0 = OFF, 1 = ON
%QX6	-	6	BOOL	Value of DO7. 0 = OFF, 1 = ON
%QX7	-	7	BOOL	Value of DO8. 0 = OFF, 1 = ON

5.4. processing power

The work contents are divided and executed in units of work objects. You can set the execution cycle for each work object. The minimum execution interval of a work object is 100ms. The maximum execution time of one work object is 1s. If the execution time is exceeded, an error is raised, and subsequent command lines are not executed.

The DST command line that can be registered as a job is up to about 1000 lines. However, it does not always match the number of rows entered by the user.

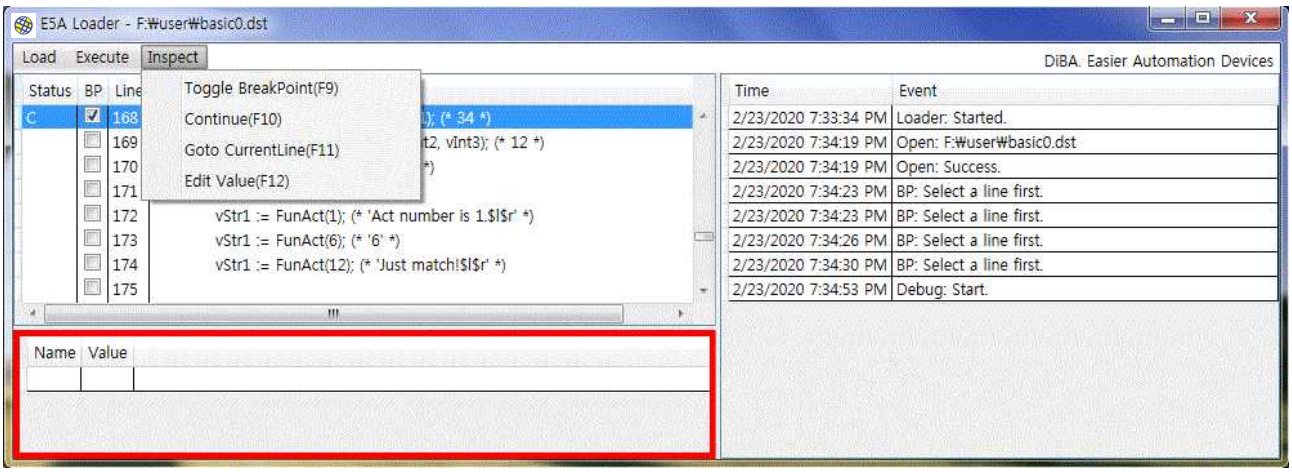
6. E5aLoader operation

The menu structure of E5aLoader is as follows. Shortcut keys are shown in parentheses.

Top menu	Sub menu	Explanation
Load	Open File(F3)	Read the DST file.
	Config Connection(F4)	Enter the E5A connection information.
Execute	Run(F5)	Save the DST file to E5A and run it.
	Debug(F6)	Test DST file at E5A.
Inspect	Toggle BreakPoint(F9)	Sets or releases the BP that stops the E5A work progress.
	Continue(F10)	Resume work stopped at BP.
	Goto CurrentLine(F11)	move the screen to the location which it stops at a BP.
	Edit Value(F12)	Change the memory value of E5A.

The Load menu and Execute menu have already been explained in 3.3., so here we will explain how to test the E5A by selecting Debug (F6).

6.1. Inspect menu



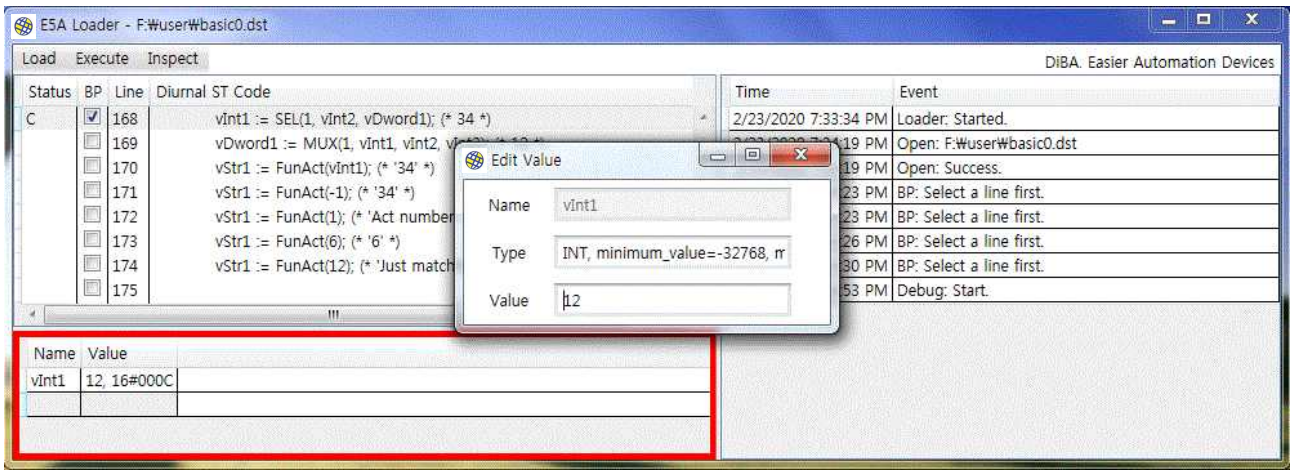
[Figure 27] Inspect menu

During the test (Debug), the Status and Value windows appear. The Status window displays the location where the operation stopped and the error information that occurred in E5A. The Value window displays the value of the user's desired location, and the border color is different when running (blue) and when stopped (red).

The user can select a line of work by using the direction key on the keyboard or mouse in the work contents window. This selection is called the cursor, and you can turn BP on or off for the position where the cursor is located. You can turn BP on/off by double-clicking the action line, selecting Toggle BreakPoint (F9) from the menu, or pressing F9 on the keyboard.

The contents of the Value window are automatically updated when the work stops at BP. The user can

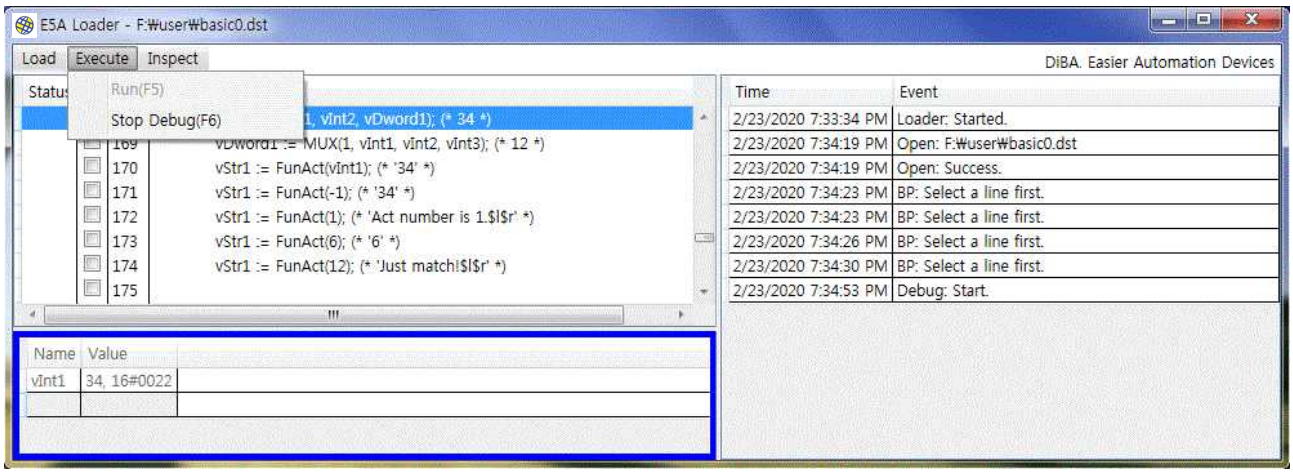
specify a new location or remove an existing location in the Value window. If you have something to display in the Value window, you can double-click it, select Edit Value (F12) from the menu, or press F12 on the keyboard to open the Edit Value window. The user can specify a new value in the Edit Value window.



[Figure 28] Edit Value

Select Continue (F10) from the menu or press F10 on the keyboard to proceed with the operation that stopped at BP again. Although the BP can be set while the E5A is running, the Value window and the Value Edit window are not available.

To stop testing for E5A, select the Stop Debug (F6) menu. [Figure 29] shows the screen when it is in the running state. The Stop Debug (F6) is still available when the E5A is stopped at the BP.



[Figure 29] Stop Debug