

# Chapter 11 FB-PLC High-Speed Counter and Timer

## 11.1 FB-PLC High-Speed Counter

The counting frequency of an ordinary PLC's software counter can only reach tens of Hz (depending on the scan time). If the frequency of input signal is higher than that, it is necessary to utilize high-speed counter (HSC), otherwise loss count or even out of counting may occur. There are usually two types of HSC implemented for PLC. The hardware high-speed counter (HHSC) employed special hardware circuit and the software high-speed counter (SHSC) which when counting signal changes state will interrupt CPU to perform the increment/decrement counting operation. FB-PLC provides up to 4 HHSCs (in ASIC chips) and 4 SHSCs. All of them are all 32 bit high speed counter.

### 11.1.1 Counting Modes of FB-PLC High-Speed Counter

As shown in the table below, each of the four FB-PLC HHSCs and SHSCs provides 8 and 3, respectively, kind of counting modes to choose from:

Counting Mode			HHSC (HSC0~HSC3)	SHSC (HSC4~HSC7)	Counting Waveform	
					Up Counting (+1)	Down Counter (-1)
Up-down pulse	MD 0	U/D	○	○	U	D
	MD 1	U/D×2	○		U	D
Pulse-direction	MD 2	K/R	○	○	K	R
	MD 3	K/R×2	○		K	R
AB phase	MD 4	A/B	○	○	A	B
	MD 5	A/B×2	○		A	B
	MD 6	A/B×3	○		A	B
	MD 7	A/B×4	○		A	B

- The up/down arrow (↑, ↓) on the positive/negative edge in the waveform represents where counting (+1 or -1) occurs.

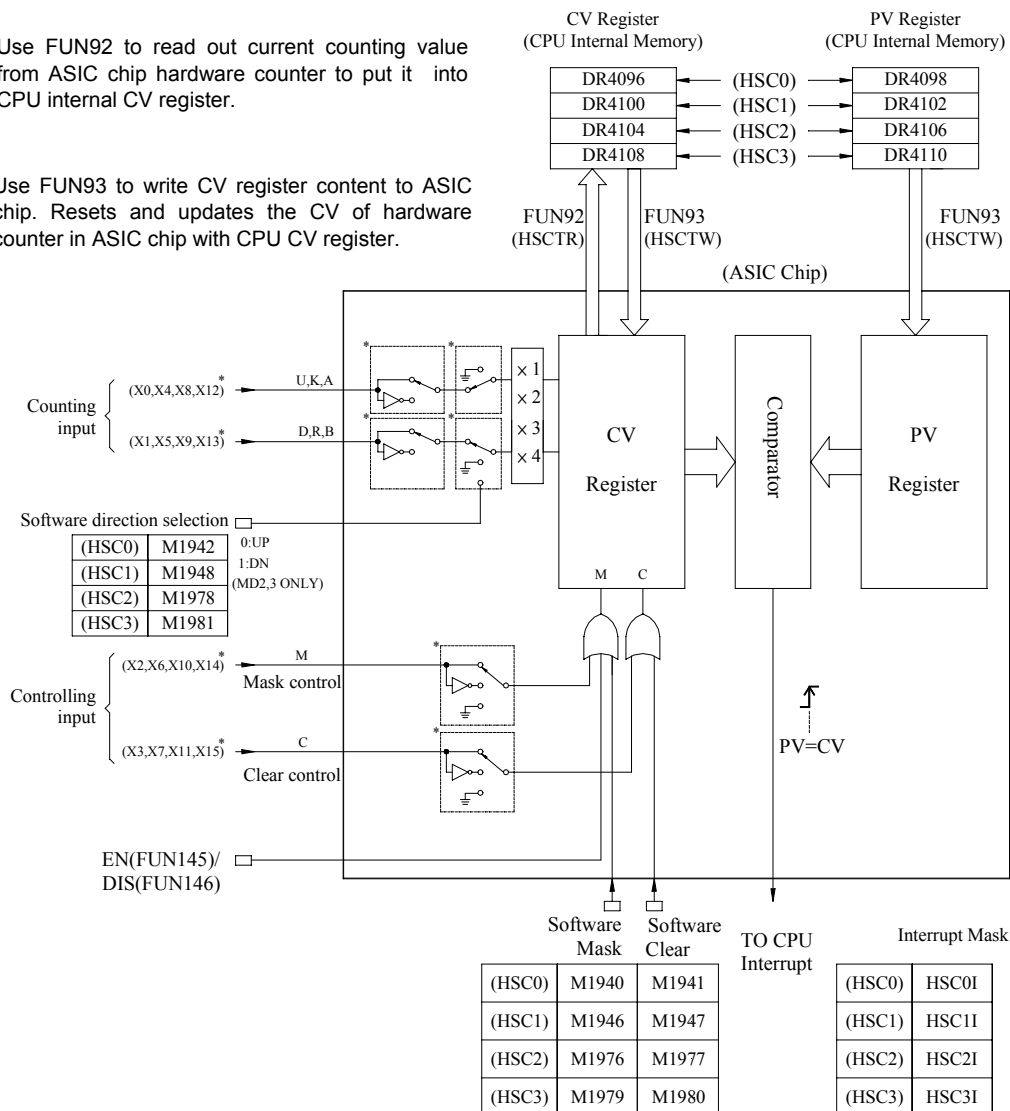
## 11.2 System Architecture of FB-PLC High-Speed Counter

The diagrams below are the system architecture for FB-PLC HHSC and SHSC where each one of them has multi-purpose input and counting functions. Some of the functions are built-in (such as CV register number, PV register number, interrupt label and relay number for software MASK, CLEAR and direction selection) that user need not to assign for configuration. However, some functions, with a "\*" marked in the diagrams below, must use the programming tool to configure the HSC (such as HSC application selection, counting mode, application of each function input, inverse polarity and appointment of corresponding input point number Xn) etc. For detailed structure and operation of the 8 kind of counting modes that assigned in configuration, please refer to section 11.2.1~11.2.3 for explanation.

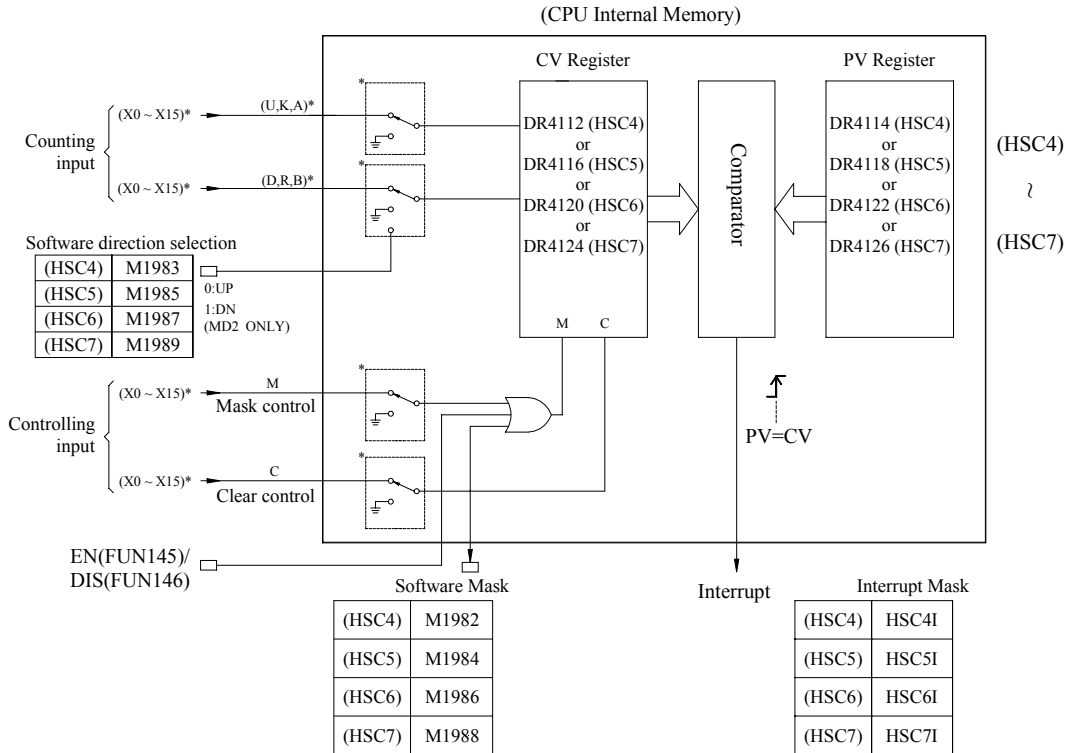
Note: CV (Current Value); PV (Preset Value).

- Use FUN92 to read out current counting value from ASIC chip hardware counter to put it into CPU internal CV register.
- Use FUN93 to write CV register content to ASIC chip. Resets and updates the CV of hardware counter in ASIC chip with CPU CV register.

- Use FUN93 to write CPU's internal PV register value to PV register of hardware counter of ASIC chip.



System Architecture of HHSC (HSC0~HSC3)



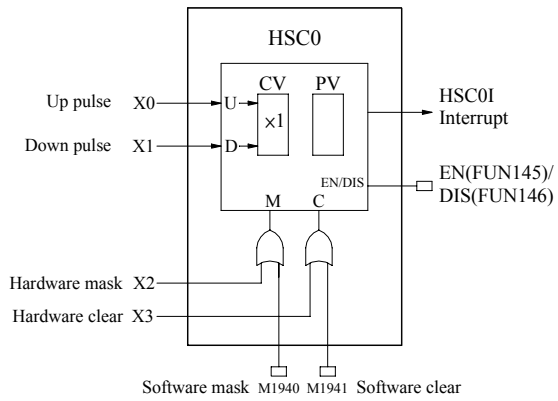
### System Architecture of SHSC (HSC4~HSC7)

- All control signals of HHSC and SHSC are default as Active High (i.e. Status =1 for active and 0 for non-active). In order to cooperate with the sensor's polarity, the HHSC counting inputs (U, D, K, R, A and B) and control inputs (M and C) can be selected for polarity inverse.
- By default when the MASK control signal, M, is 1, the HSC counting pulse will be masked without any counting being performed and all HSC internal status (such as CV and PV) will remain unchanged. The HSC will function normally only when M returns to "0". Some sensors have Enable outputs which function is on the contrary to MASK. Counters will not count when Enable = 0 and can only start functioning when Enable = 1. Then, function of inverse polarity input of MASK can be selected to cooperate with the sensors having Enable output.
- When the CLEAR control signal, C, is 1, the HSC internal CV register will be cleared to 0 and no counting will be performed. The HSC will start counting from 0 when C returns to 0. Ladder program can also directly clear the CV register (DR4112, DR4116, DR4120, and DR4124), so as to clear the current counting value to 0.
- The four sets of FB-PLC HHSC are located in the ASIC chips where the CV or the PV registers the user can't access directly. What the user can access are the CV registers (DR4096~DR4110) located in the CPU internal memory. Ideally, the contents of CV and PV registers in the chips should be updated simultaneously with the CV and PV registers in the CPU internal memory. However, to keep the correspondence between the two must be loaded or read by the CPU when they, in fact, belong to two different hardware circuits. It is necessary to use FUN93 to load the CV and the PV registers inside the CPU to the respective CV and PV registers (to allow HHSC to start counting from this initial value. Then, FUN92 can be used to read back the counting value of the HHSC CV register in the chips to the CV register in the CPU (i.e. the CV register in the CPU has the bi-direction function). Since read can only be carried out when FUN92 is executed (so-called "sampling" reading), it might result in difference between the HHSC CV value in the chips and the CV value in the CPU, the deviation will getting greater especially when the counting frequency is high.

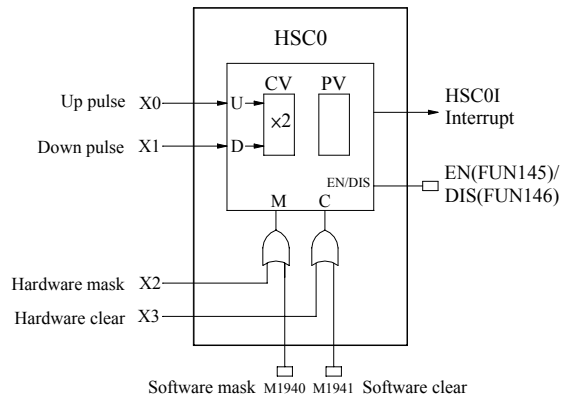
- When the counting frequency is not high or the demand for positioning precision is not so much, using FUN92 in the main program to read the current counting value and then incorporate comparator instruction is adequate for a simple counting positioning control.
- When the demand for positioning precision is higher, or in the multi-zone count setting control, it may use the FUN92 to read the current counting value while in the time base interrupt routine and incorporate compare instruction to perform more precise counting positioning control (for this application mode, the counter is confined to 16 bit application).
- As the demand for positioning precision is extremely high, it must use the preset interrupt function of hardware counter. The preset value can load by FUN93 into the PV register of HHSC in the chipset. When CV value of HHSC reaches this preset value, the hardware comparator in the HHSC will send interrupt to CPU at the very moment CV=PV, and jump to interrupt subroutine to do real time control or procession.
- SHSC, on the other hand, uses the interrupt method to request an interrupt signal to the CPU when the counting input is on the rising edge. Then, the CPU will determine whether it should decrease or increase the internal CV register (since the CV register itself in the CPU is a SHSC CV register, no FUN92 or FUN93 is required). Each time when CV is updated, if the CPU find that it is equal to the PV register value, the CPU will jump immediately to the corresponding SHSC interrupt service routine for processing. Whenever there has a change in SHSC counting or control input can cause the CPU to be interrupted. The higher the counting frequency, the more of CPU time will be occupied. The CPU responding time will be considerably increased or even Watchdog time-out will be caused to force the PLC to stop operating. Therefore, it is preferred to use HHSC first; if it needs to use SHSC, the sum of all FB-PLC SHSC input frequencies should not exceed 8KHz.
- None of the special relay controls, such as software MASK, CLEAR and direction control, is real time. This means that although MASK, CLEAR or direction change has been set during routine scanning, the signal will only be transmitted to HSC when I/O updating is under way after the completion of routine scanning. Hence, it is not suitable for the real time control in HSC operation (which should be mainly used for initial setting before HSC operation). Should real time control be required, please use hardware to control input or apply the FUN145(EN), FUN146(DIS), FUN92(HSCTR), and FUN93(HSCTW) etc. instructions for control.
- Every HSC is equipped with the functions, ENable(FUN145) and DISable(FUN146), and can only be operated when HSC is enabled. When HSC is disabled, the whole HSC, no matter it is HHSC or SHSC, will be in a complete stagnant status (CV and PV values will remain the same without interrupt as if no HSC exists) until the Enable command is executed. When Enable is executed, HSC will return to the status and the function before Disable. HSC is default as enable when HSC configuration is made. Control of enable and disable can be made at any time in the routine according to actual requirement.
- In the interrupt service subroutines of HSTAI, 1MS~100MS, if it is used with the FUN92 to read the current counting value of hardware high speed counter, only the 16 bit of Low Word (R4096, R4100, R4104, R4108) is effective.

### 11.2.1 The Up/Down Pulse Input Mode High-Speed Counter (MD0, MD1)

The up/down pulse input of high-speed counter has up counting pulse input (U) and down counting pulse input (D) that are independent to each other without any phase relationship. Each of them will +1 (U) or -1 (D) on the CV value when the rising edge of the pulse input occurs (both positive and negative edge for MD1). This also applies when the rising (or falling) edge of the U and D pulse occur simultaneously (it will offset with each other). Both of the two modes have the built-in software MASK and CLEAR (CLEAR is not available for SHSC) control functions, when the control function are not in use should keep the status (such as M1940 and M1941) as "0". Apart from the built-in software MASK and CLEAR, the controls of hardware MASK and CLEAR can also be configured. The MASK control is first performed by the OR operation of the hardware and software control, then the result is send to the HSC MASK control M, and so does CLEAR. Taking HSC0 as an example, the function schematic diagrams for MD0 and MD1 configured separately are shown as below.

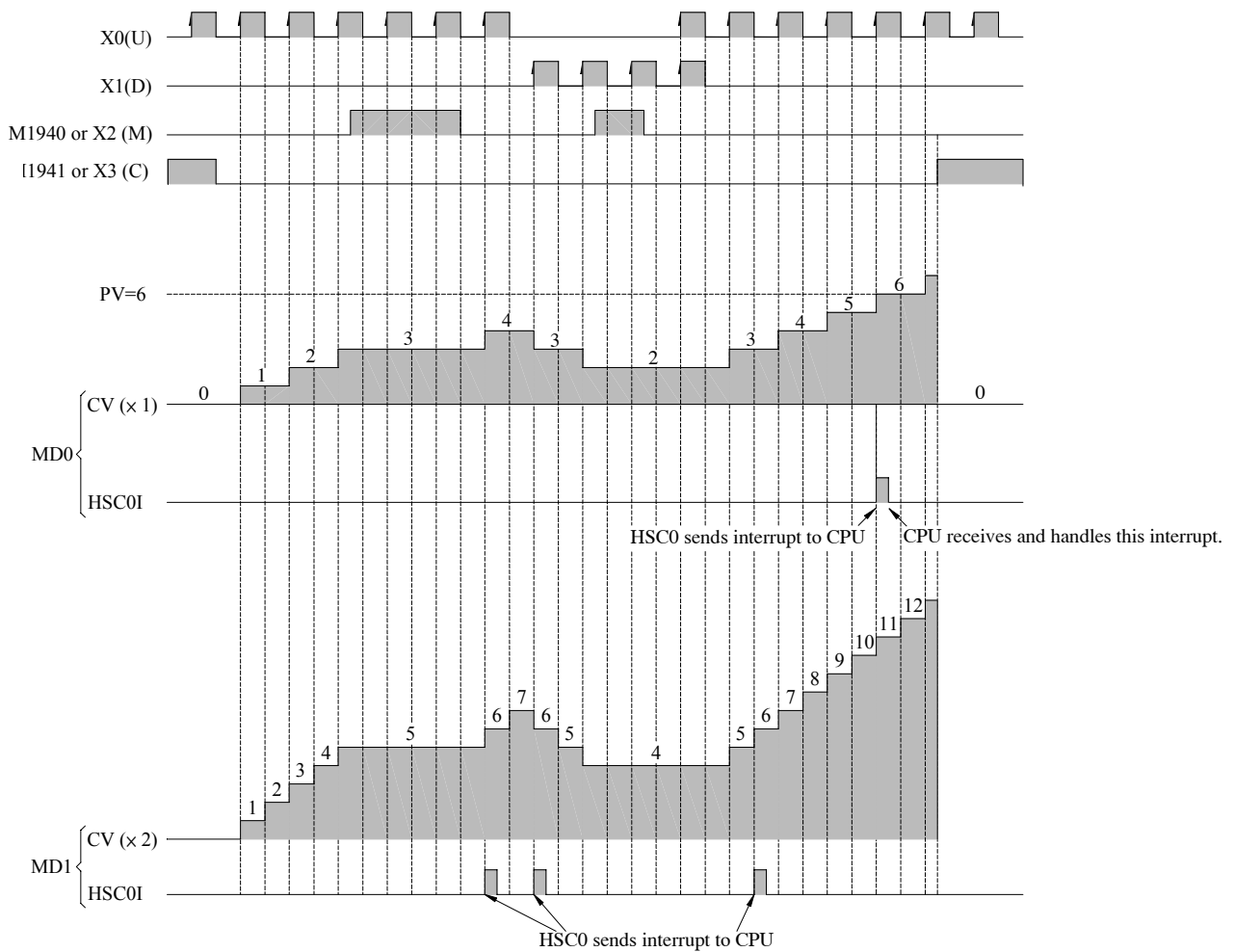


MD0 (U/D)



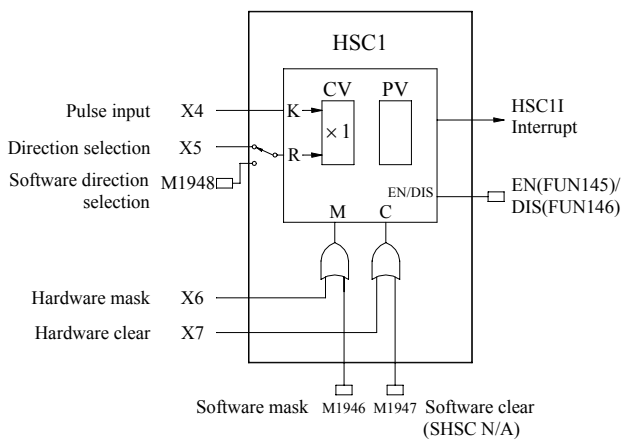
MD1 (U/Dx2) (HHSC Only)

The Waveforms of the HSC, which is configured as up/down pulse input mode, and PV value is preset to 6:

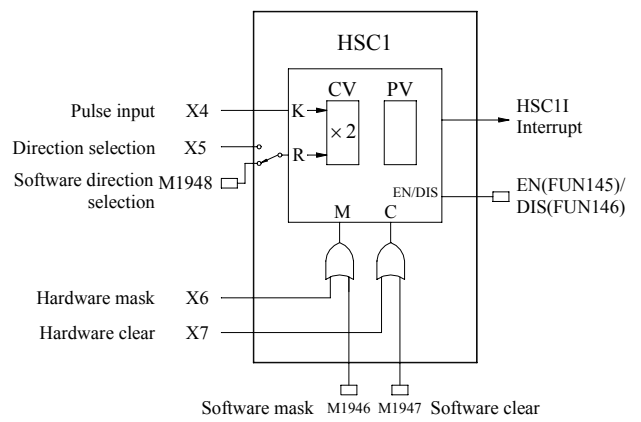


### 11.2.2 Pulse-direction Input Mode High-Speed Counter (MD2, MD3)

The pulse-direction input mode high-speed counter only has one counting pulse input K (Clock). It requires another direction input R (Direction) to decide whether the CV value should +1 (R=0) or -1 (R=1) when the rising edge (both rising and falling edges for MD3) of counting pulse arrives. The same applies to counting of MD2 and MD3 except that MD2 only counts on the rising edge (+1 or -1) and MD3 counts on both rising and falling edges of CK pulse (twice the counts of MD2). These two modes have built-in software MASK, software CLEAR (SHSC does not have clear). When control function is not in use, it must keep the status (such as M1946 and M1947 in this example) to be 0. Apart from the built-in software MASK and CLEAR, the controls of hardware MASK and CLEAR can also be configured. The MASK control is first performed by the OR operation of the hardware and software control, then the result is send to the HSC MASK control M, and so does CLEAR. The function schematic diagrams of HSC1 configured individually for MD2 and MD3 are shown as below.



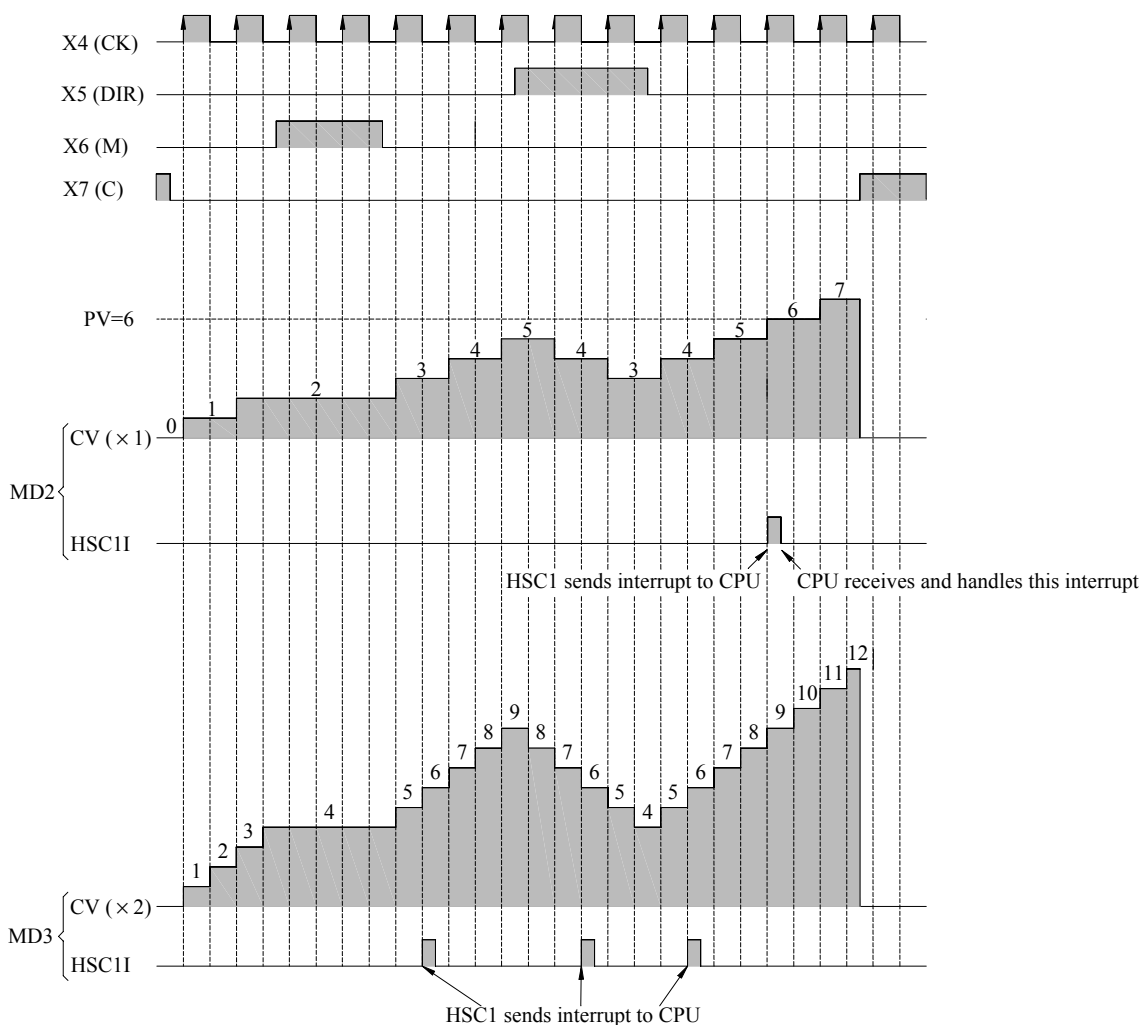
MD2 (K/R)



MD3 (K/Rx2) (HHSC Only)

Direction selection of MD2 and MD3 HSC, for HSC or SHSC, can be come from the external inputs (such as X5 in this example) or the special relay in CPU (such as M1948 in this example) to reduce the usage of external input points.

The diagram below is the waveform diagram for the relationship between counting and control of the two HSC. In this example the PV value is to 6.

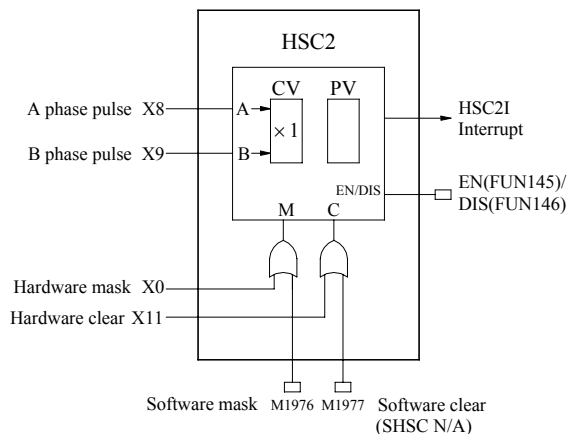


### 11.2.3 AB Phase Input Mode High-Speed Counter (MD4,MD5,MD6,MD7)

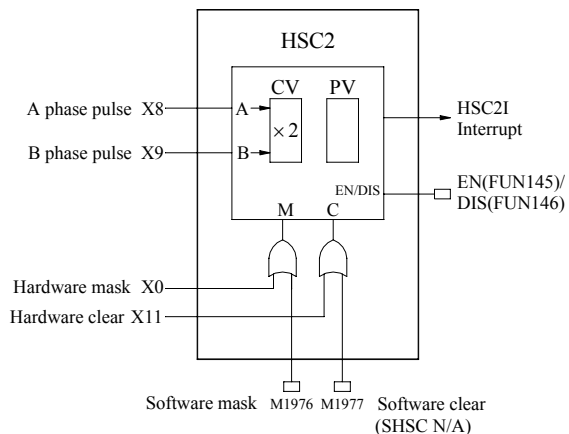
The AB phase high-speed counter is equipped with phase A and phase B pulse input with counting value +1 or -1, depending on the phase relationship between the two, i.e. the related counting of the two phases. If phase A is ahead of phase B, the CV value should be +1, else, the CV value should be -1. The counting of the four modes, MD4 (A/B), MD5 (A/B×2), MD6 (A/B×3) and MD7 (A/B×4), of AB phase HSC are similar. Their differences are:

- ① MD4 (A/B) : The rising edge of A is +1 when A is ahead of B and the falling edge of A is -1 when A is behind B.
- ② MD5 (A/B×2): The rising and falling edges of A are +1 when A is ahead of B, and -1 when A is behind B (twice the counts of MD4).
- ③ MD6 (A/B×3): The rising and falling edges of A and rising edge of B are +1 when A is ahead of B. The rising and falling edges of A and the falling edge of B are -1 when A is behind B (three times the counts of MD4).
- ④ MD7 (A/B×4): The rising and falling edges of A and B are +1 when A is ahead of B and the rising and falling edges of A and B are -1 when A is behind B (four times the counts of MD4).

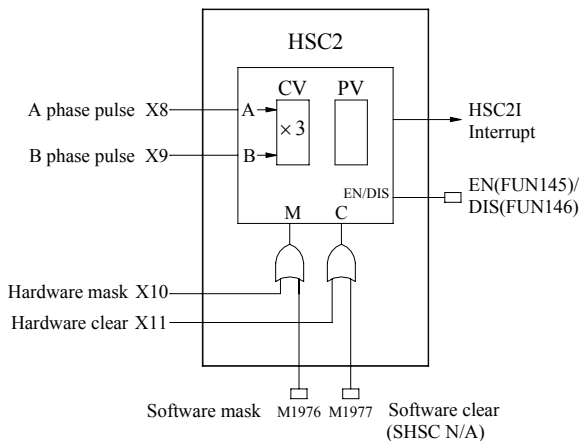
Other MD4~MD7 HSC modes also have built-in software MASK, software CLEAR (SHSC does not have clear). When control function is not in use, it must keep the status (such as M1946 and M1947 in this example) to be 0. Apart from the built-in software MASK and CLEAR, the controls of hardware MASK and CLEAR can also be configured. The MASK control is first performed by the OR operation of the hardware and software control, then the result is send to the HSC MASK control M, and so does CLEAR. The function schematic diagrams of HSC2 for the four MD4~MD7 HSC modes are shown as below.



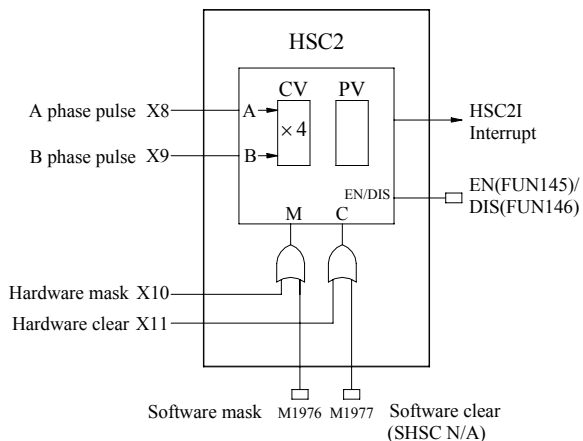
**MD4 (A/B)**



**MD5 (A/Bx2) (HHSC Only)**



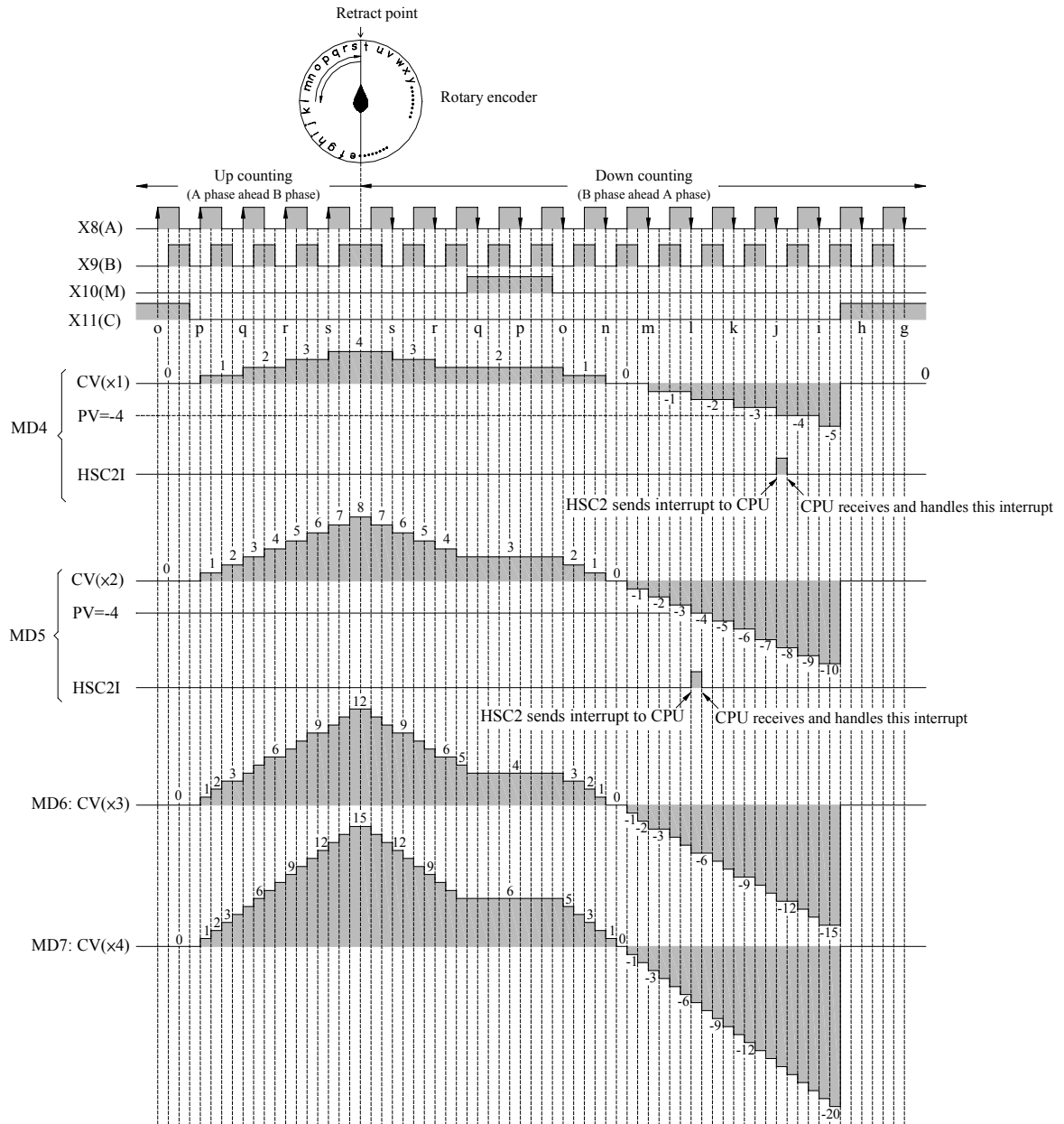
**MD6 (A/Bx3) (HHSC Only)**



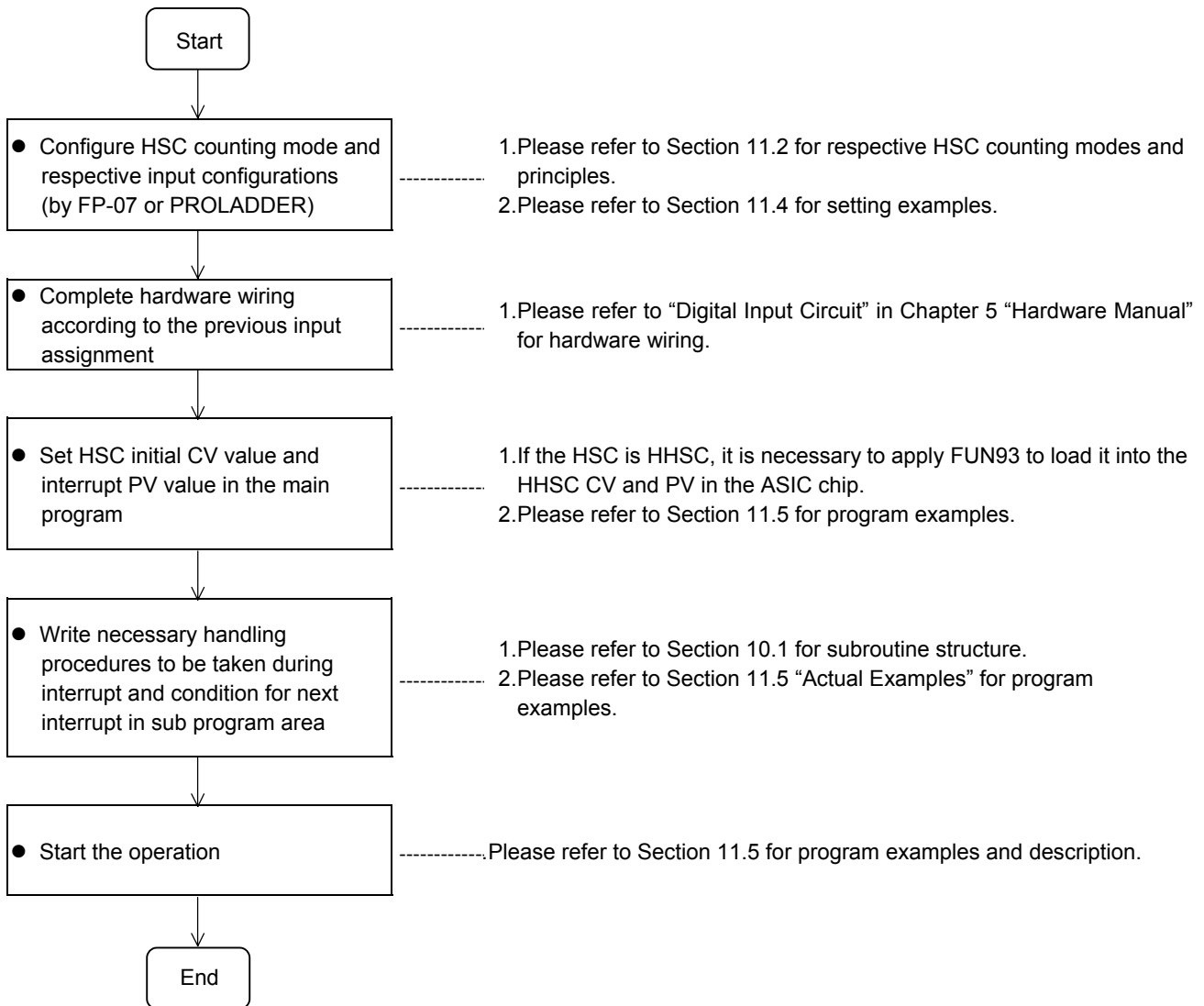
**MD7 (A/Bx4) (HHSC Only)**



The diagram below is the waveform diagram for the relationship between counting and control of the four HSC modes in this example when the PV value is set as at 6.



### 11.3 Procedure for FB-PLC High-Speed Counter Application



### 11.4 HSC/HST Configuration

The screen of FP-07 will be taken as an example to describe HSC Configuration in this section (as to PROLADDER, please refer to the description for PROLADDER). The HSC Configuration, in sequence, includes the following 5 items:

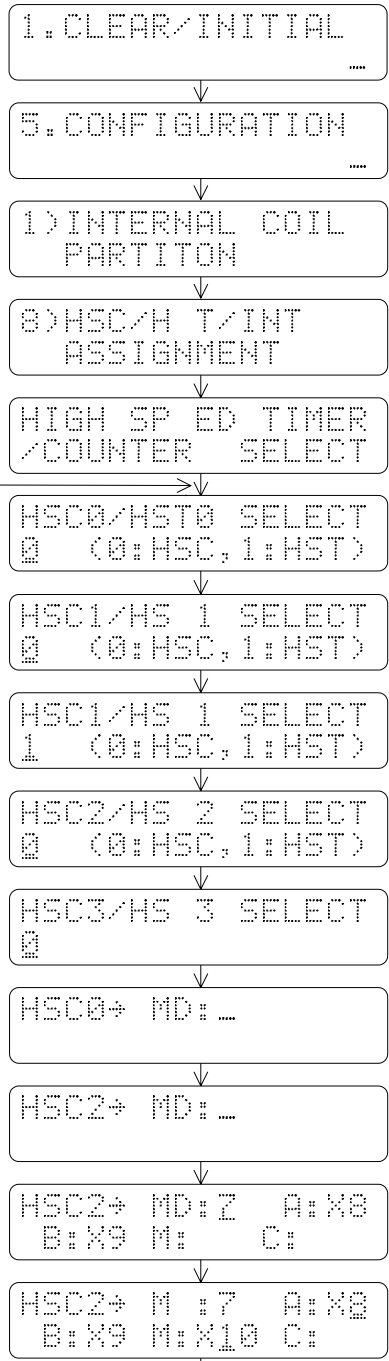
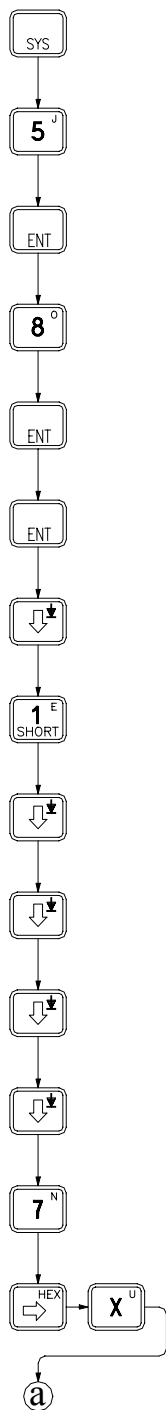
- ① Select assignment for HSC/HST (only HHSC provides this item selection function). Proceed to next item if selection is HSC. No other items are required if configured as HST.
- ② Assign respective HSC counting modes (MD0~MD7). After keying in the mode number, FP-07 will automatically display the HSC counting and control input names of the mode and reserve space for users to key in the external input point number Xn. The blank mode field indicates the HSC is not in use.
- ③ Determine whether the respective counting inputs (U, D, K, R, A and B) and control inputs (M and C) are to be applied or not (reserve the space if not in use and fill in the Xn value if it is to be applied. As respective Xn input values of HHSC are fixed, it requires only to key in alphabet "X" and FP-07 will automatically make up the preset number n).

- ④ Select whether the polarity of each HHSC counting input (U, D, K, R, A and B) is inverse or not, so as to match the polarity of the encoder (0: Not inverse, 1: Inverse. Preset as 0).
- ⑤ Select whether the polarity of each HHSC control input (M and C) is inverse or not, so as to match the polarity of the encoder (0: Not inverse, 1: Inverse. Preset as 0).

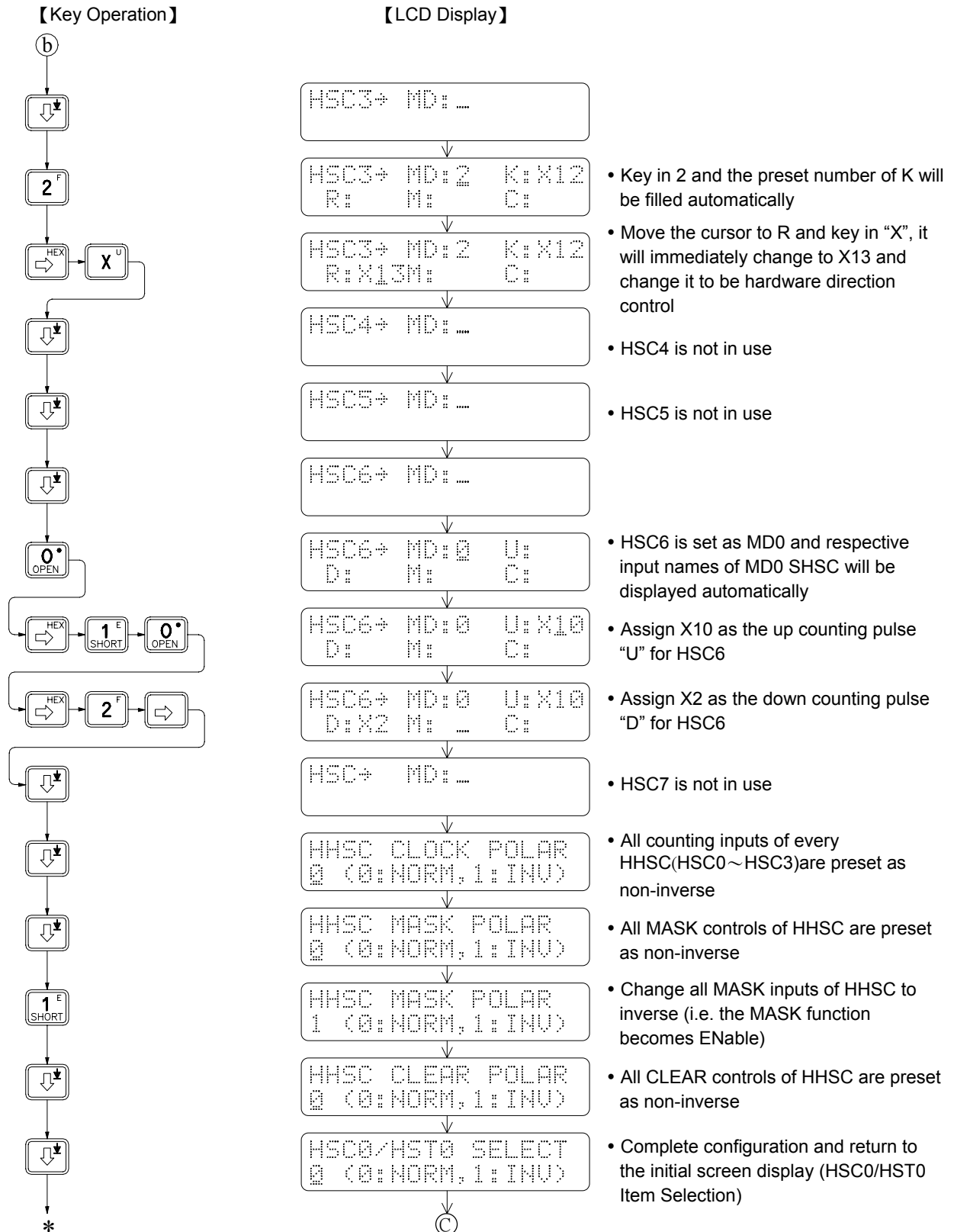
Examples applying FP-07 to perform the above mentioned ①~⑤ configurations


**【Key Operation】**

**【LCD Display】**



- HSC0 is preset as HSC
- HSC1 is preset as HSC
- HSC1 is used as a high-speed counter HST1
- HSC2 is preset as HSC
- HSC3 is preset as HSC
- MD field is blank indicating that HSC0 is not in use
- There is no need to configured HSC1 as it has been set to HST (No Display).
- MD field of HSC2 is blank indicating MD is not in use
- \* After 7 is keyed in, the respective MD7 input names will be displayed and the preset values for A and B (X8 and X9) will be filled automatically
- If MASK is required, just key in X and it will automatically fills number 10



- Input value modification can be made by directly key in the new value to overwrite. Use  key to delete any input value, if required.
- A blank field (without any value input) indicates the application of the HSC or the input is not required.
- "CLOCK" in the previous example represents the "Counting Input", i.e. U and D, K and R or A and B, of HHSC.
- "POLAR" represents "POLARITY", i.e. selection of inverse or non-inverse.

- The input point for respective HHSC counting and control inputs are fixed. Therefore, in the “Configuration Examples” of the previous example, it needs only to key in “X” for each HHSC input to indicate that the input is to be applied and FP-07 or PROLADDER will automatically make up the preset number for X, to which no change will be allowed. The user may assign respective SHSC counting or control inputs between X0~X15 freely. Hence, it is necessary to key in both the “X” and the number n for SHSC input point number to make it complete. All preset or selectable input point numbers, software MASK, software CLEAR, direction selection and other related numbers of HHSC and SHSC are summarized in the table below:

Type		HHSC				SHSC			
		HSC0	HSC1	HSC2	HSC3	HSC4	HSC5	HSC6	HSC7
Signal Allowed									
CV Register Number		DR4096	DR4100	DR4104	DR4108	DR4112	DR4116	DR4120	DR4124
PV Register Number		DR4098	DR4102	DR4106	DR4110	DR4114	DR4118	DR4122	DR4126
Counting Input	U, K or A	X0	X4	X8	X12	X0~X15	X0~X15	X0~X15	X0~X15
	D, R or B	X1	X5	X9	X13	X0~X15	X0~X15	X0~X15	X0~X15
Control Input	M	X2	X6	X10	X14	X0~X15	X0~X15	X0~X15	X0~X15
	C	X3	X7	X11	X15	X0~X15	X0~X15	X0~X15	X0~X15
Software MASK Relay		M1940	M1946	M1976	M1979	M1982	M1984	M1986	M1988
Software CLEAR Relay		M1941	M1947	M1977	M1980	Not available			
Software Direction Selection (MD2,3 Only)		M1942	M1948	M1978	M1981	M1983	M1985	M1987	M1989
Interrupt Subroutine Label		HSC0I	HSC1I	HSC2I	HSC3I	HSC4I	HSC5I	HSC6I	HSC7I

\* MA model CPU provides two SHSCs - HSC2 and HSC3

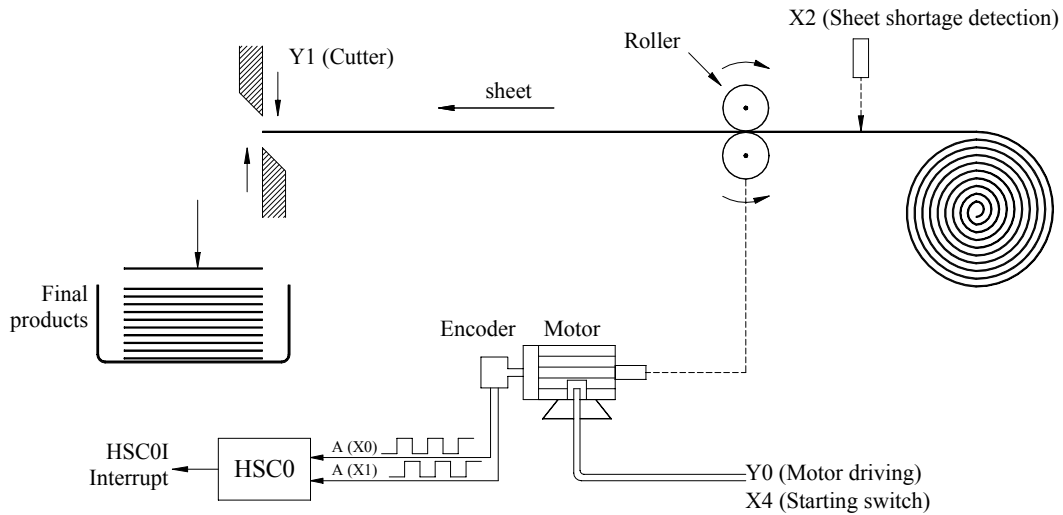
As far as HHSC is concerned, since all input points are fixed, some input points, if required, will need to exist but cannot be selected by the user (e.g. HSC2 is MD7; in this example, whose A/B input must be used in pair, as X8 and X9. For HSC3 is MD2; K must be X12). FP-07 or PROLADDER will automatically fill these input points, and they should not be changed. For those input points that do not need to be applied in pair or the user can select their existence (such as M and C of HHSC, U and D of MD0 or all SHSC inputs), FP-07 or PROLADDER will leave a space for selection input.

- The input point of X0~X15 in the table above can only be assigned once (i.e. used as one function), which can't repeat to be used.
- FBN-20MC contains a set of high speed differential input interface (X0~X3); the frequency can reach up to 512 KHz.
- FBN-28MC contains 2 sets of high speed differential input interface (X0~X7); the frequency can reach up to 512 KHz.
- FBN-20MC contains 4 sets of high speed differential input interface (X0~X15); the frequency can reach up to 512 KHz.
- The max. input frequency of hardware HSC of FBE or FBN (exclude high speed differential input) MC models, can reach 20KHz for single phase, and AB phase input frequency can reach up to 10KHz.
- The total input frequencies of SHSC can't be exceed 8 KHz; the higher the frequency, the more it occupy the system (CPU) time, and the scanning duration will be extended abruptly.

## 11.5 Examples for Application of High-Speed Counter

**Example 1** This example uses high-speed counter for equal-length cutting control.

### Mechanism



**HSC Configuration** (Just set HSC0 to MD7 and complete the configuration)

```
HSC0/HST0 SELECT
0 (0:HSC, 1:HST)
```

- No change is required on preset values

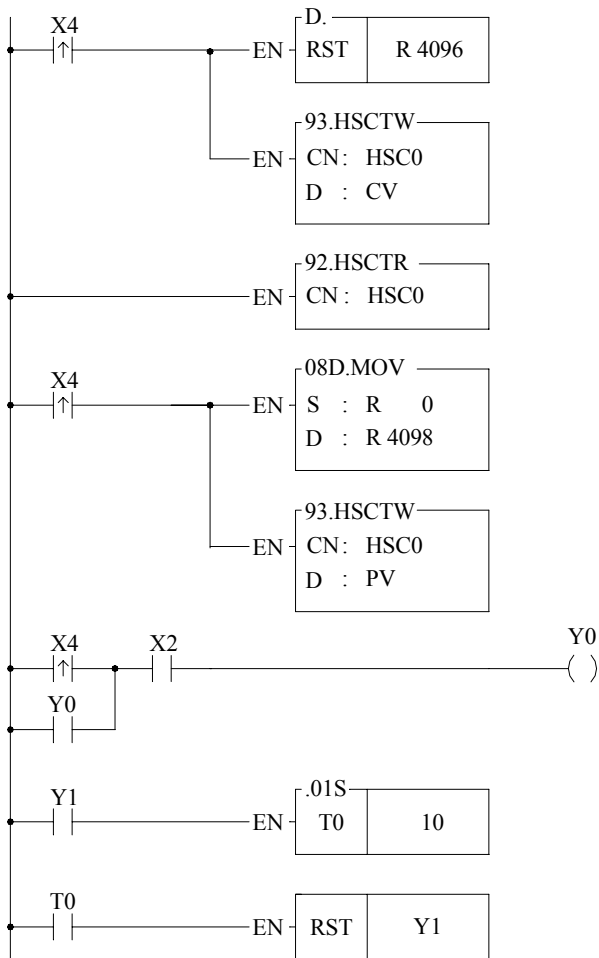
```
HSC0+ MD: 7 A: X 0
      B: X1 M:      C:
```

- Setting HSC0 to be MD7 (A/B×4), and resolution of cutting will be increased by 4 times.
- M and C are not required for application

- All other settings (polarity of counting and control inputs) are default (non-inverse) and need not to be changed.

## Control Program

### 【Main Program】



- CLEAR the current value register DR4096 of HSC0

- Use FUN 93 to write the contents of the current value register into the CV register of HSC0 in the ASIC chip  
CN =0 indicates HSC0  
D =0 indicates CV

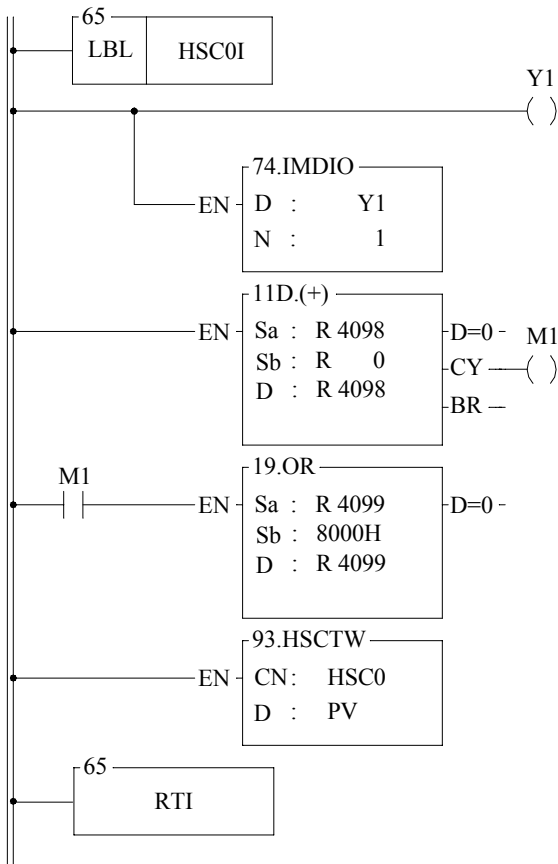
- Use FUN 92 to read the counting value of the HSC0 CV register in the ASIC chip (store into DR4096)

- Store the counting of cutting length DR0 into DR4098 and use FUN93 to store the value into the PV register of HSC0 in the ASIC chip  
CN =0 indicates HSC0  
D =1 indicates PV

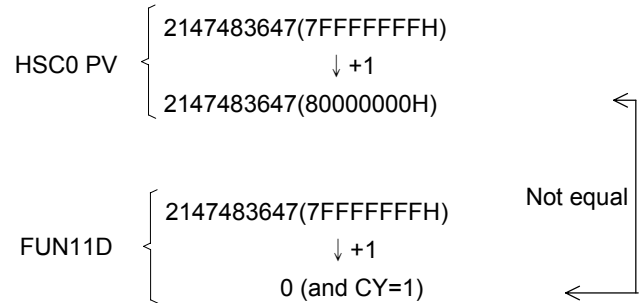
- Start the motor

- Turn the cutter Y1 ON for 0.1 second

**【Subroutine】**



- When HSC0 CV=PV in the ASIC chip, the hardware will automatically execute the interrupt subroutine labeled HSC0I
- When counting is up, turn Y1 ON (to cut materials)
- Output Y1 immediately to reduce the error caused by scan time
- Calculate new cutting position and load HSC0 PV



Therefore, it is necessary to use the CY output of FUN11D to rectify DR4098 (1→b31)

**【Description】**

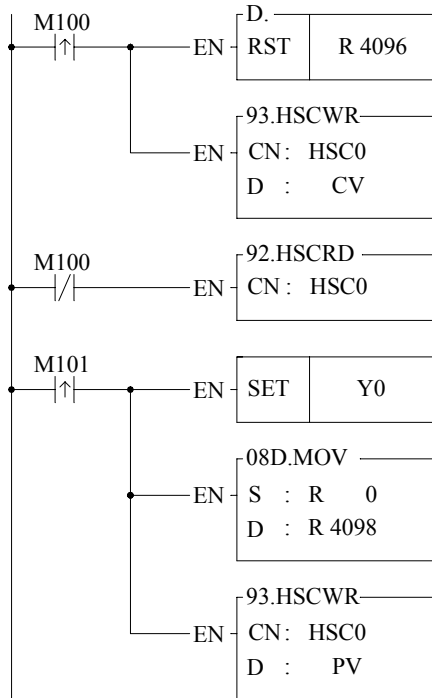
1. The main program will initialize the HSC0 CV (CV=0) in advance and move the cropping length (DR0) to the HSC0 PV before starts Y0 to turn on the motor for material conveying.
2. When CV reaches PV, the length of R0 is added to the PV before being reloaded into HSC0 PV.
3. When all materials are rolled out, the material shortage detector X2 will be ON and stop the motor.



**Example 2**

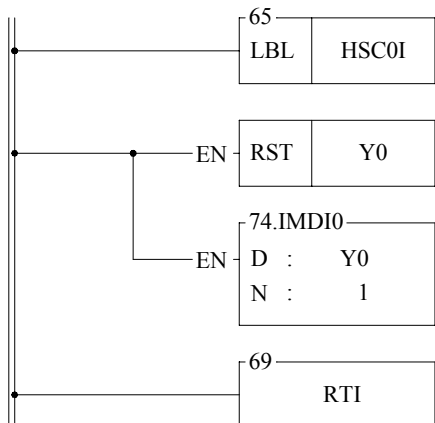
Example of high speed counting up action processed by Interrupt

**【Main Program】**



- As M100 change from 0→1, it clears the current value register to 0
- Employ FUN93 to write the content of current value register into the CV of HSC0 in ASIC chip (reset)  
CN =0, represents HSC0  
D =0, represents CV
- Employ FUN92 to read out the current counting value of HSC0 in ASIC chip, and store it into the CV register (DR4096)  
CN=0, represents HSC0
- As M101 change from 0→1, start Y0 ON (begin to operate)
- Move target point DR0 to preset register DR4098
- Employ FUN93 to write the content of preset register into HSC0 PV in ASIC chip, which serves as setting value of counting up interrupt  
CN=0, represents HSC0  
D =1, represents PV

**【Subroutine】**

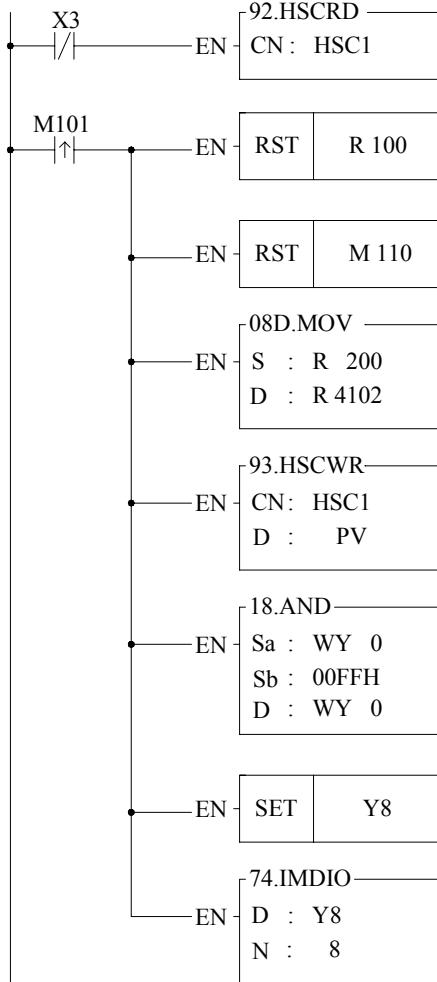


- Hardware high speed counter #0 interrupt label
- When time up, it sets Y0 OFF (stop)
- Let Y0 out immediately, so as to stop promptly (otherwise Y0 will have a scan time output delay)

**Example 3**

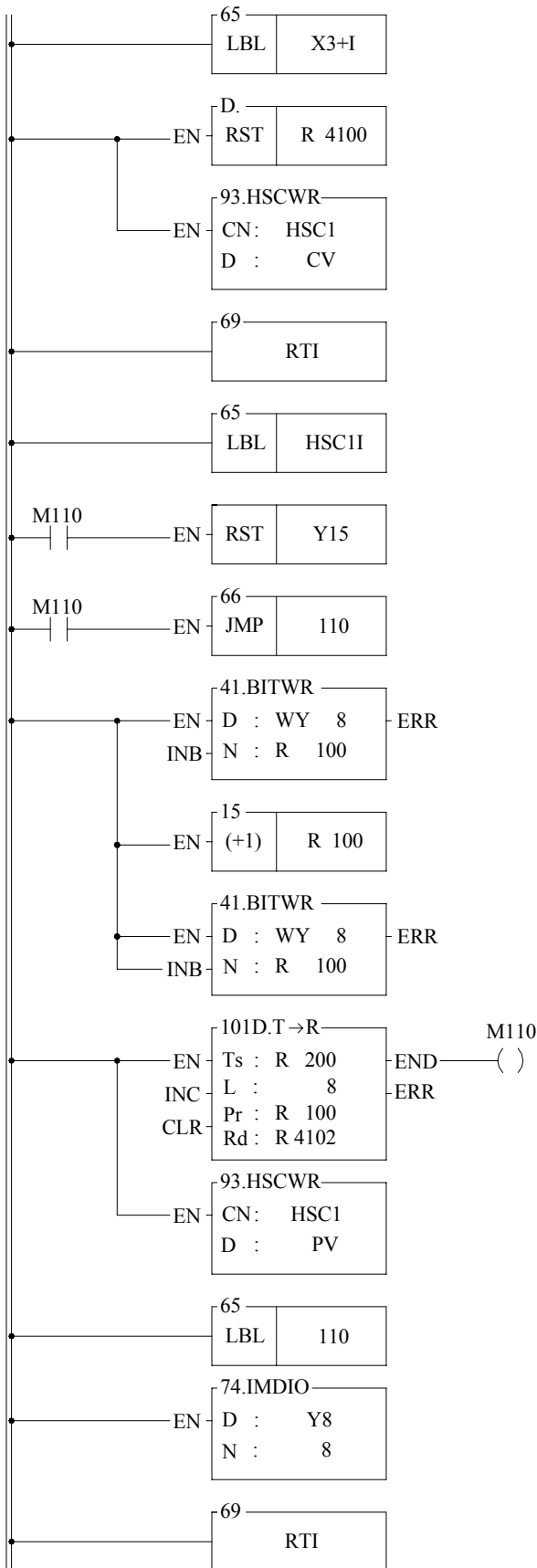
Example of Immediate response of multi-zone high speed counting up by Interrupt Processing

**【Main program】**



- Employ FUN92 to read out the current value of HSC1 in ASIC chip, and store it into current value register DR4100  
CN =1, represents HSC1
- As M101 change from 0→1, clears the pointer register to 0
- Clears the flag of the last zone to be OFF
- Move the counting of travel length DR200 (section 0) to preset register DR4102
- Employ FUN93 to write preset register content into HSC1 PV in ASIC chip, which serve as counting up setting vlue.  
CN =1, represents HSC1  
D =1, represents PV
- Clear Y8~Y15 to be OFF
- Set Y8 ON, it represents that it is at the zone 0 currently
- Set Y8~Y15 output t immediately

【Subroutine】



- Label name for the X3 rising edge interrupt service subroutine of X3+1 (it must assign X3 to be the rising edge interrupt input)
- When X3 changes from 0→1, it clears the current register to be 0
- Employ FUN93 to write the current register content to the HSC1 CV in ASIC chip (reset).  
CN =1, represents HSC1  
D =1, represents CV

- Labeled as HSC1I hardware high speed counter interrupt service subroutine.

- Turn Y15 OFF when the last zone finished.

- Make the previous zone output OFF

- Set the pointer point to the next zone

- Set the output of next zone to be ON

- Move the counting value of next zone (beginning from DR200 pointer pointed register) to the preset register DR4102
- When it's the last zone, the M110 is ON

- Employ the FUN93 to write the preset value into the HSC1 PV in the ASIC chip, which serves as counting up interrupt setting point.  
CN =1, represents HSC1  
D =1, represents PV

- Y8~Y15 output transmitting immediately

## 11.6 FB-PLC High-Speed Timer

The minimum timing unit (time base) of an ordinary PLC can only reach 1ms, on which the deviation in scan time should also be added. Therefore, it is necessary to apply high-speed timer (HST) if a more precise timing (e.g. using timer to cooperate with HSC for frequency measurement) is required.

FB-PLC is built in a high-speed timer (HSTA) with a time base of 16 bits/0.1ms and, as described previously, four 32-bit high-speed counters (HSC0~HSC3) of HHSC that can be converted to high speed timer (HST0~HST3) with a time base of 32 bits/0.1ms for using. Thus, FB-PLC can have up to five high-speed timers. As HSC and INT, all HST can be enabled or disabled (default as enable) by the instructions EN (FUN145) and DIS (FUN146). HSTA and HST0~HST3 are respectively described as below.

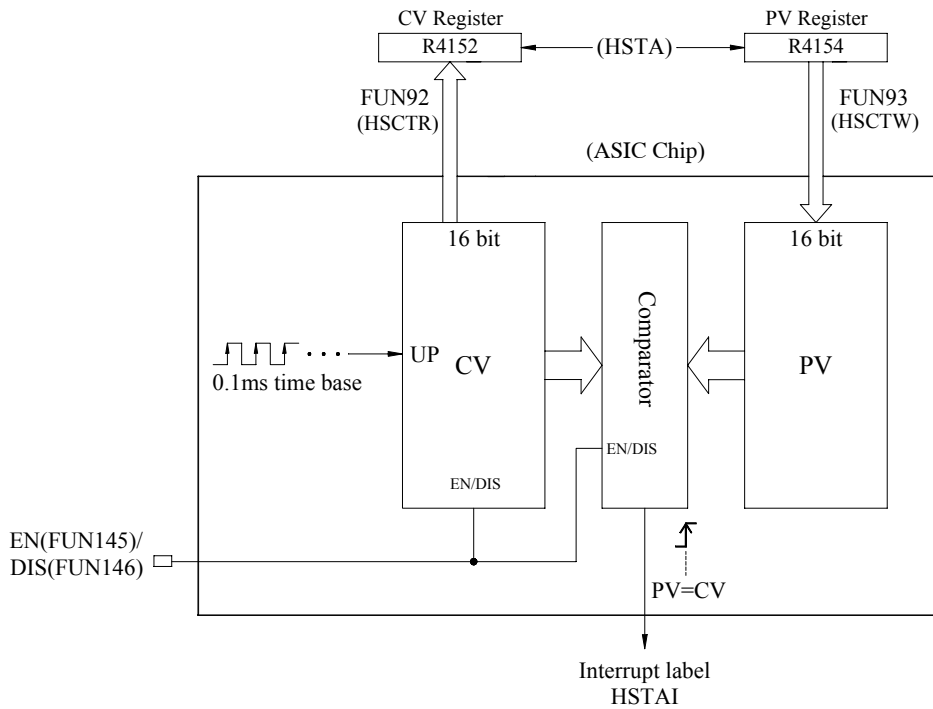
The finest time base for most of the ordinary PLC is 10ms. Though some PLC may have HST with a time base of 1ms. When deviations in the PLC scan time is taken into consideration (e.g. if the scan time is 10ms when the time base is 1ms, the total deviation still exceeds 10ms), the figure of 1ms becomes meaningless. Therefore, these PLCs can't be applied in high precision timing. FB-PLC, having a time base of 0.1ms, has no deviation in scan time for its time up is sent out by interrupt to provide a precision 100 times better than ordinary PLCs' timer application and can be used for many applications demanding precision timing.

### 11.6.1 HSTA High-Speed Timer

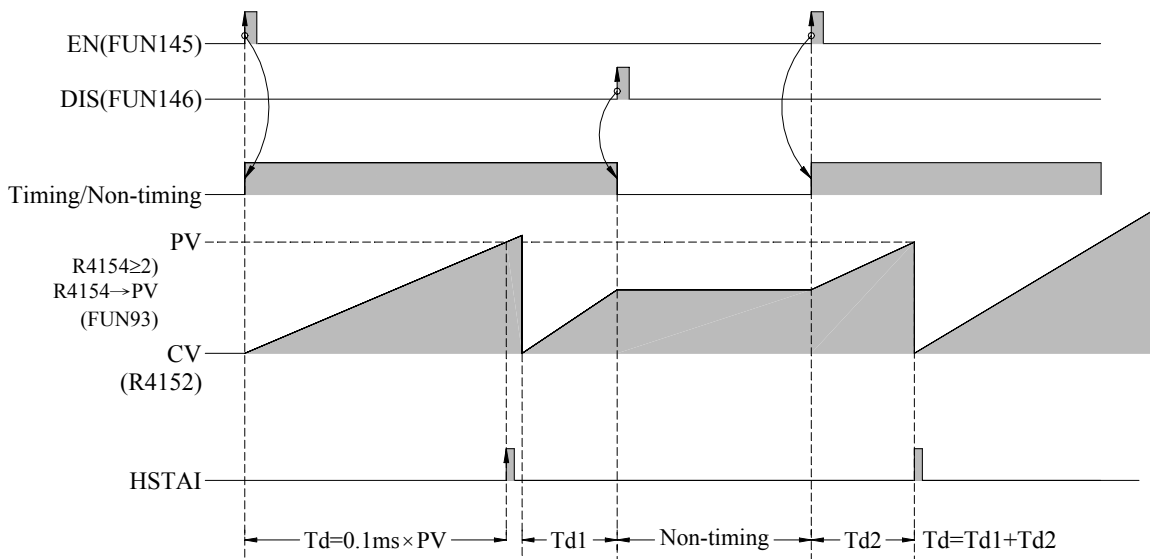
HSTA is a 16-bit hardware timer built in the ASIC chip. As HHSC, it must use the instruction FUN93 (HSCTW) to load the HSTA and PV register (R4154) to the HSTA PV in the chip, and with the instruction FUN92 (HSCTR) to read for CV. HSTA can be used as a timer having two different functions. FB-PLC will use it as a general 16-bit delay timer when  $PV \geq 2$  and as a 32-bit cyclic timer when  $PV=0$ .

**A. HSTA 16-Bit High-Speed Delay Timer** (Timely Interrupt Timer)

After HSTA starts timing, the delay timer will delay for a time of  $PV \times 0.1ms$  before sending an interrupt out. When  $PV > 0$ , HSTA served as a delay timer which is 16-bit and its PV value can be set as 0002H~FFFFH (65535 having no positive or negative sign), i.e. the delay time can be set as 0.2ms~6.5535 seconds. Except that having a more precise time base and being able to send an interrupt out immediately at time-up to provide a much higher timing precision, the applications of HSTA are the same as an ordinary delay timer. The diagram below is the structure diagram for HSTA being used as a delay timer. Please refer to Section 11.6.3 "Program Examples" for detailed function and application.



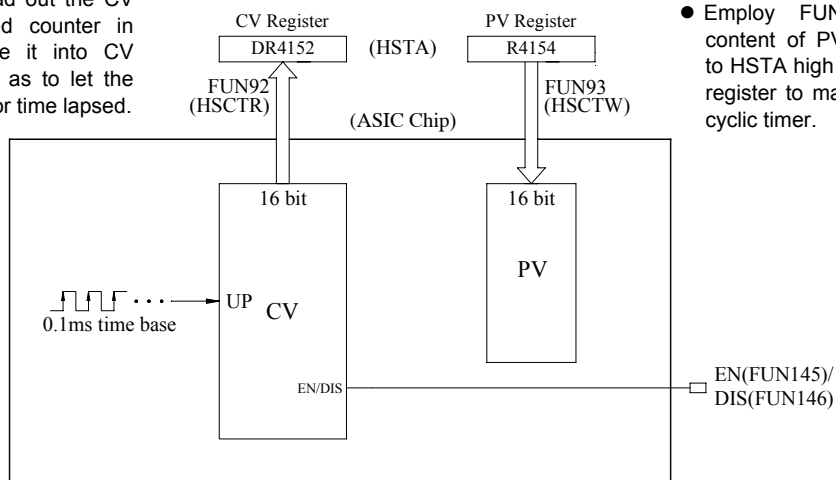
- Apply FUN93 to write the content of PV register ( $R4154 \geq 2$ ) into preset register of HSTA high speed timer in ASIC chip, which serves as timely interrupt timer (for every set point of timer it perform once the timely interrupt subroutine with label name of "HSTAI").



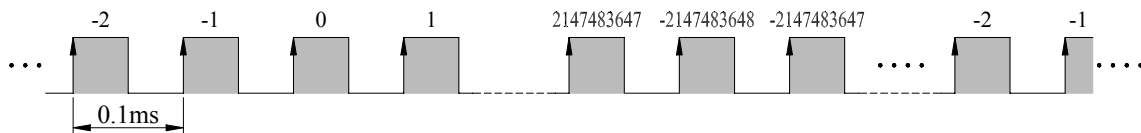
## B. HSTA 32-Bit High-Speed Cyclic Timer

The so-called "Cyclic Timer" is a timer that add 1 to its current value for every fixed interval and will persistently carry out up counting cyclic timing. Its CV value will cycle around as 0, 1, 2, ... 2147483647, -2147483648, -2147483647, ... -2, -1, 0, 1, 2, ... (as the time base is 0.1ms, CV value x 0.1ms will be its accumulative time). In fact, the cyclic timer is an up counting cyclic timing clock having a time base of 0.1ms that can operate endlessly and be used to read any two events at the time when they occurred and to calculate the time interval between the occurrence of the said two events. The Diagram B as shown below is the structure diagram for HSTA being used as a 32-bit cyclic timer. As shown in diagram, when cyclic timer PV=0, it will not send out the interrupt. To obtain the timing value, it is necessary to use FUN92 to access the CV value from the ASIC chip and save it to the 32-bit CV register (DR4152) in the PLC. The typical application of the cyclic timer is for more precision of turning speed (RPM) detection under the circumstances when the change in turning speed (RPM) is huge or when it is extremely low. Please refer to Example of Section 11.6.3 for description.

- Employ FUN92 to read out the CV of HSTA high speed counter in ASIC chip and store it into CV register (DR4152) so as to let the user know the value for time lapsed.



- Employ FUN93 to write the content of PV register (R4154=0) to HSTA high speed timer set point register to make it serve as 32 bit cyclic timer.

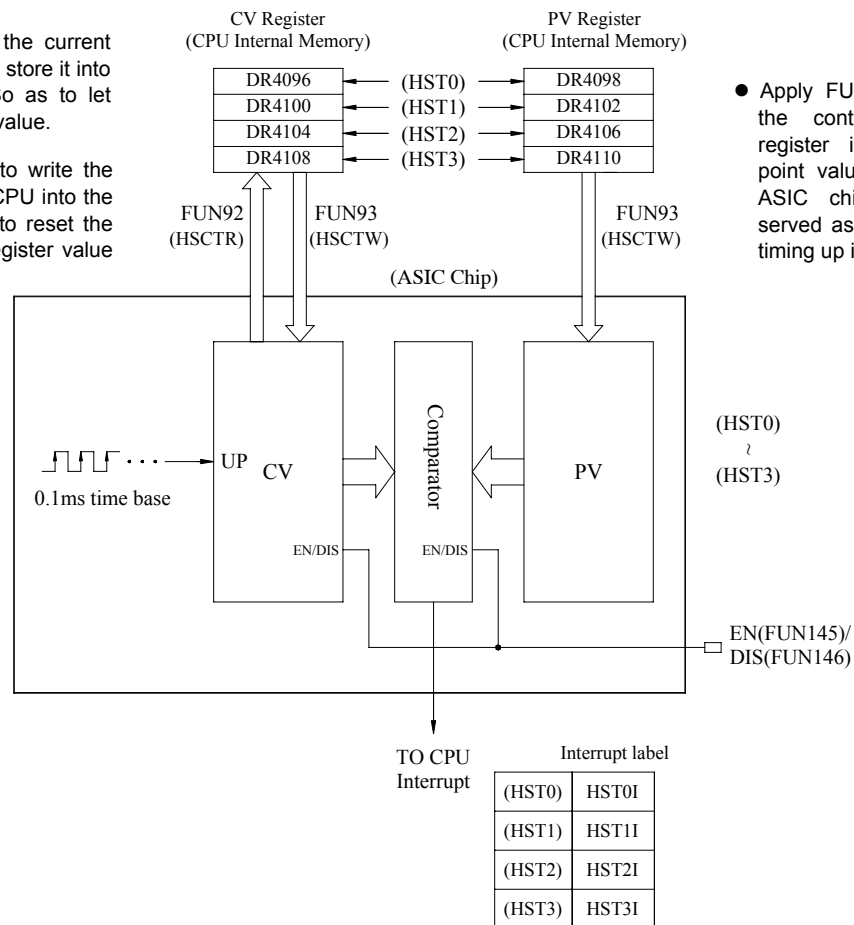


## 11.6.2 HST0~HST3 High-Speed delay timers

### A. HST0~HST3 High-Speed Delay Timer (Timely Interrupt Timer)

HHSC (HSC0~HSC3) can be planned as four 32-bit high-speed delay timers, HST0~HST3. They have the same functions and time base as a 16-bit HSTA delay timer except that HST0~HST3 are 32 bit to plan HHSC as HST only needs to select "1" in the HSC/HST Item Selection under Item 8 "HSC/HST/INT" of FP-07 or PROLADDER "Configuration". Please refer to the example (to configure HSC1 as HST1) in Section 11.4 "HSC/HST Configuration". The diagram below is the function structure diagram for HHSC being planned as a HST. Its applications are the same as that of a 16-bit HSTA. Please refer to Section 11.6.4 "Program Examples".

- Employ FUN92 to read out the current timing value in ASIC chip and store it into the CV register of CPU. So as to let user know the current timing value.
- It may also employ FUN93 to write the content of CV register from CPU into the CV in the ASIC chip so as to reset the timing value to be the CV register value of CPU.



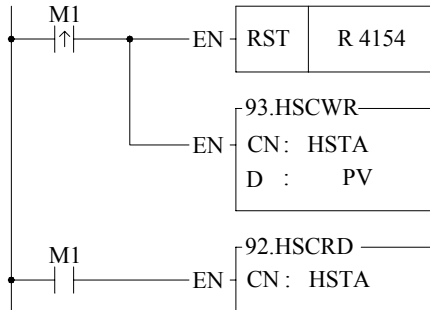
- Apply FUN93 to write the content of PV register into the set point value register in ASIC chip which is served as set point for timing up interrupt.

### B. HST0~HST3 32bit Cyclic Timer

According to demand, configured the HHSC(HSC0~HSC3) to be the 32-bit timers of HST0~HST3. For interval of every 0.1ms, the current timing value register in ASIC chip will be increased by 1. User may use FUN92 instruction to read out the current timing value and store it into the CV registers (DR4096, DR4100, DR4104, and DR4108) of CPU. Therefore the content of CV register of CPU become 0, 1, 2, ....., 7FFFFFFFH, 80000000H, ....., FFFFFFFFH, 0, 1, ..... etc. variation of values for 32-bit. With the timing calculation technique to count the interval between two events, it can obtain infinite number of 0.1ms 32-bit timers.

### 11.6.3 Examples for Application of High-Speed Timer HSTA

#### Example 1 HSTA serve as 32-bit cyclic timer

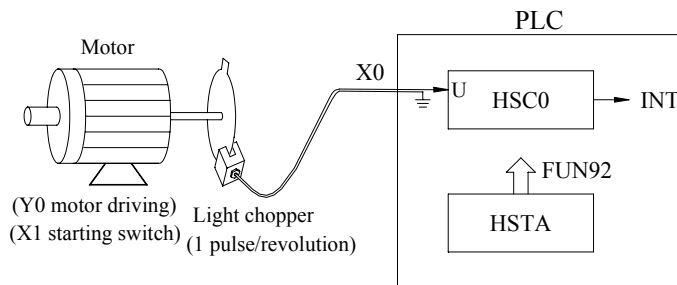


- R4154=0, treat HSTA as 32 bit cyclic timer
- Employ FUN93 to write the preset value into the HSTA PV in the ASIC chip  
CN =4, represents HSTA  
D =1, represents PV
- Employ FUN 92 to read out the current timing value of HSTA in ASIC chip and store it to R4152  
(DR4152 value change from 0,1,2, …,FFFFFFF,0,1,2, …cyclic variation, the unit is 0.1mS)
- CN =4, represents HSTA

#### Example 2 Application example for cyclic timer

This example uses HSTA as a cyclic timer, cooperating with HSC0, to read the time interval for accumulation of 10 pulses and sending an interrupt out each time as 10 pulses are accumulated and, reciprocally, find out the required RPM (the number of pulses is fixed when the time varies).

#### Mechanism



#### HSC and HST Configuration

- ① As HSTA is built in, no configuration is required. Simply make PV (R4154)=0 to make it as a 32-bit cyclic timer.
- ② To cooperate with the photo interrupter, set the HSC0 as an up counting counter having single input (MD0, but use only U input).

```
HSC0/HST0 SELECT
0 (0:HSC, 1:HST)
```

- No change of the preset value is required

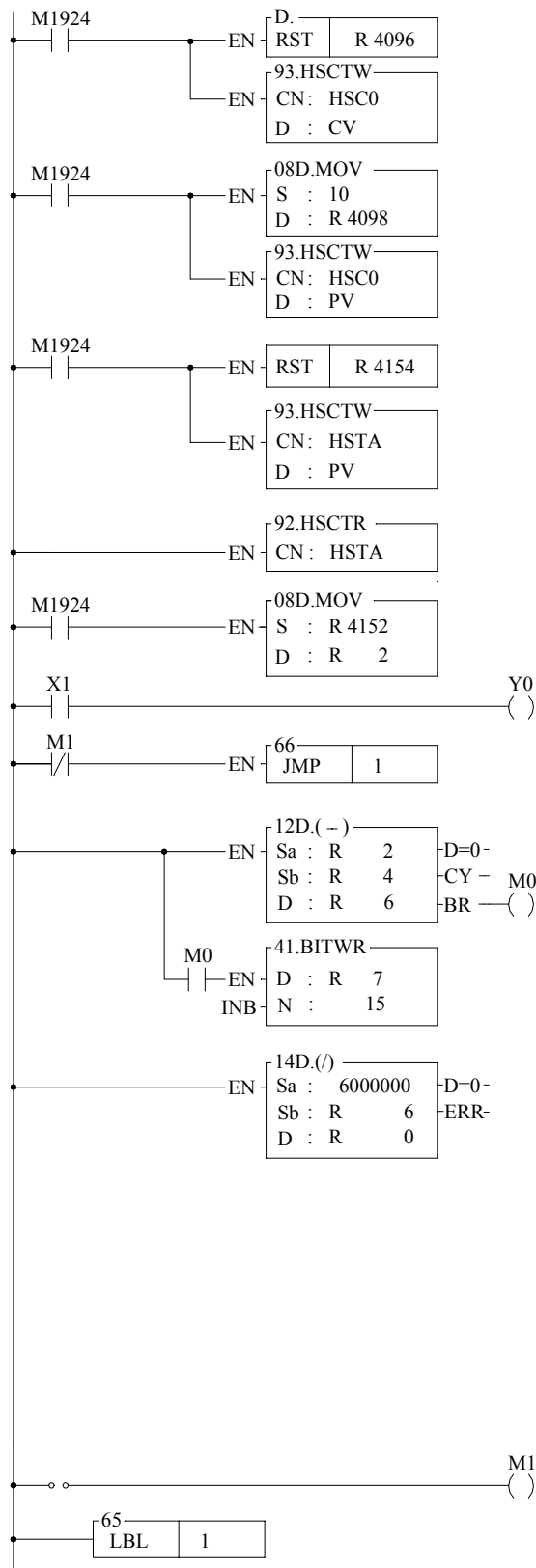
```
HSC0+ MD:0 U:X4
D: N: C:
```

- Configure HSC0 as an up counting counter with single input only
- No application of other inputs is required

All other settings (polarity of counting and control inputs) are preset (non-inverse) and should not be changed.



**【Main Program】**



- The initial value of HSC0 CV register is 0
- Write 0(DR4096) into CV register (reset the counts) in ASIC chip; FUN93 CN=0 indicates HSC0 and D=0 indicates CV
- The initial value of HSC0 PV register (DR4098) is 10
- Write 10(DR4098) into the preset register in ASIC chip, which acts as interrupt value for counting up; FUN93 CN=0 indicates HSC0 and D=1 indicates PV
- Make R4154=0
- Write 0(R4154) into the preset register, and HSTA is configured as a 32-bit high-speed cyclic timer FUN93 CN=4 indicates HSTA and D=1 indicates PV
- Read the current timing value
- The initial value of HSTA CV register is stored to DR2

- Find interval for each HSC0 interrupt

$$\Delta T(DR6 \times 0.1 \text{ out the ims})$$

$$\begin{aligned}
 \text{CV value of HST (DR4152)} & \begin{cases} 2147483647(7FFFFFFFH) \text{-----A} \\ \downarrow +1 \\ -2147483648(80000000H) \text{-----B} \end{cases} \\
 \text{FUN12D} & \begin{cases} B-A=-2147483647(80000001H) \\ \text{And BR}=1 \end{cases}
 \end{aligned}$$

Consequently it need to use FUN12D BR output for DR6 rectification (1→b31)

- Rotating speed =  $\frac{N}{\Delta T} \times 60 \text{ RPM}$

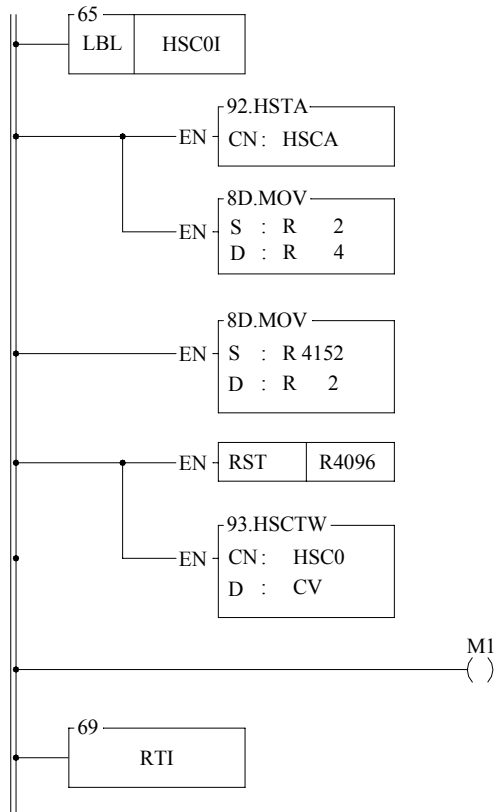
$$N=10, \Delta T = \Delta CV \times 0.1 \text{ms} = \frac{(\text{currentCV} - \text{previousCV})}{10000S}$$

$$\text{Therefore rotating speed} = \frac{6000000}{\Delta CV} \text{RPM}$$

- R0=RPM

- Clear the calculation flag of RPM

**【Subroutine】**

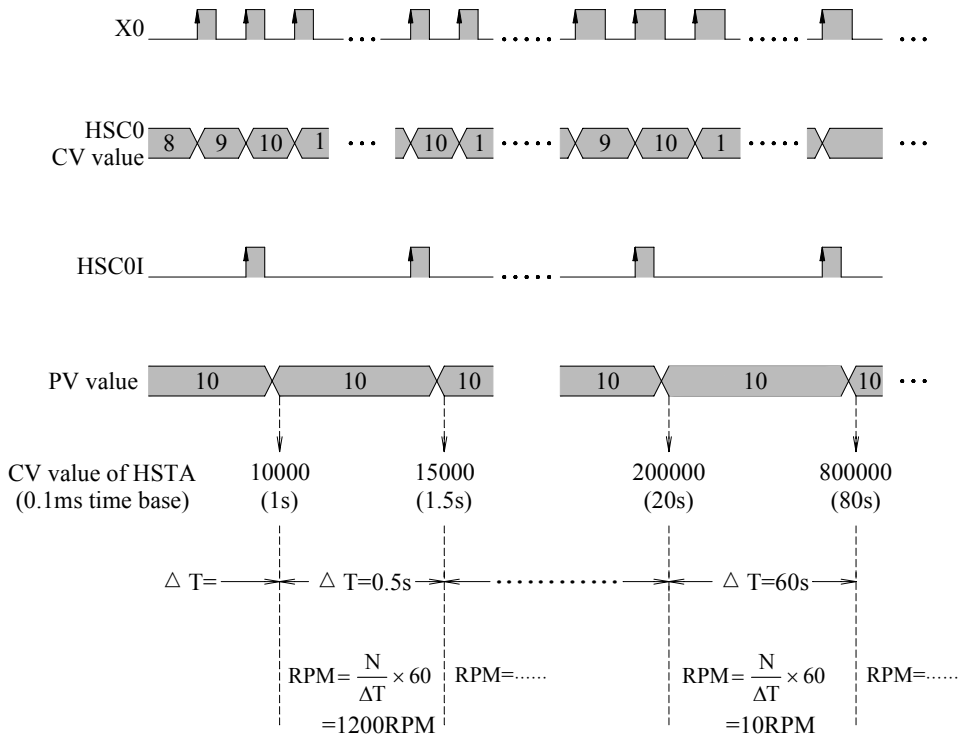


• Each time when HSC0 accumulates 10 pulses, the hardware will automatically run this interrupt subroutine

• Read the HSTA CV

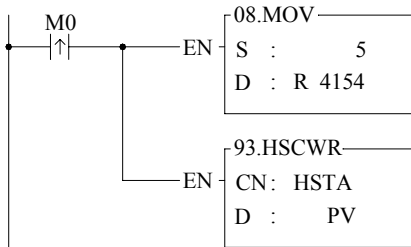
• Reset the current value to 0

• M1=ON, RPM calculating flag



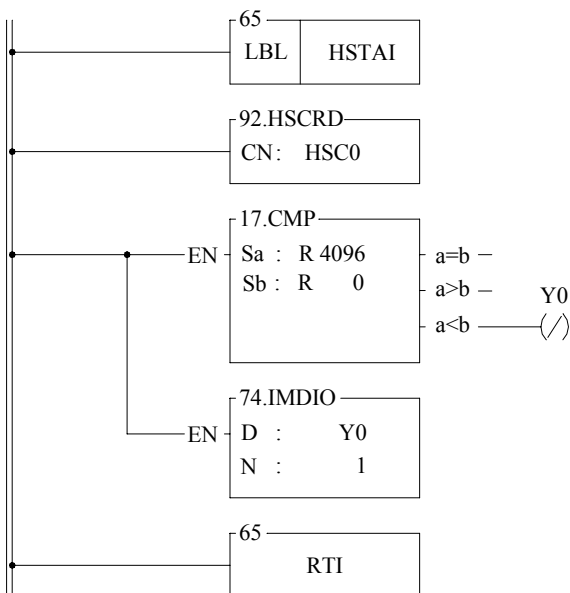
**Example 3 HSTA Serve as Timely Interrupt Timer Program**

**【Main Program】**



- Set up the period of timely interrupt time. R4154=5 represents that it performs the interrupt service subroutine with the label name of HSTAI every 0.5mS.
- Employ FUN93 to write the preset value into HSTA PV in ASIC chip, which serve as time up for interrupt preset value. CN =4, represents HSTA  
D =1, represents PV

**【Subroutine】**



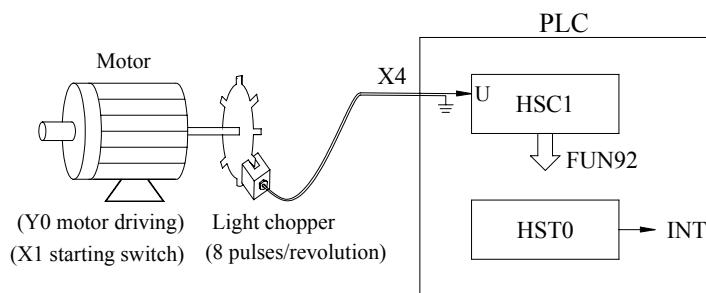
- Interrupt service subroutine with the label name of HSTA.
- Read the current value of hardware high speed counter HSC0 once every 0.5mS.
- To tell whether the current counting value is greater than R0, if yes, then Y0 will be ON.  
※ While reading the current counting value from hardware high speed counter (HSC0~HSC3) in HSTAI timely interrupt program, only the 16-bit of Low Word is effective.
- Update output Y0 immediately, so as to reach the high speed output reaction (otherwise there will be introduced a delay in scan time)

## 11.6.4 Examples for Application of High-Speed Timer HST0~HST3

### Example 1 Application example for delay timer

This example configures HSC0 HST as a HST0 delay timer. At the same time, by connecting the high-speed counter HSC1 with a rotary motor of an automatic wood drilling machine and sending out an interrupt at a fixed period. Each time interrupt occur will read the counting value of the counter. Then, by comparing the change in speed between the number of the motor's rotation when no loading is applied (operating without drilling) and that when the drill head is pressing down (drilling), the change of the motor's RPM can be calculated. It is understood that resistance will be less and motor's RPM will be faster when the drill head is normal (sharp) than when the drill head is blunt. When the drill head is broken, it works like operating without drilling that no resistance exists and RPM is the fastest. Usually the difference in rotating speed among the three conditions is not significant and which cannot be sampled and detected by an ordinary timer having a more than tens of ms of deviation. However, applied with an HST having a time base of 0.1ms that incorporating interrupt, the drill head's status (normal, blunt or broken) can be detected and, thus, warning can be given or operation can be stopped in due time for drill head replacement. 【The time is fixed and the number of pulses varies】

### Mechanism



### HSC and HST Configuration

```
HSC0/HST0 SELECT
1 (0:HSC, 1:HST)
```

- HSC0 is set as HST0

```
HSC1/HST SELECT
0 (0:HSC, 1:HST)
```

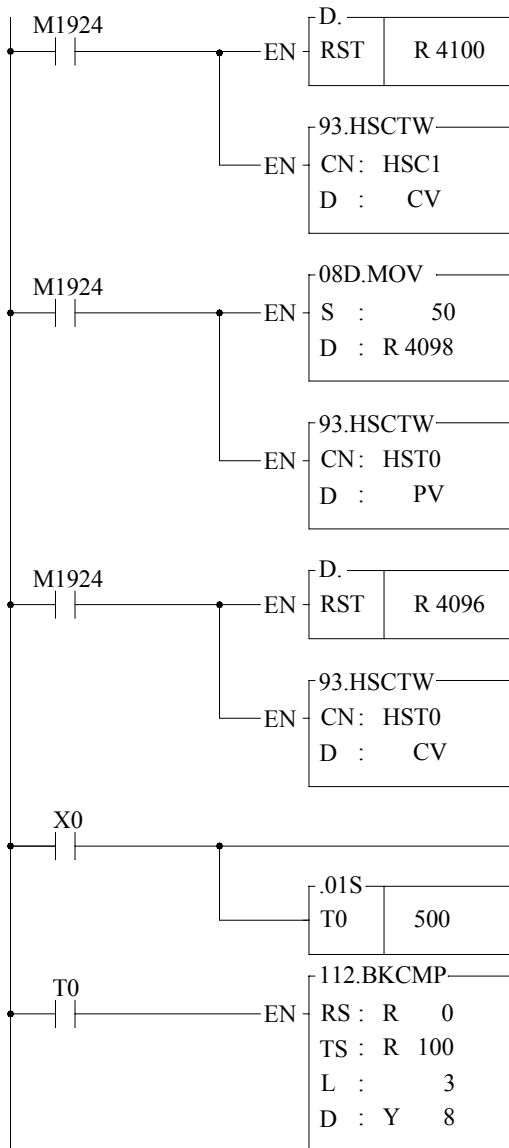
- HSC1 is preset as HSC

```
HSC1+ MD:0 U:X4
D: N: C:
```

- HSC1 is set as MD0, an up counting counter with single input. Other inputs will not be used.

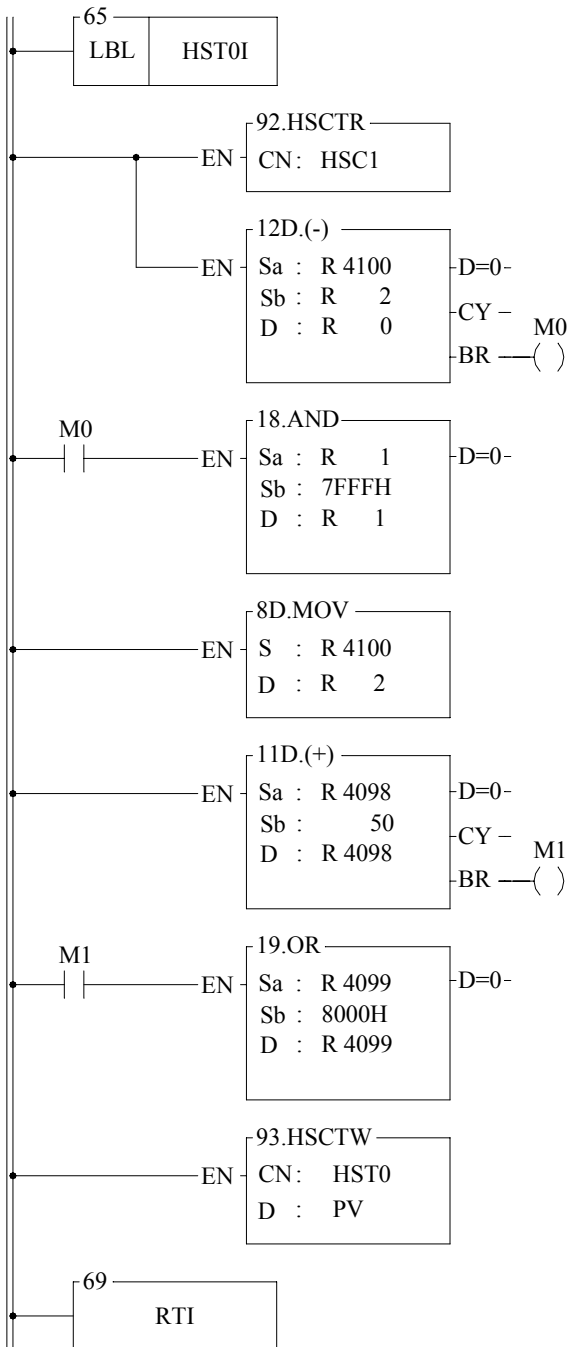
- All other settings (polarity of counting and control inputs) are default (Non-inverse) and should not be changed.

**【Main Program】**



- The initial value of HSC1 CV register is 0
- Employ FUN93 to write into current value register in ASIC chip. FUN93 CN=1 indicates HSC1 and D=0 indicates CV
- HST0 PV value is set as 50, i.e. one interrupt every 5ms (50×0.1ms)
- The initial value of HST0 CV register is 0
- Use FUN112 to compare the drill head's RPM speed after starting the motor for 5 seconds  
R0: The number of HSC1 pulses obtained in every 5ms

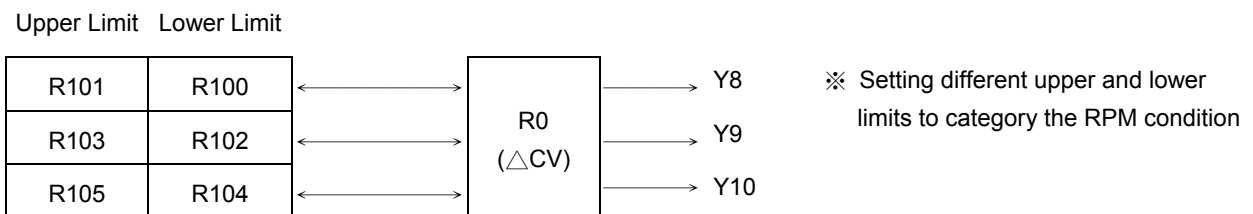
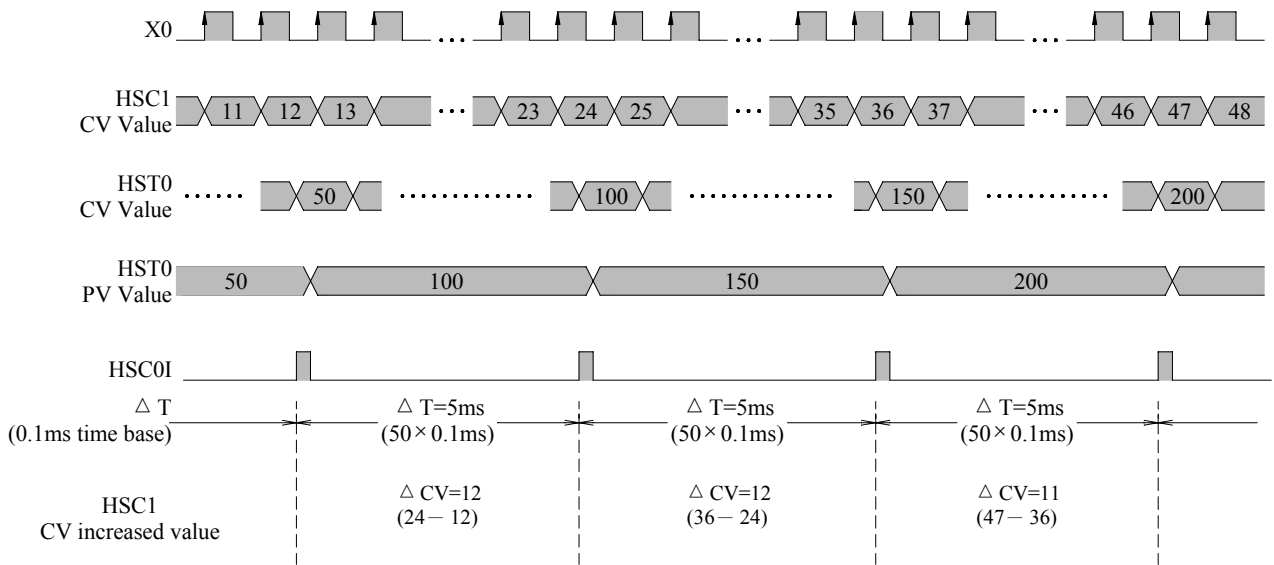
**【Subroutine】**



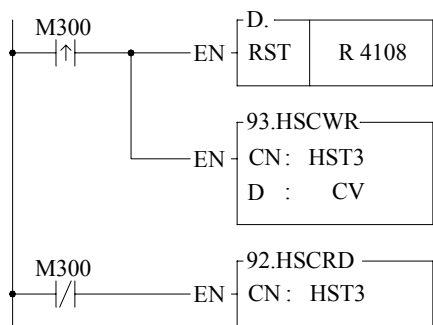
- The hardware will execute this subroutine once every 5ms
- Find out the increment of HSC1 CV value in this 5ms interval and store the value into DR0 (practically R1=0)
- Calculate the new HSC0 PV

**【Description】**

Supposed that the drill head's normal RPM is 18000rpm and the photo interrupter will generate 8 pulses in one revolution, then the frequency of the pin U of HSC1 is  $18000/60 \times 8 = 2400\text{Hz}$ , i.e. 120 pulses will be generated for every 5ms. Therefore, HST0 can be used to send an interrupt and read the HSC1 CV value every 5ms to get the RPM value.



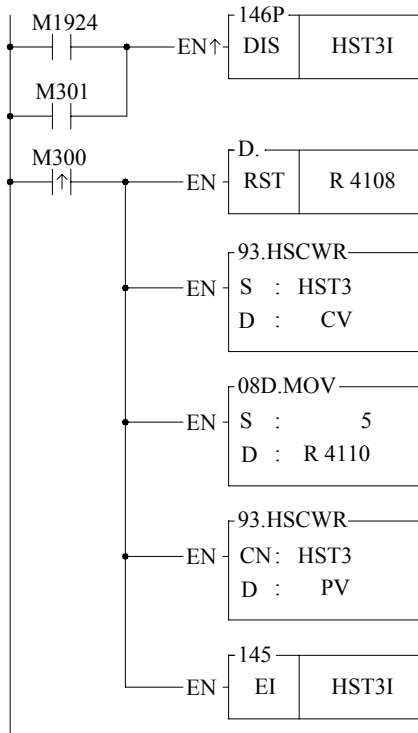
**Example 2 Hardware high speed timer HST3 serve as 32-bit cyclic timer**



- As M300 change from 0→1, clear the current value register to 0
- Employ FUN 93 to write the content of current value register into the HST3 CV (reset) in ASIC chip  
CN =3, represents HST3  
D =0, represents CV
- Employ FUN92 to read out the current timing value of HST3 in ASIC chip and store it into the current value register DR4108  
(DR4108 value cyclically changes from 0, 1, 2, ..., FFFFFFFF, 0, 1, 2, ... the unit is 0.1mS)  
CN =3, represents HST3

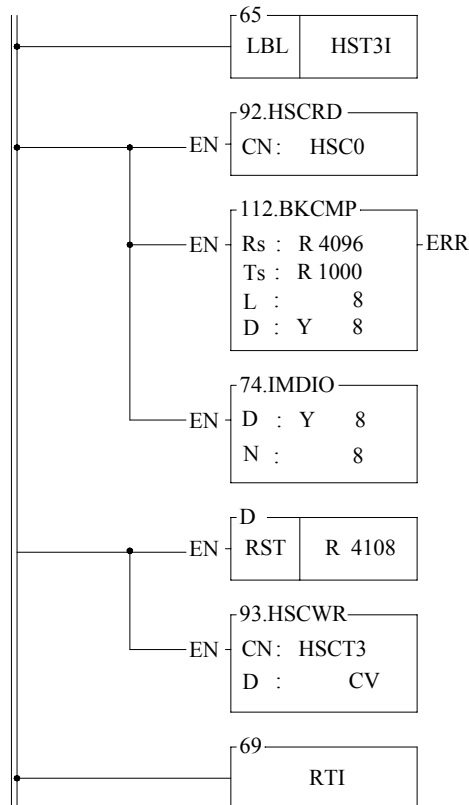
**Example 3 Hardware High Speed Timer HST3 Serve as Periodic Interrupt Timer**

**【Main Program】**



- Turn on or M301 is ON, it prohibits the HST3 from sending periodic interrupt
- As M300 change from 0→1, clear the current register to 0
- Employ FUN93 to write the content of current value register into the HST3 CV (reset) in ASIC chip.  
CN =3, represents HST3; D=0, represents CV
- Set up periodic interrupt interval; DR4110=5 represent every 0.5mS perform once the interrupt service subroutine with label name of HST3I.
- Employ FUN93 to write the content of preset register into the HST3 PV in ASIC chip, which serve as time up interrupt preset value.  
CN=3 represents HST3; D=1 represents PV
- Enable the HST3 interrupt

**【Subroutine】**



- Hardware high speed Interrupt service subroutine with the label name of HST3I.
- Read the current value of hardware high speed counter HSC0 once every 0.5mS.
- To tell which zone of the electronic drum does the current counting value fall, and set the corresponding output point to be ON.
- Update output Y8~Y15 immediately
- Clear the current value register to be 0
- Employ FUN93 to write the content of current value register into the HST3 CV in ASIC chip (reset).  
CN=3 represents HST3; D=0, represents CV