Chapter 17　FB-7SG 7-Segment LED Display Module
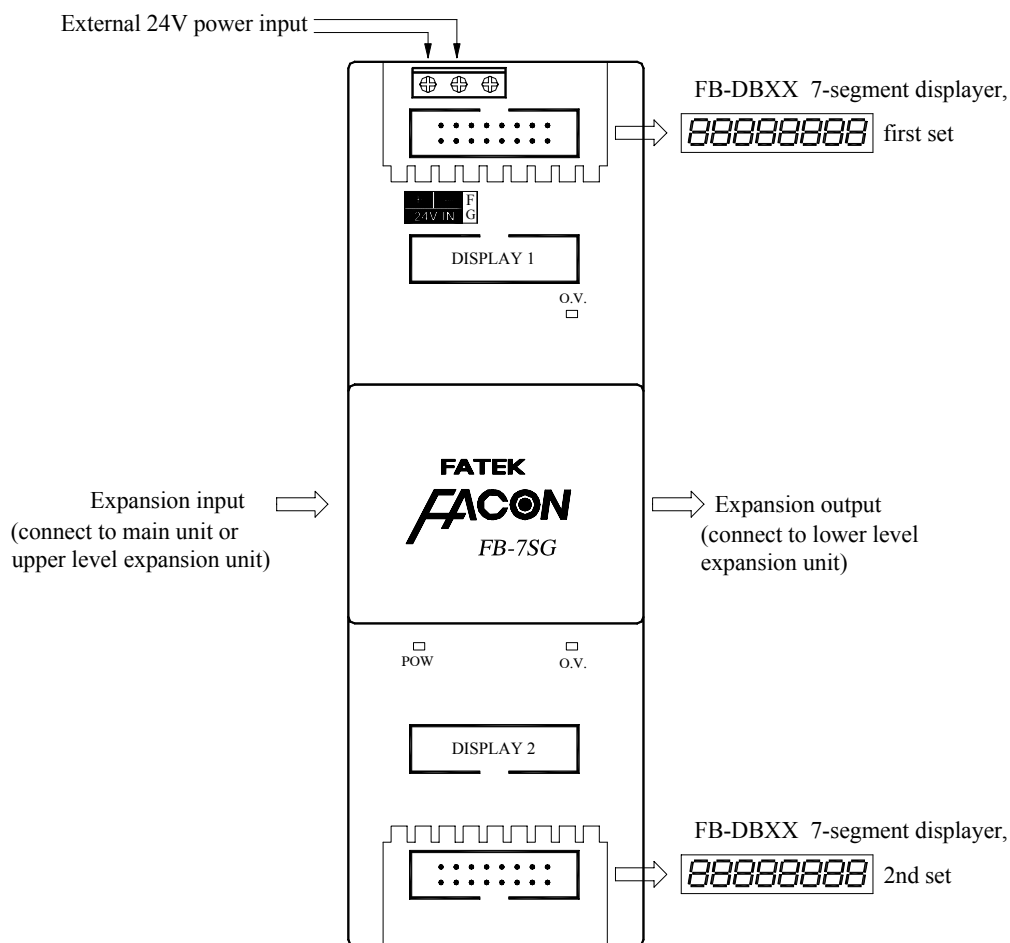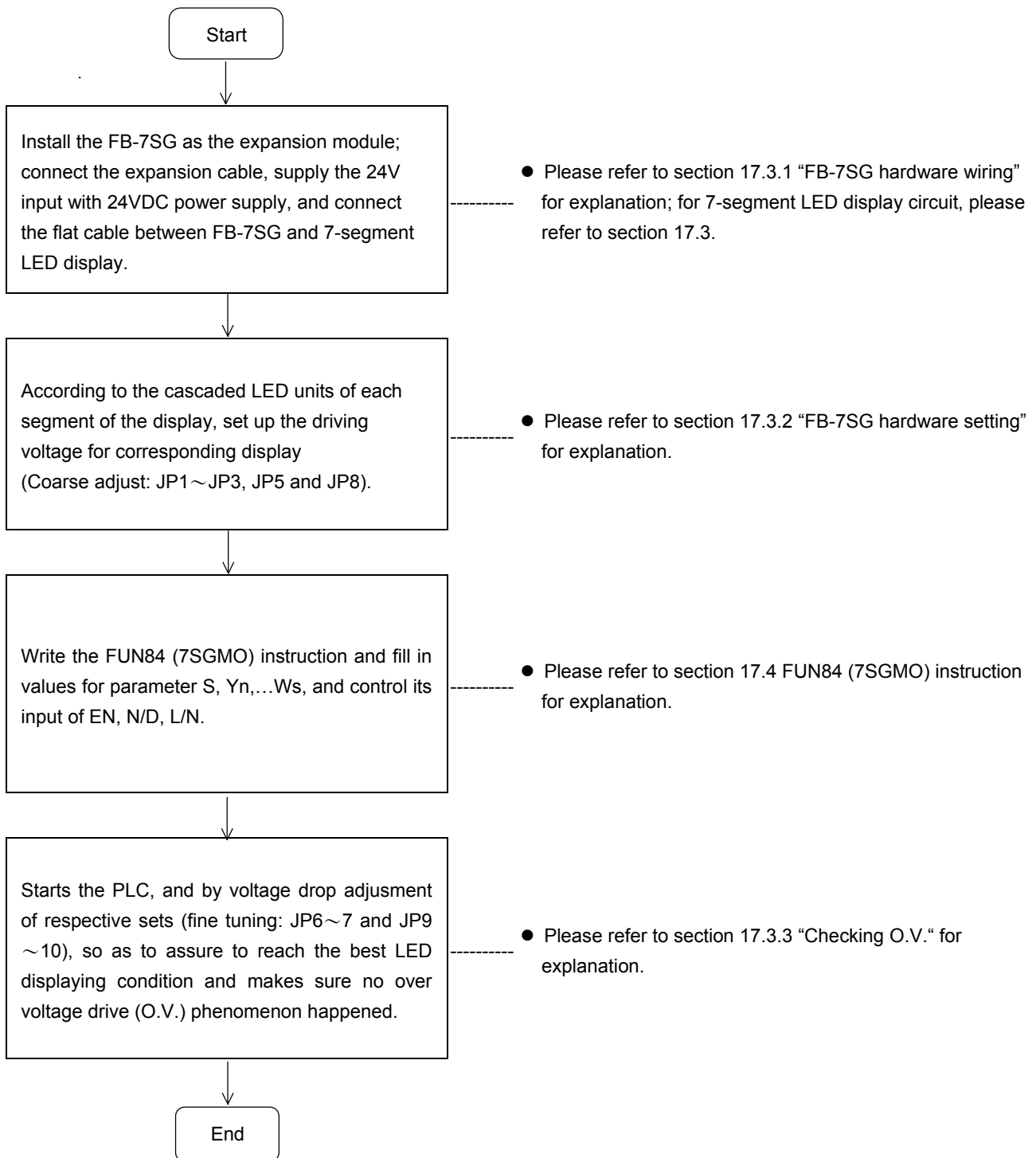
　　　　FB-7SG includes 7SG1 and 7SG2 two type of modules, they are equipped with 1 or 2 display IC(s) which can display 8 numerical characters (digits) each.　And they can drive 8 or 16 common cathode 7-segment LED display.　The following diagram illustrated the example of FB-7SG2.

Outlook View

　　The FB-7SG is equipped with dedicated 7-segment LED display IC, which performs multiplexing scan for 1～8 digits of 7-segment LED display.　The user merely needs to connect with a 16 pins flat cable, and can attain to 8 digits of numerical characters displaying or 64 points of independent LED lamp displaying (one digit of displaying can form to 8 independent display, or it can select the mixture of digits and independent points of displaying).　Every set of display occupies 16 point of expansion output points.　Since the maximum expansion output are 248 points (while connecting to CPU unit with 20 I/O points), it can control up to 15 sets of display, i.e. 120 digits or 960 independent points displaying.

17.2 Procedure for FB-7SG 7-segment LED Display Module Usage

Start

Install the FB-7SG as the expansion module; connect the expansion cable, supply the 24V input with 24VDC power supply, and connect the flat cable between FB-7SG and 7-segment LED display.

---------- ● Please refer to section 17.3.1 "FB-7SG hardware wiring" for explanation; for 7-segment LED display circuit, please refer to section 17.3.

According to the cascaded LED units of each segment of the display, set up the driving voltage for corresponding display (Coarse adjust: JP1～JP3, JP5 and JP8).

---------- ● Please refer to section 17.3.2 "FB-7SG hardware setting" for explanation.

Write the FUN84 (7SGMO) instruction and fill in values for parameter S, Yn,…Ws, and control its input of EN, N/D, L/N.

---------- ● Please refer to section 17.4 FUN84 (7SGMO) instruction for explanation.

Starts the PLC, and by voltage drop adjusment of respective sets (fine tuning: JP6～7 and JP9 ～10), so as to assure to reach the best LED displaying condition and makes sure no over voltage drive (O.V.) phenomenon happened.

---------- ● Please refer to section 17.3.3 "Checking O.V." for explanation.

End

## 17.3 Hardware Connection and Configuration for FB-7SG

17.3.1 FB-7SG Hardware Wiring Layout

The hardware connection of FB-7SG is illustrated as the diagram above.   In addition to the basic wiring of 24VDC input supplied by external power supply, expansion input and the expansion output, the output of FB-7SG needs merely 16-pin flat cable with IDC connector to connect to 7-segment LED display board and it will work.

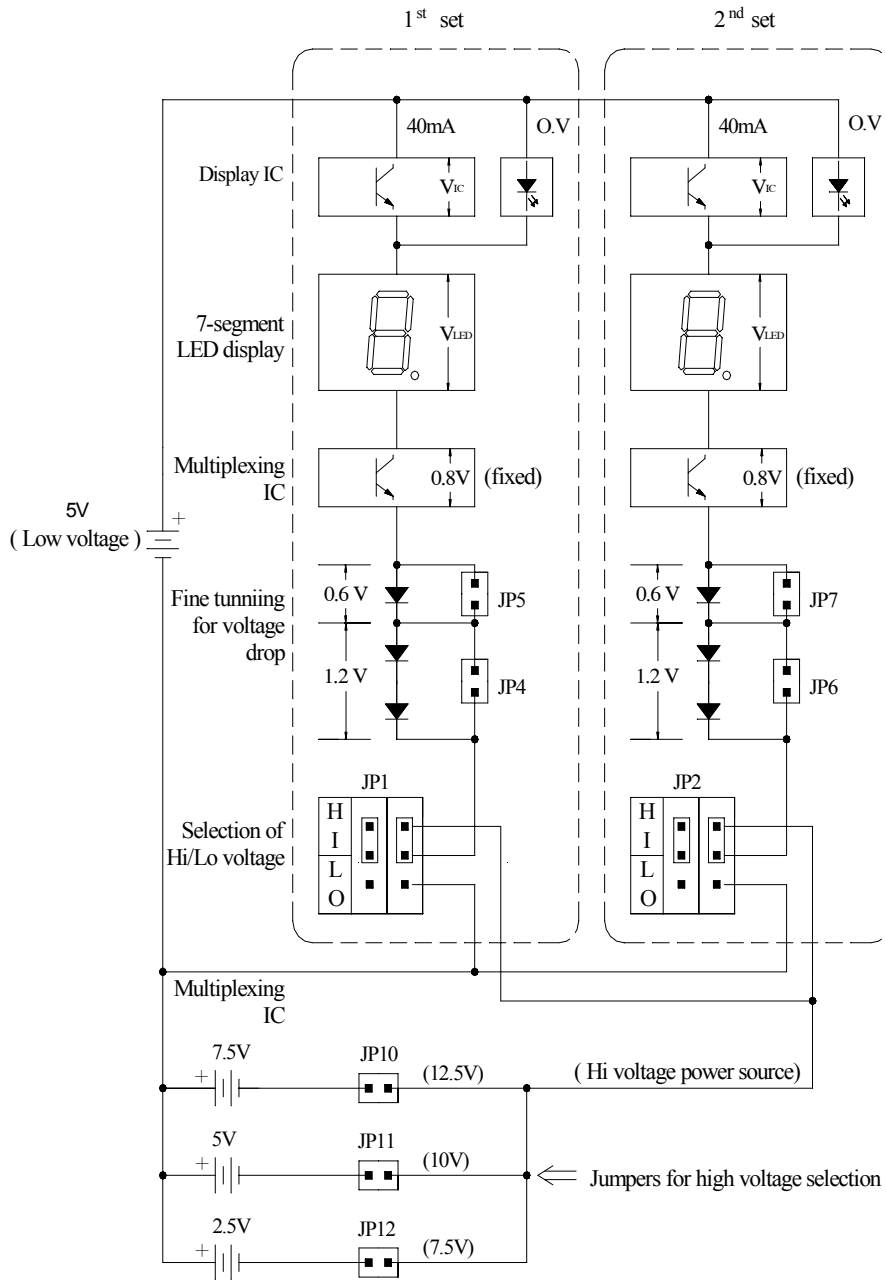| ⚠ Caution |
|---|
| Because the connectors of expansion input and expansion output as well as respective sets of LED display output's are all adopting the same kind of 16-pin IDC connectors, they must be correctly inserted as the diagram illustrated without confusion, so as to make the FB-7SG normally work; otherwise, it will disable the system working or even burn out the FB-7SG module or 7-segment LED display. |

17.3.2 The Hardware Setting of FB-7SG

The following diagram shows the output driving circuit of FB-7SG internal display IC:
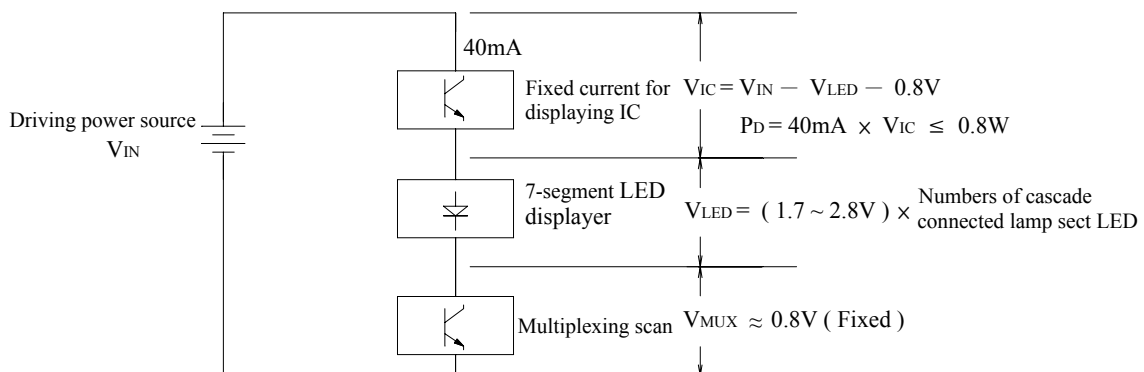
The display IC consumes 40mA constant current, therefore its power dissipation depends utterly on the voltage drop of V_{IC} ($P_D = 40mA \times V_{IC}$).   As shown in the above mentioned $V_{IC} = V_{IN} - V_{LED} - 0.8V$, the V_{IC} is influenced by driving power source voltage V_{IN} and 7-segment segment voltage drop V_{LED} because the safety power dissipation must be confined under 0.8W in the inferior temperature circumstance condition, i.e. the V_{IC} must be smaller than 2V.   If the V_{IC} is too low, it will cause the display insufficient in brightness or can't even been displayed; if the V_{IC} is too high, it will cause the display incorrect (those which shouldn't light up are also lighting), or even damaged the display IC.

The voltage drop of LED usually falls between 1.7V~2.8V; nevertheless, the 7_segment LED display's respective section (or called as respective segment, such as a~g) are usually formed with 1~5 piece of cascaded LED.   Therefore, their voltage drop of respective segment could have a large difference ranging from 1.7V~14V, and to drive with unitary voltage for various LED display seems to be impossible.   For the convenience of driving most of 7-segment LED displays, the FB-7SG provides 5V (low voltage), 7.5V, 10V, and 12.5V (these are categorized as high voltage) four driving voltages, and cascaded with diode and Jumper to make 0.6~1.8V (Vic) range of voltage fine tuning.   It not only could drive various kinds of voltage drop LEDs, but also to assure the V_{IC} not to burn out the display IC for exceeding 2V.   The following diagram shows the output circuit for LED display of FB-7SG, high/low voltage setting (shared in using), and choice of high/low voltage driving for respective set of display and jumpers for voltage drop fine tuning, as well as its diagram for actual location setting layout.   The hardware settings mentioned here are base on the pertaining settings of driving voltage V_{IN}, choice of high/low voltage driving, and fine tuning of voltage drop to make the 7-segment LED display to reach the best illumination displaying, without burn out the display IC nor shorten their usage durations.

LED driving circuit of FB-7SG

| ⚠ Caution |
| :--- |
| 1. The jumpers (JP5 and JP8) for choice of High/low voltage driving must be both vertically inserted to the HI side or both to LO side; if one to be HI and another LO, or horizontally placed, it will cause the abnormal working or damaging the display IC. |
| 2. The jumpers (JP1～JP3) of high voltage setting can only set to be one jumper short (ON) at any time; otherwise, it will cause the power circuit short that disables its working or burns out the circuit. |
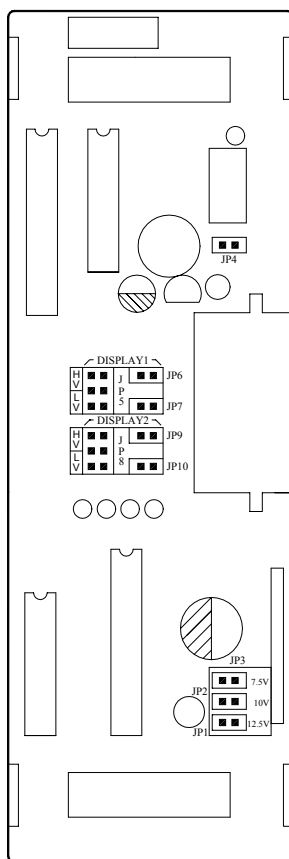
Layout of jumpers location

17.3.3 Checking the Over Voltage (O.V.) of FB-7SG

As above mentioned, the FB-7SG must be based on the above mentioned jumpers setting to place V_{IC} below 2V, after choosing the 7-segment LED display. Nonetheless, it's difficult for user to measure the V_{IC} under multiplexing scan. Therefore, the FB-7SG has been designed to have the over voltage (O.V.) indicator for user to check whether there is the over voltage driving happening. The O.V. indicator is easy to find on the front pannel of FB-7SG module.

To reach the outcome of O.V. displaying, it must first turn on all of the LED segments (Including fraction points, Totally 64 points) of the tested set of 7-segment LED display to make sense. In this case, if the O.V. indicator distinguished, it means that there doesn't exist the O.V. condition; if the O.V. indicator turns on, it means the O.V. happened (if not all the tested LED segments been turned on, the O.V. indicator may become flashing or lighted all the time, then the O.V. indicator does not make any sense). The easiest way to turn on all LED segments for O.V. test is that by forced both 〝N/D〞 and 〝L/N〞 inputs of FUN84(7SGMO) to 〝1〞 (please refer to P17-10), in addition to that the user can write the ladder program to turn on all LED segments then do O.V. check and adjustment. On the other hand, while using the FB-7SG module, before the FUN84 (7SGMO) is written into the ladder program for display control, start (let PLC be "RUN") the PLC first, all of the LED segments and friction points of the 7-segment LED display, which connected to FB-7SG module, will be all turned on. With this characteristic, the user can also view that whether the respective LED segments of display are working normally and to do O. V. check and adjustment as well.

17-5
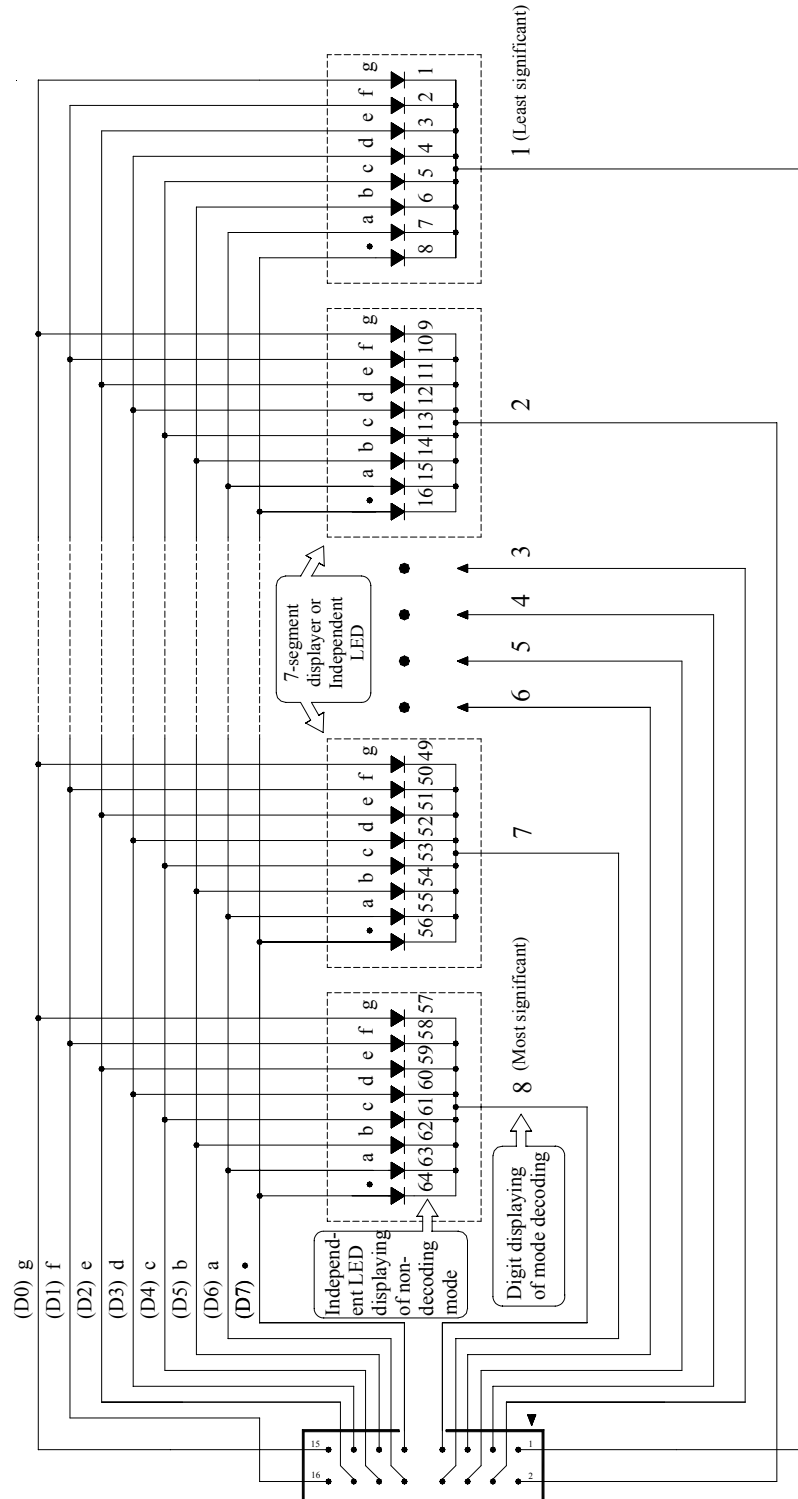
The circuit above is the layout of wire connection (common cathode) for FB-7SG module and 7-segment LED displays or independent LED displays; user may make the display by himself according to this wiring layout, and connect to any display output of FB-7SG with 16 pin flat cable. For convenient in using, the FATEK provides 4 kinds of size of 7-segment display board or final product which the user may select to use.   The following are the specifications:

Model number	Size and characters	The dividable characters of display board
DB.56　（DB.56LED）	0.56　inch ×8	8 characters ×1 or 4 characters ×2
DB.8　（DB.8LED）	0.8　inch ×8	8 characters ×1 or 4 characters ×2
DB2.3　（DB2.3LED）	2.3　inch ×8	It may base on a character for division, and to assemble from 1～8 characters.
DB4.0　（DB4.0LED）	4.0　inch ×4	

※　The model number in the parenthesis represents the final product of 7-segment disply.

17.5 Decode and Non-decode Display

The 7-segment display has 7 LED segments (a～g) and another fraction point for displaying as following illustrated figure. Its main purpose is for the display of number 0～9, there are two ways of displaying method for the control of respective LED segments.
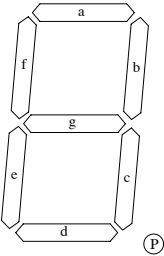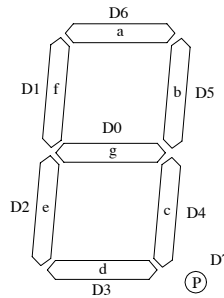

① **Non-decode display**: (To turn on or turn off respective LED segments are independently controlled by the user's application program).
This means that the displaying method of independent control over LED segments must be controlled by the user's application program according to the number to be displayed, e.g. "3", and make the corresponding segments light up (i.e. D0, D3, D4, D5, D6 turns on, and D1, D2, D7 turns off).   Every segment must have one corresponding bit to control. For each numeric character display, the user must use 8 bits (D0～D7) controlling the light up or distinguish of 7 segments iclude friction point. In application, the user must first configure the corresponding segments to number of 0～9 for their luminiferous on/off table (i.e. the "encoding" of number to be displayed), and then based on number to be displayed to transmit the segments controlling signal to 7-segment display for displaying.   Since it controls 8 bits indirectly, usually we don't recommend to use it for normal numeric character displaying; it's mainly used for independent indication displaying.   The respective segments of 7-segment LED and their corresponding cotrol bits D0～D7 are illustrated as the figure above.   If it needs to display numeric character with non-decoding, it may employ FUN59 (→7SG) instruction to decode and convert the non displaying nibble value, thus it may save the complicated encoding works done by user.

Note: When a set of display needs to partially display with numeric character, and partially with independent LED displaying, it must employ the non-decoding displaying method.   The independent LED can be correspondingly controlled one after another, and numeric character displaying adopting FUN59 (→7SG) instruction to help to convert the numeric character to displaying character form and it can be easily attained.   Please refer to example 3 of section 17.8.

② **Decode display**: Directly express the nibble of BCD value and by the following list of default encoding form to display the corresponding numeric digits.

Because the numeric character 0∼9 could be expressed with 4 bits (called as Nibble) of BCD value, the so called "decode display" is using the hardware circuit to perform the conversion of the above mentioned numerical character 0∼9 BCD code to a∼g segment signals, and transmit to the 7-segment display for displaying. Since the decoding job is completed by the circuit, the user needs merely to pass the nibble of BCD code to the display module, and the 7-segment display will be able to correctly display the numeric form of 0∼9. The display model is simple and convenient, but it has only 16 kind of characters for choice (as the following list of numeric forms for display), and it can't independently control the respective segments as freely as the non-decode ones. Because the nibble can express 16 kind of messages, in addition to the BCD code of 0∼9, it can still display another 6 text forms. The following list is the decoding of nibble value to be displayed in numeric form for FB-7SG module.

Nibble value		Structure of 7-segment display	Segment off (0) on (1)							Displaying of numeric form
Hex decimal	Binary		a	b	c	d	e	f	g	
0	0000		1	1	1	1	1	1	0	
1	0001		0	1	1	0	0	0	0	
2	0010		1	1	0	1	1	0	1	
3	0011		1	1	1	1	0	0	1	
4	0100		0	1	1	0	0	1	1	
5	0101		1	0	1	1	0	1	1	
6	0110		1	0	1	1	1	1	1	
7	0111		1	1	1	0	0	1	0	
8	1000		1	1	1	1	1	1	1	
9	1001		1	1	1	1	0	1	1	
A	1010		0	0	0	0	0	0	1	
B	1011		1	0	0	1	1	1	1	
C	1100		0	1	1	0	1	1	1	
D	1101		0	0	0	1	1	1	0	
E	1110		1	0	0	1	1	1	1	
F	1111		0	0	0	0	0	0	0	

17.6 The Power Input Specifications and Power Dissipation of FB-7SG

The FB-7SG builts in an isolated power supply driven by external 24VDC input, which supplies the power for FB-7SG internal circuit and 7-segment LED display.   The accommodated input of voltage range is DC 24V±20%.

The static power dissipation of FB-7SG module itself is 2Wmax; the dynamic power dissipation is getting greater along with the increasing of the driving of 7-segment display.   Since the driving current of respective segment for any set of FB-7SG displaying IC is 40mA, one numeric digit consists of 8 segments is fixed at 320mA, and maximum power dissipation of any set can be calculated by following equation:

$$P_d = 320mA \times V_{IN} \text{ (LED driving voltage)} \div 0.8 \text{(power efficiency)W}$$

$$\text{Total dissipation} = 2 + P_d \times n(W)$$

For example, the FB-7SG2 (2 sets of output) in the maximum power dissipation (V_{IN} = 12.5V, 8 digits of segments are all at the brightest condition), the total power dissipation will be

$$2W + (320mA \times 12.5V \div 8) = 7W$$

17.7 Explanation of FUN84: 7SGMO , which is the Convenient Instruction for FB-7SG

The following pages are the instruction explanation of FUN84 (7SGMO).

FUN 84 7SGMO	Convenient instruction proper to FB-7SG Module	FUN 84 7SGMO

```
             ┌ 84.7SGMO ─────
Execution control─ EN ─│ S  :
                       │ Yn :
Non-decode / Decode─N/D─│ Dn :
                       │ PT :
                       │ IT :
Leading zero / Nonleading zero─L/N─│ WS:
```

S : Starting address of registers to be displayed.

Yn: Starting address of displaying output of this module.

Dn: Number of characters (digits) to be displayed.

Pt : Designation of fraction point.

IT : Designation of brightness level.

Ws: Working register for the operation of this instruction.

Range Ope- rand	Y Y0 | Y240	WX WX0 | WX240	WY WY0 | WY240	WM WM0 | WM1896	WS WS0 | WS984	TMR T0 | T255	CTR C0 | C255	HR R0 | R3839	IR R3840 | R3903	OR R3904 | R3967	SR R3968 | R4167	ROR R5000 | R8071	DR D0 | D3071	K 16/32 bits positive number
S		○	○	○	○	○	○	○	○	○	○	○	○	○
Yn	○													
Dn		○	○	○	○	○	○	○	○	○	○	○	○	1-8
Pt		○	○	○	○	○	○	○	○	○	○	○	○	0-FFH
It		○	○	○	○	○	○	○	○	○	○	○	○	1-16
Ws			○	○	○	○	○	○		○*	○*	○*	○	

Input Control

EN: Execution control; =1, update the displaying; =0, not to update the displaying.

N/D: Decode/Non_decode selection

L/N: Leading zero/Non-leading zero selection

These two selections have the compound function as follows

N/D	L/N	Displaying mode
0	0	Decode, Non-leading zero
0	1	Decode, Leading zero.
1	0	Non-decode
1	1	Test mode

※Refer to section 17.5 for explanation of decode/non-decode display

※Suppose S is 8-digit of numeric characters, its value is 123.

Non-leading zero displaying　　　:　　　123

Leading zero displaying　　　:　　00000123

(Leading zero has meaning only when in decode displaying)

Explanation of Operand

S: Starting address of the registers whose contents will be displayed; it's the least significant digit for display. Each nibble will be displayed at one digit while in decoding mode, it needs 2 registers S and S+1 to display a set of 8 digits. In non-decoding mode, it needs S～S+3 totally 4 registers to display a set of 8-digit. In decoding displaying, fills the BCD value (2 words,8×4bits) to be displayed into S～S+1, and this instruction will display the 8-digit numeric number. While in non-decoding displaying, the user must fill the 8-digit with 64 bits of on/off signals into S～S+3 (totally 4 registers), then, it is able to display the value of that 8-digit.
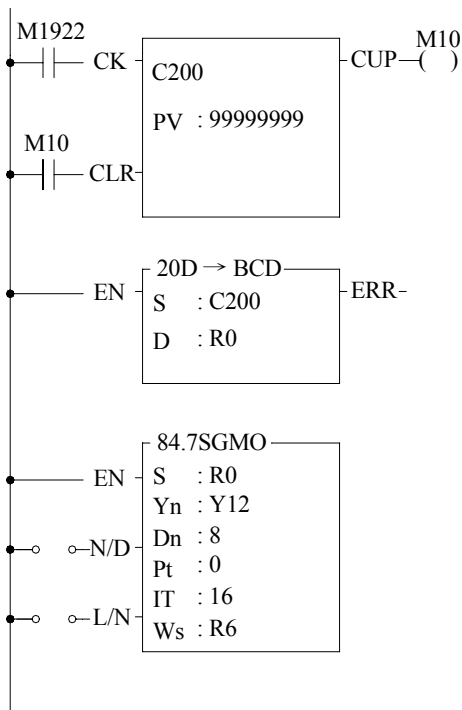
FUN 84 7SGMO	Convenient instruction proper to FB-7SG Module	FUN 84 7SGMO

Yn: FB-7SG is the expansion module, the physical hardware output address of it is the summation of the outputs of CPU board and the outputs of expansion modules before it. For example, there are FBx-28MX CPU board (with 12 outputs) and FB-40EA expansion module (with 16 outputs) before it, consequently the starting output address of the FB-7SG module is $Y_{(12+16)}$ = Y28. The value of Yn must be consistent to the physical output address of FB-7SG to work correctly, and each set (8-digit) of display needs successive 16 outputs beginning from Yn to control. Therefore the Yn of the second set of 7-segment display will be the Yn of first set of display plus 16.

Each set (8-digit) of 7-segment display needs independent FUN84 instruction to control, it means FB-7SG2 needs 2 FUN84 instructions to work.

Dn: Valid digits to show for a set of 7-segment display (8-digit). While it didn't need to display all of the digits, it may use the displaying digits assigned by Dn. Dn can be set from 1～8. When Dn is set to be smaller, the scanning of displaying will be increased hence the brightness level will be getting higher.

Pt: Specify the bit of a word data to designate the position of fraction point; only low byte (B7～B0) is used to assign the fraction point of that digit to be lighten up. e.g. Pt = 0001H, it means to light up the fraction point of the least significant digit (1st digit), and 0081H means to light up the fraction points of the most significant digit (8th digit) and the first digit.

IT: Level of the brightness; it could be 1～16, the brightness is proportional to the setting value.

Ws: The working register for operation of this instruction, which controls one word. It can't repeat in using by other program.

Instruction Explanation

● When execution control "EN" =1, this instruction will update the displaying output with the contents of the specified registers.
When "EN" =0, it will not update the displaying, and the display will stay as before.

● Each FUN84 instruction can display up to 8 digits at the most; for digit exceeding 8 digits,it must employ another FUN84 instruction, it means FB-7SG2 needs 2nd FUN84 instruction to work.

● For the selection of Non-decode/Decode ("N/D") and the selection of Leading zero/Non_leading zero ("L/N"), please refer to previous page of displaying mode list for explanation.

17.8 Program Example

The following example1～example3 are using the same hardware (FBE-28MC+FB-7SG1), and it performs the decode (numeric character display), non-decode (independent LED display), and the mixture of mentioned above to achieve the 7-segment or independent LED displaying.

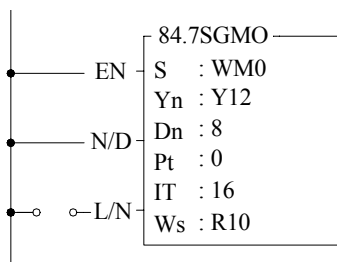Example 1: Numeric character display by "decode" mode

Using counter C200 to count the internal 1 second clock of PLC , and converts the current value of C200 to be BCD code for FB-7SG1 to show.

```
M1922
 ┤├─ CK ┌ C200      ─┐       M10
         │           │─CUP─( )
 M10     │ PV : 99999999
 ┤├─ CLR └           ─┘

          ┌ 20D → BCD ──┐
 ─── EN   │ S  : C200   │─ERR─
          │ D  : R0     │
          └─────────────┘

          ┌ 84.7SGMO ──┐
 ─── EN   │ S  : R0    │
          │ Yn : Y12   │
          │ Dn : 8     │
 ─o o─N/D │ Pt : 0     │
          │ IT : 16    │
 ─o o─L/N │ Ws : R6    │
          └────────────┘
```

- Increasing C200 per second up to value of 99999999 and then return to 0→1→2…. cycling counting.

- Converts the current value of C200 (binary) to be decimal format (BCD) and stores it into DR0 for displaying.

- Select "decode" mode to show the 8 digits BCD code of DR0 on 7-segment display, and not to light up the fraction point; brightness level is the most.

Example 2: Independent LED display by "Non_decode" mode

To turn on or turn off the 64 independent LEDs (number 1～64) showing in the circuit on section 17.4 through FB-7SG, we have to select the "Non-decode" mode to work, and with internal relay M0～M63 for corresponding mapping.

```
          ┌ 84.7SGMO ──┐
 ─── EN   │ S  : WM0   │
          │ Yn : Y12   │
          │ Dn : 8     │
 ─── N/D  │ Pt : 0     │
          │ IT : 16    │
 ─o o─L/N │ Ws : R10   │
          └────────────┘
```

- LED1～LED64 will indicate the on/off status of M0～M63.
  LED1 shows the status of M0
  …
  LED64 shows the status of M63

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Replacing the LED33∼LED64 of example 2 by 7-segment LED display to show the content of DR100; and LED1∼
LED32 remain to indicate the status of internal relay M0∼M31.

```
         ┌ 59. → 7SG ──┐
 ──── EN ┤ S  : R100    ├ ERR─
         │ N  : 3       │
         │ D  : WM32    │
         └──────────────┘
```
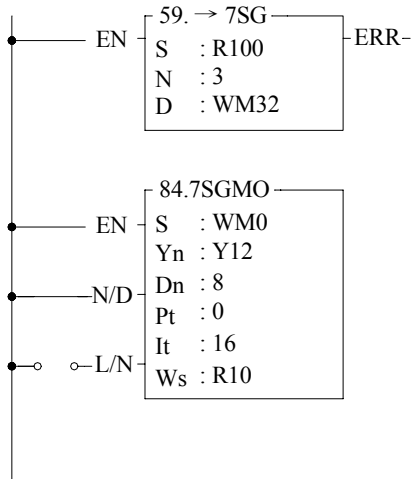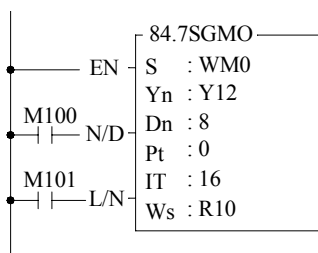
● Converts the current BCD value of R100 (N=3,it means 4 digits that
   Nibble0∼Nibble3) to be 7-segment display patterns and stores
   them into DWM32 (M32∼M63) for 4-digit of 7-segment display to
   show.

```
         ┌ 84.7SGMO ───┐
 ──── EN ┤ S  : WM0     │
         │ Yn : Y12     │
 ──── N/D┤ Dn : 8       │
         │ Pt : 0       │
         │ It : 16      │
─o o─ L/N┤ Ws : R10     │
         └──────────────┘
```

● Select "Non-decode" mode to display
● LED1∼LED64 will indicate the on/off status of M0∼M63,where
   LED1 shows the status of M0
   …
   LED32 shows the status of M31
   LED33∼LED64 were replaced by 4-digit of 7-segment display and
    showing the content of DR100.

※ When there are independent LEDs to display, it must employ "Non-decode" mode.   While in "Non-decode"
displaying, it can employ FUN59 converting BCD code to 7-segment displaying pattern, so as to easily
display the numeric character.

   The handy instruction FUN84 supports the "Lamp Test" function while both control inputs "N/D" and "L/N" of this
instruction are all ON, there will turn on all segments of the 7-segment display include fraction points if this instruction
being executed. At the same time, the user may check the O.V. indicator for over voltage adjustment. If the O.V.
indicator distinguished, it means that there doesn't exist the O.V. condition, it is required; if the O.V. indicator turns on, it
means the O.V. happened, it is necessary to set the jumpers mentioned in 17.3.2 for normal operation.

* The O.V. indicator may become flashing or lighted all the time if not all the LED segments been turned on, in this case
   the O.V. indicator does not make any sense.

```
              ┌ 84.7SGMO ───┐
 ───── EN ────┤ S  : WM0     │
              │ Yn : Y12     │
 M100         │ Dn : 8       │
 ─┤ ├─ N/D ───┤ Pt : 0       │
 M101         │ IT : 16      │
 ─┤ ├─ L/N ───┤ Ws : R10     │
              └──────────────┘
```

● Disable and force on M100 and M101 to perform the lamp test and
   over voltage adjustment.