



STV9427 STV9428-STV9429

HIGH SPEED MULTISYNCH ON-SCREEN DISPLAY FOR MONITOR

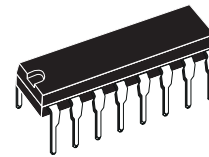
- CMOS SINGLE CHIP OSD FOR MONITOR
- BUILT IN 1 KBYTE RAM HOLDING :
 - CHARACTER CODES
 - USER DEFINABLE CHARACTERS
- 207 ALPHANUMERIC CHARACTERS OR GRAPHIC SYMBOLS IN INTERNAL ROM
- 12 x 18 CHARACTER DOT MATRIX
- PROGRAMMABLE ACCENTUATED CHARACTER SET
- CHARACTER BLINKING
- RAM DEFINABLE COLOR LOOK UP TABLE
- UP TO 16 USER DEFINABLE CHARACTERS
- UP TO 80MHz PIXEL CLOCK
- INTERNAL HORIZONTAL PLL (15 TO 120kHz)
- PROGRAMMABLE VERTICAL HEIGHT OF CHARACTER WITH A SLICE INTERPOLATOR TO MEET MULTI-SYNCH REQUIREMENTS
- PROGRAMMABLE VERTICAL AND HORIZONTAL POSITIONING
- FLEXIBLE SCREEN DESCRIPTION
- 22 CONTROL CODES FOR POWERFULL SERIAL ATTRIBUTES
- 2-WIRES ASYNCHRONOUS SERIAL MCU INTERFACE (I²C PROTOCOL)
- 8 x 8 BITS PWM DAC OUTPUTS
- SINGLE POSITIVE 5V SUPPLY

DESCRIPTION

The STV9427/28/29 is an ON SCREEN DISPLAY for monitor. It is built as a slave peripheral connected to a host MCU via a serial I²C bus. It includes a display memory, controls all the display attributes and generates pixels from the data read in its on chip memory. The line PLL and a special slice interpolator allow to have a display aspect which does not depend on the line and frame frequencies. I²C interface allows MCU to make transparent internal access to prepare the next pages during the display of the current page. Toggle from one page to another by programming only one register.

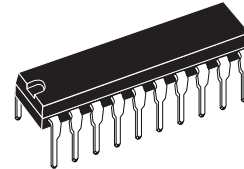
8 x 8 bits PWM DAC are available to provide DC voltage control to other peripherals.

The STV9427/28/29 provides the user an easy to use and cost effective solution to display alphanumeric or graphic information on monitor screen.



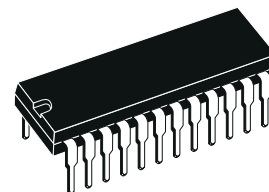
DIP16
(Plastic Package)

ORDER CODE : STV9427



DIP20
(Plastic Package)

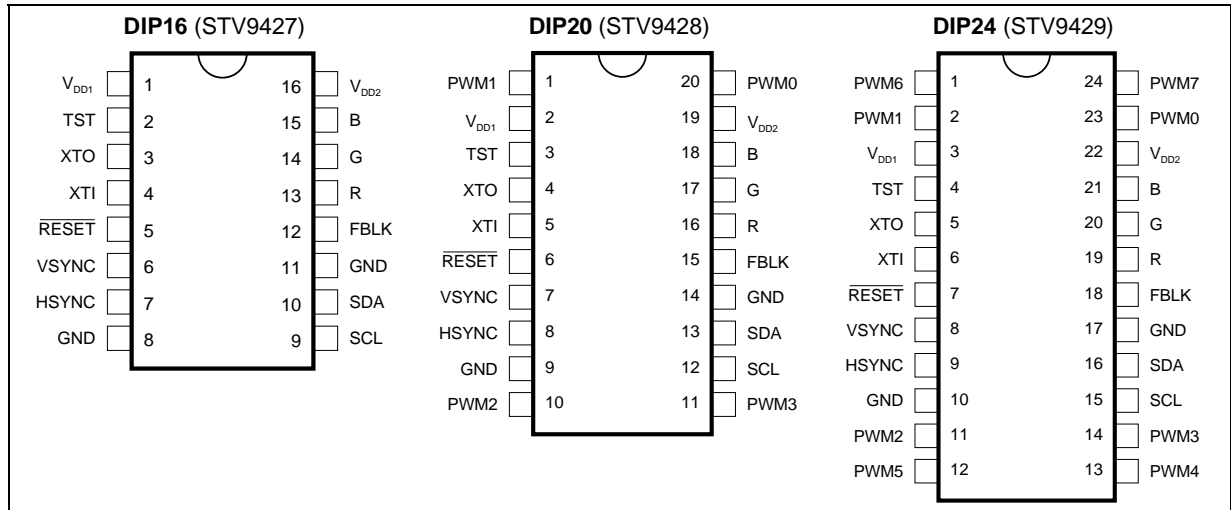
ORDER CODE : STV9428



DIP24
(Plastic Package)

ORDER CODE : STV9429

PIN CONNECTIONS



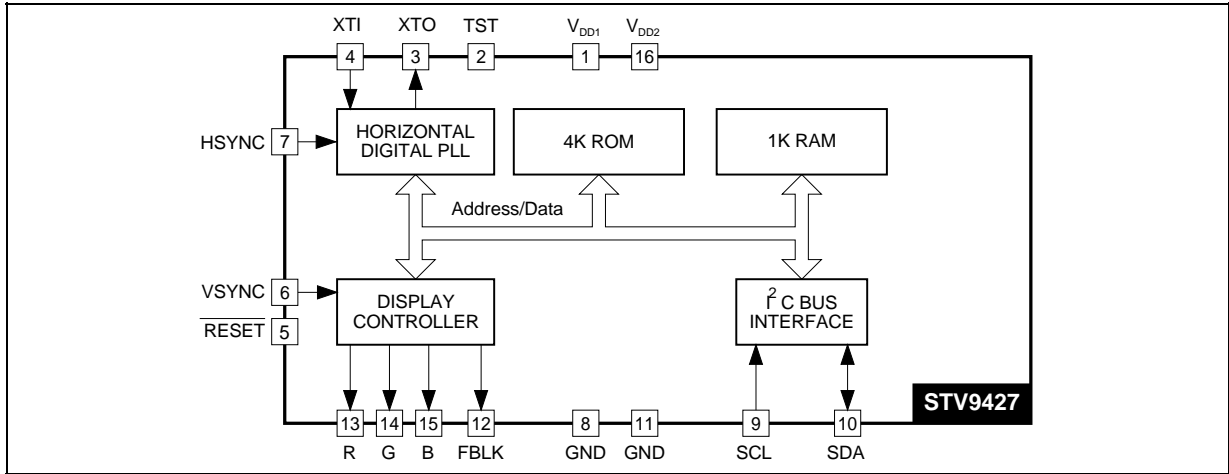
9427-01.EPS / 9428-01.EPS / 9429-01.EPS

PIN DESCRIPTION

| Symbol | Pin Number | | | I/O | Description |
|------------------|------------|-------|-------|-----|--------------------------------|
| | DIP24 | DIP20 | DIP16 | | |
| PWM6 | 1 | - | - | O | DAC0 Output |
| PWM1 | 2 | 1 | - | O | DAC1 Output |
| V _{DD1} | 3 | 2 | 1 | S | +5V Logic Supply |
| TST | 4 | 3 | 2 | I | Reserved (not to be connected) |
| XTO | 5 | 4 | 3 | O | Crystal Output |
| XTI | 6 | 5 | 4 | I | Crystal or Clock Input |
| RESET | 7 | 6 | 5 | I | Reset Input (Active Low) |
| VSYNC | 8 | 7 | 6 | I | Vertical Sync Input |
| HSYNC | 9 | 8 | 7 | I | Horizontal Sync Input |
| GND | 10 | 9 | 8 | S | Logic Ground |
| PWM2 | 11 | 10 | - | O | DAC2 Output |
| PWM5 | 12 | - | - | O | DAC3 Output |
| PWM4 | 13 | - | - | O | DAC4 Output |
| PWM3 | 14 | 11 | - | O | DAC5 Output |
| SCL | 15 | 12 | 9 | I | Serial Clock |
| SDA | 16 | 13 | 10 | I/O | Serial Input/output Data |
| GND | 17 | 14 | 11 | S | Ground |
| FBLK | 18 | 15 | 12 | O | Fast Blanking Output |
| R | 19 | 16 | 13 | O | Red Output |
| G | 20 | 17 | 14 | O | Green Output |
| B | 21 | 18 | 15 | O | Blue Output |
| V _{DD2} | 22 | 19 | 16 | S | +5V Outputs Supply |
| PWM0 | 23 | 20 | - | O | DAC6 Output |
| PWM7 | 24 | - | - | O | DAC7 Output |

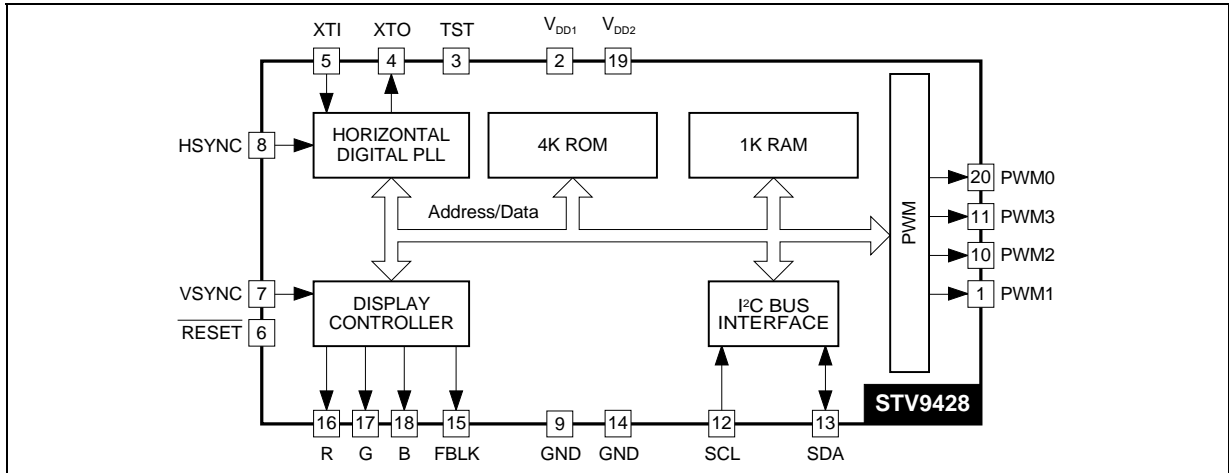
9427-01.TBL

BLOCK DIAGRAMS
STV9427



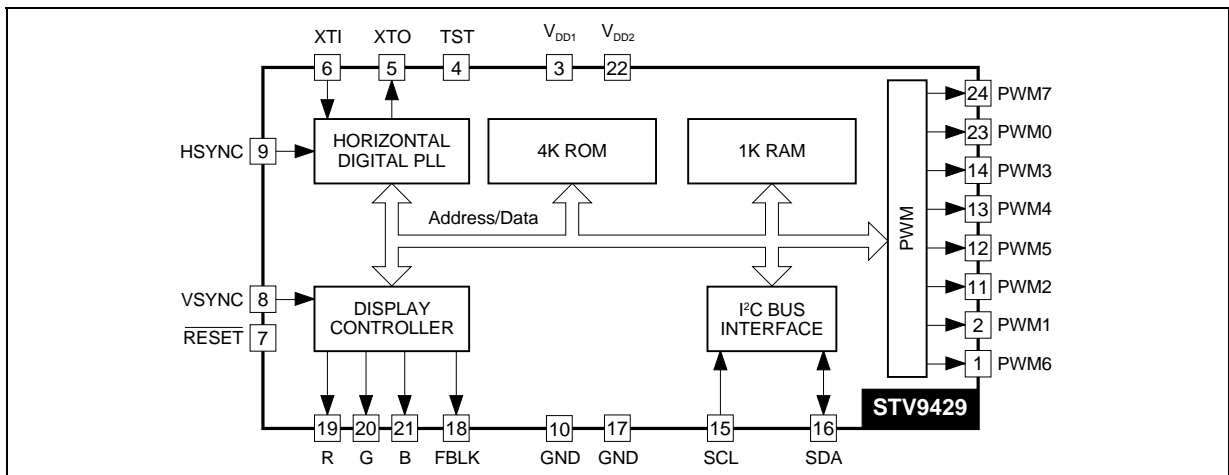
9427-02.EPS

STV9428



9428-02.EPS

STV9429



9429-02.EPS

ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Value | Unit |
|-------------------|-----------------------|------------|------|
| V _{DD} | Supply Voltage | -0.3, +7.0 | V |
| V _{IN} | Input Voltage | -0.3, +7.0 | V |
| T _{OPER} | Operating Temperature | 0, +70 | °C |
| T _{STG} | Storage Temperature | -40, +125 | °C |

9427-02.TBL

ELECTRICAL CHARACTERISTICS

(V_{DD1} = V_{DD2} = 5V, V_{SS} = 0V, T_A = 0 to 70°C, f_{XTAL} = 8 to 15MHz, TEST = 0 V, unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|--------|-----------|------|------|------|------|
|--------|-----------|------|------|------|------|

SUPPLY

| | | | | | |
|-----------------|----------------|------|----|------|----|
| V _{DD} | Supply Voltage | 4.75 | 5 | 5.25 | V |
| I _{DD} | Supply Current | - | 65 | 90 | mA |

INPUTS

| SCL, SDA, $\overline{\text{RESET}}$, VSYNC and HSYNC | | | | | |
|---|-----------------------|-----|--|-----|----|
| V _{IL} | Input Low Voltage | | | 0.8 | V |
| V _{IH} | Input High Voltage | 2.4 | | | V |
| I _{IL} | Input Leakage Current | -10 | | +10 | μA |

OUTPUTS

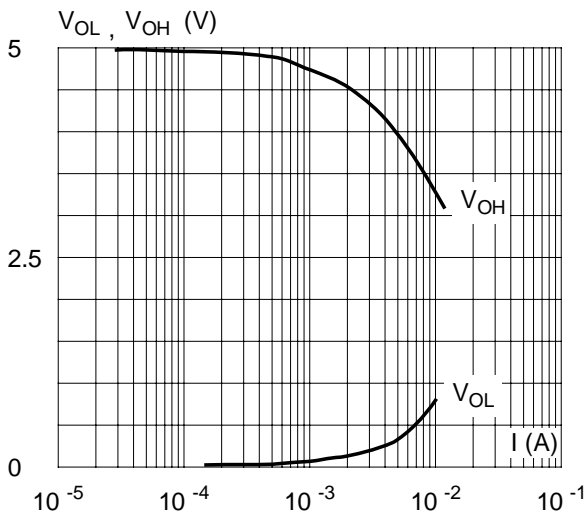
| SDA open drain and PWMi (i = 0 to 7) | | | | | |
|--------------------------------------|--|--------------------|--|-----------------|---|
| V _{OL} | Output Low Voltage (I _{OL} = 1.6mA) | 0 | | 0.4 | V |
| V _{OH} | Output High Voltage (I _{OH} = -0.1mA) | 0.9V _{DD} | | V _{DD} | V |

R, G, B, FBLK

| | | | | | |
|-----------------|--|--------------------|--|-----------------|---|
| V _{OL} | Output Low Voltage (I _{OL} = 1.6mA) | 0 | | 0.4 | V |
| V _{OH} | Output High Voltage (I _{OH} = -0.1mA) | 0.9V _{DD} | | V _{DD} | V |

9427-03.TBL

Figure 1 : R, G, B, FBLK Typical Outputs Static Characteristics



9427-17.EPS

TIMINGS

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|--------|-----------|------|------|------|------|
|--------|-----------|------|------|------|------|

OSCILATOR INPUT : XTI (see Figure 2)

| | | | | | |
|------------|------------------|----|--|----|-----|
| t_{WH} | Clock High Level | 20 | | | ns |
| t_{WL} | Clock Low Level | 20 | | | ns |
| f_{XTAL} | Clock Frequency | 6 | | 15 | MHz |
| f_{PXL} | Pixel Frequency | 30 | | 80 | MHz |

RESET

| | | | | | |
|-----------|------------------------------------|---|--|--|---------|
| t_{RES} | \overline{RESET} Low Level Pulse | 4 | | | μs |
|-----------|------------------------------------|---|--|--|---------|

R, G, B, FBLK ($C_{LOAD} = 30pF$)

| | | | | | |
|------------|----------------------------|--|---|--|----|
| t_R | Rise Time (see Note 1) | | 5 | | ns |
| t_F | Fall Time (see Note 1) | | 5 | | ns |
| t_{SKEW} | Skew between R, G, B, FBLK | | 5 | | ns |

I²C INTERFACE : SDA AND SCL (see Figure 3)

| | | | | | |
|-------------|--|--|--|-----|-----|
| f_{SCL} | SCL Clock Frequency (Horizontal frequency = 32kHz) | | | 288 | kHz |
| t_{BUF} | Time the bus must be free between 2 access | 500 | | | ns |
| t_{HDS} | Hold Time for Start Condition | 500 | | | ns |
| t_{SUP} | Set up Time for Stop Condition | 500 | | | ns |
| t_{LOW} | Clock Low Level | 400 | | | ns |
| t_{HIGH} | Clock High Level | 400 | | | ns |
| t_{HDAT} | Hold Time Data | 0 | | | ns |
| t_{SUDAT} | Set up Time Data | 500 | | | ns |
| t_F | SDA Fall Time | | | 20 | ns |
| t_R | SCL and SDA Rise Time | Depend on the pull-up resistor and on the load capacitance | | | |

Note 1 : These parameters are not tested on each unit. They are measured during our internal qualification procedure which includes characterization on batches coming from corners of our processes and also temperature characterization.

Figure 2

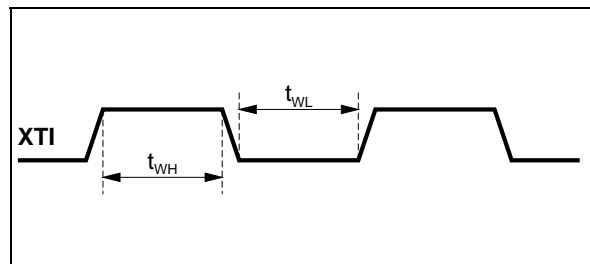
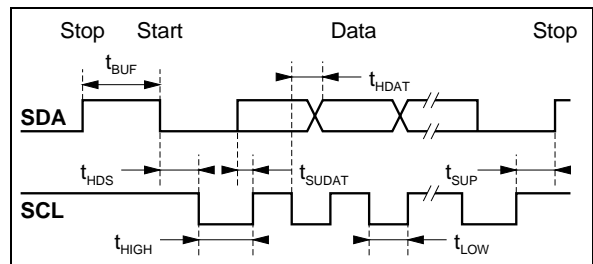


Figure 3



FUNCTIONAL DESCRIPTION

The STV9427/28/29 display processor operation is controlled by a host MCU via the I²C interface. It is fully programmable through internal read/write registers and performs all the display functions by generating pixels from data stored in its internal memory. After the page downloading from the MCU, the STV9427/28/29 refreshes screen by its built in processor, without any MCU control (access). In addition, the host MCU has a direct access to the on chip 1Kbytes RAM during the display of the current page to make any update of its contents.

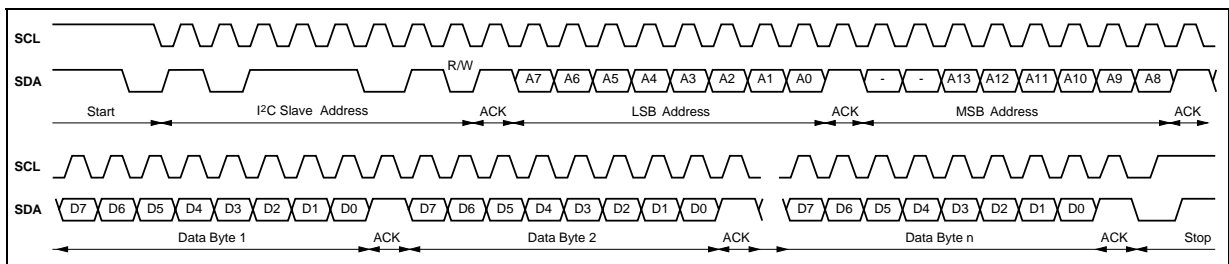
With the STV9427/28/29, a page displayed on the screen is made of several strips which can be of 2 types : spacing or character and which are described by a table of descriptors and character codes in RAM. Several pages can be downloaded at the same time in the RAM and the choice of the current display page is made by programming the DISPLAY CONTROL register.

I - Serial Interface

The 2-wires serial interface is an I²C interface. To be connected to the I²C bus, a device must own its slave address ; the slave address of the STV9427/28/29 is BA (in hexadecimal).

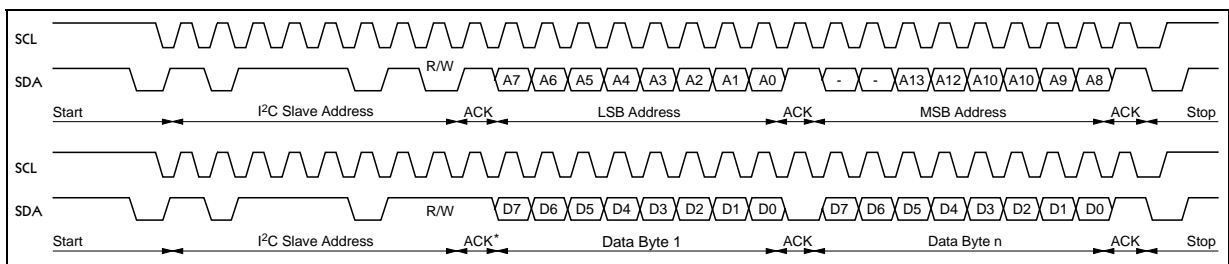
| | | | | | | | |
|----|----|----|----|----|----|----|-----|
| A6 | A5 | A4 | A3 | A2 | A1 | A0 | R/W |
| 1 | 0 | 1 | 1 | 1 | 0 | 1 | |

Figure 4 : MCU I²C Write Operation



9427-06.EPS

Figure 5 : MCU I²C Read Operation



9427-06.EPS

Note : The first data bit out (D7) is valid after one scanline period.

I.1 - Data Transfer in Write Mode

The host MCU can write data into the STV9427/28/29 registers or RAM.

To write data into the STV9427/28/29, after a start, the MCU must send (Figure 4) :

- First, the I²C address slave byte with a low level for the R/W bit,
- The two bytes of the internal address where the MCU wants to write data(s),
- The successive bytes of data(s).

All bytes are sent MSB bit first and the write data transfer is closed by a stop.

Each byte is synchronously transferred at each HSYNC period.

I.2 - Data Transfer in Read Mode

The host MCU can read data from the STV9427/28/29 registers, RAM or ROM.

To read data from the STV9427/28/29 (Figure 5), the MCU must send 2 different I²C sequences. The first one is made of I²C slave address byte with R/W bit at low level and the 2 internal address bytes.

The second one is made of I²C slave address byte with R/W bit at high level and all the successive data bytes read at successive addresses starting from the initial address given by the first sequence. Each byte is synchronously transferred at each HSYNC period. The first data byte, in read mode, is available one Hsync period after the acknowledge of the address byte.

FUNCTIONAL DESCRIPTION (continued)

I.3 - Addressing Space

I.3.1 - General Mapping

STV9427/28/29 registers, RAM and ROM are mapped in a 16Kbytes addressing space. The mapping is the following :

| | | |
|------|-------------------------|---|
| 0000 | 1024 bytes RAM | Descriptors character codes and user definable characters |
| 03FF | | |
| 0400 | Empty Space | |
| 07FF | | |
| 0800 | Character Generator ROM | |
| 3FBF | | |
| 3FC0 | Empty Space | |
| 3FD0 | | |
| 3FCF | Internal Registers | |
| 3FD0 | | |

I.3.2 - I²C Registers Mapping

| | | |
|------|-----------------------|----------------------------|
| 3FCF | | PWM registers |
| 3FD0 | PWM0 | |
| | PWM1 | |
| | PWM2 | |
| | PWM3 | |
| | PWM4 | |
| | PWM5 | |
| | PWM6 | |
| 3FD7 | PWM7 | |
| 3FD8 | Reserved | |
| 3FDF | | Color look-up table (CLUT) |
| 3FE0 | Color 0 | |
| | Color 1 | |
| | Color 2 | |
| | Color 3 | |
| | Color 4 | |
| | Color 5 | |
| | Color 6 | |
| 3FE7 | Color 7 | |
| 3FE8 | Color 8 | |
| | Color 9 | |
| | Color 10 | |
| | Color 11 | |
| | Color 12 | |
| | Color 13 | |
| | Color 14 | |
| 3FEF | Color 15 | |
| 3FF0 | Line Duration | Control registers |
| | Top Margin | |
| | Horizontal Delay | |
| | Character Height | |
| | Display Control | |
| | Locking Time Constant | |
| | Capture Time Constant | |
| | Initial Pixel period | |
| 3FF8 | Frequency Multiplier | |
| 3FF9 | Reserved | |
| 3FFF | Reserved | |

I.4 - Register Set

I.4.1 - PWM Registers

The eight registers described below are only available with the STV9429 :

PULSE WIDTH MODULATOR 0 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD0 | V07 | V06 | V05 | V04 | V03 | V02 | V01 | V00 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V0[7:0] : Digital value of the 1st PWM D to A converter.

PULSE WIDTH MODULATOR 1 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD1 | V17 | V16 | V15 | V14 | V13 | V12 | V11 | V10 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V1[7:0] : Digital value of the 2nd PWM DAC.

PULSE WIDTH MODULATOR 2 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD2 | V27 | V26 | V25 | V24 | V23 | V22 | V21 | V20 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V2[7:0] : Digital value of the 3rd PWM DAC.

PULSE WIDTH MODULATOR 3 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD3 | V37 | V36 | V35 | V34 | V33 | V32 | V31 | V30 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V3[7:0] : Digital value of the 4th PWM DAC.

PULSE WIDTH MODULATOR 4 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD4 | V47 | V46 | V45 | V44 | V43 | V42 | V41 | V40 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V4[7:0] : Digital value of the 5th PWM DAC.

PULSE WIDTH MODULATOR 5 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD5 | V57 | V56 | V55 | V54 | V53 | V52 | V51 | V50 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V5[7:0] : Digital value of the 6th PWM DAC.

PULSE WIDTH MODULATOR 6 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD6 | V67 | V66 | V65 | V64 | V63 | V62 | V61 | V60 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V6[7:0] : Digital value of the 7th PWM DAC.

PULSE WIDTH MODULATOR 7 (STV9429)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FD7 | V77 | V76 | V75 | V74 | V73 | V72 | V71 | V70 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

V7[7:0] : Digital value of the 8th PWM DAC.

Note : Power on reset default value of PMW register is 00H

FUNCTIONAL DESCRIPTION (continued)

I.4.2 - Look-up Table Registers

Color look-up table [CLUT] is read/write RAM table. Mapping address is described in Chapter I.3.2.

The CLUT is splitted in 2 blocks of 8 bytes. Each byte contains foreground and background informations as described below :

| | | | | | | | |
|-----|----|----|----|----|----|----|----|
| SHA | BR | BG | BB | FL | FR | FG | FB |
|-----|----|----|----|----|----|----|----|

SHA : Shadowing
 FL : Flashing foreground
 BR, BG, BB : Background color
 FR, FG, FB : Foreground color

If SHA = 1 and BR = BG = BB = 0, the background of the character is transparent.

Each block may store a different set of colors. One block of colors may be used for the normal items of the menu while the second block, with brighter colors, may be used for selected items of the menu.

The block selection is done by programming bit CLU3 of CLU[3:0] of the character descriptor (see Table 1). It remains selected all the row long. Bit CLU2, CLU1 and CLU0 of CLU[3:0] of the character descriptor select the active color at the beginning of the row.

The active color can be changed along the row, using 8 control codes COL0 to COL7.

Each control code (COL0 to COL7) active a dedicated color byte in the CLUT as described in Table 2.

Table 1 : CLUT Block Selection

| CLU3 | CLU[2:0] | Code Name | Ram @ (hex) | Reset Value (hex) |
|------|----------|-----------|-------------|-------------------|
| 0 | 0 | Col 0 | @3FE0 | 07 |
| | 1 | Col 1 | @3FE1 | 16 |
| | 2 | Col 2 | @3FE2 | 25 |
| | 3 | Col 3 | @3FE3 | 34 |
| | 4 | Col 4 | @3FE4 | 43 |
| | 5 | Col 5 | @3FE5 | 52 |
| | 6 | Col 6 | @3FE6 | 61 |
| | 7 | Col 7 | @3FE7 | 70 |
| 1 | 0 | Col 0 | @3FE8 | 70 |
| | 1 | Col 1 | @3FE9 | 61 |
| | 2 | Col 2 | @3FEA | 52 |
| | 3 | Col 3 | @3FEB | 43 |
| | 4 | Col 4 | @3FEC | 34 |
| | 5 | Col 5 | @3FED | 25 |
| | 6 | Col 6 | @3FEE | 16 |
| | 7 | Col 7 | @3FEF | 07 |

Table 2 : CLUT Color Selection

| Code Name | Code Nbr (h) | Color Look-up Table in RAM |
|-----------|--------------|----------------------------|
| COL1 | 10 | @ 3FE0 : Color 0 |
| COL2 | 11 | @ 3FE1 : Color 1 |
| COL6 | 16 | @ 3FE6 : Color 6 |
| COL7 | 17 | @ 3FE7 : Color 7 |
| COL0 | 10 | @ 3FE8 : Color 8 |
| COL1 | 11 | @ 3FE9 : Color 9 |
| COL6 | 16 | @ 3FEE : Color 14 |
| COL7 | 17 | @ 3FEF : Color 15 |

I.4.3 - Control Registers

LINE DURATION (Reset Value : 20h)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FF0 | VSP | HSP | LD6 | LD5 | LD4 | LD3 | LD2 | LD1 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

VSP : V-SYNC active edge selection
 = 0, falling egde,
 = 1, rising edge.

HSP : H-SYNC active edge selection
 = 0, falling egde,
 = 1, rising edge.

LD[6:1] : LINE DURATION
 LD0 = 0
 LD1 = 2 periods of character
 One character period is 12 pixels long.

TOP MARGIN (Reset Value : 60h)

| | | | | | | | | |
|------|----|----|----|----|----|----|----|----|
| 3FF1 | M8 | M7 | M6 | M5 | M4 | M3 | M2 | M1 |
|------|----|----|----|----|----|----|----|----|

M[8:1] : TOP MARGIN height from the VSYNC reference edge.
 M0 = 0
 M1 = 2 scan lines

Note : The top margin is displayed before the first strip of descriptor list. It can be black if FBK of DISPLAY CONTROL register is set or transparent if FBK is clear.

HORIZONTAL DELAY (Reset Value : 20h)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FF2 | DD7 | DD6 | DD5 | DD4 | DD3 | DD2 | DD1 | DD0 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

DD[7:0] : HORIZONTAL DISPLAY DELAY from the HSYNC reference edge to the 1st pixel position of the character strips.
 Unit = 6 pixel periods. Minimum value is 08h.
 First pixel position = [DD[7:0] - 6] x 6 + 54.
 with DD[7:0] = 1,3,5 then the delay is 60 pixel.

FUNCTIONAL DESCRIPTION (continued)

CHARACTERS HEIGHT (Reset Value : 24h)

| | | | | | | | | |
|------|---|---|-----|-----|-----|-----|-----|-----|
| 3FF3 | - | - | CH5 | CH4 | CH3 | CH2 | CH1 | CH0 |
|------|---|---|-----|-----|-----|-----|-----|-----|

CH[5:0] : HEIGHT of the character strips in scan lines. For each scan line, the number of the slice which is displayed is given by :

$$\text{SLICE-NUMBER} = \text{round} \left(\frac{\text{SCAN-LINE-NUMBER} \times 18}{\text{CH}[5:0]} \right)$$

SCAN-LINE-NUMBER = Number of the current scan line of the strip.

DISPLAY CONTROL (Reset Value : 00h)

| | | | | | | | | |
|------|-----|-----|-----|-----|----|----|----|----|
| 3FF4 | OSD | FBK | FL1 | FL0 | P9 | P8 | P7 | P6 |
|------|-----|-----|-----|-----|----|----|----|----|

OSD : ON/OFF (if 0, R, G, B and FBLK outputs are 0).
 FBK : Fast blanking control :
 = 1, forces FBLK pin at "1" outside and inside the OSD area. This leads to blank video RGB and to only display OSD RGB.
 = 0, FBLK pin is driven according character code for normal display of OSD data.

FL[1:0] : Flashing mode :
 - 00 : No flashing.
 The character attribute is ignored,
 - 01 : Flashing at f_F (50% duty cycle),
 - 10 : Flashing at 2 f_F ,
 - 11 : Flashing at 4 f_F .
Note : f_F is 128 time vertical frequency.

P[9:6] : Address of the 1st descriptor of the current displayed pages.
 P[13:10] and P[5:0] = 0 ; up to 16 different pages can be stored in the RAM.

LOCKING CONDITION TIME CONSTANT
 (Reset Value : 01h)

| | | | | | | | | |
|------|----|-----|-----|-----|-----|-----|-----|-----|
| 3FF5 | FR | AS2 | AS1 | AS0 | LUK | BS2 | BS1 | BS0 |
|------|----|-----|-----|-----|-----|-----|-----|-----|

FR : Free Running ; if = 1 PLL is disabled and the pixel frequency keeps its last value.
 AS[2:0] : Phase constant during locking conditions.
 BS[2:0] : Frequency constant during locking conditions.
 LUK : Lock unlock status bit
 0 = unlocked PLL
 1 = Locked PLL

CAPTURE PROCESS TIME CONSTANT
 (Reset Value : 24h)

| | | | | | | | | |
|------|-----|-----|-----|-----|---|-----|-----|-----|
| 3FF6 | LEN | AF2 | AF1 | AF0 | - | BF2 | BF1 | BF0 |
|------|-----|-----|-----|-----|---|-----|-----|-----|

LEN : Lock enable
 0 = R,G,B, FBLK are always enabled,
 1 = R,G,B, FBLK are enabled only when PLL is locked.

AF[2:0] : Phase constant during the capture process.
 BF[2:0] : Frequency constant during the capture process.

INITIAL PIXEL PERIOD (Reset Value : 28h)

| | | | | | | | | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 3FF7 | PP7 | PP6 | PP5 | PP4 | PP3 | PP2 | PP1 | PP0 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|

PP[7:0] : Value to initialize the pixel period of the PLL.

FREQUENCY MULTIPLIER (Reset Value : 0Ah)

| | | | | | | | | |
|------|---|---|---|---|-----|-----|-----|-----|
| 3FF8 | - | - | - | - | FM3 | FM2 | FM1 | FM0 |
|------|---|---|---|---|-----|-----|-----|-----|

FM[3:0] : Frequency multiplier of the crystal frequency to reach the high frequency used by the PLL to derive the pixel frequency.

Note : For high pixel frequency (over 70MHz), write at address 3FFF, Data F0h.

II - Descriptors

SPACING

| | | | | | | | |
|-----|---|-----|---|---|---|---|---|
| MSB | 0 | L/C | - | - | - | - | - |
|-----|---|-----|---|---|---|---|---|

| | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| LSB | SL7 | SL6 | SL5 | SL4 | SL3 | SL2 | SL1 | SL0 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|

L/C : LINE or CHARACTER spacing :
 = 0, spacing descriptor defined as character height (SL[7:0] = 1 to 255 character).
 = 1, spacing descriptor defined as scan line height (SL[7:0] = 1 to 255 scan lines).

SL[7:0] : Number of selected height (character or scan lines according L/C).

CHARACTER

| | | | | | | | | |
|-----|---|----|------|------|------|------|----|----|
| MSB | 1 | DE | CLU3 | CLU2 | CLU1 | CLU0 | C9 | C8 |
|-----|---|----|------|------|------|------|----|----|

| | | | | | | | | |
|-----|----|----|----|----|----|----|----|-----|
| LSB | C7 | C6 | C5 | C4 | C3 | C2 | C1 | UEN |
|-----|----|----|----|----|----|----|----|-----|

DE : Display enable :
 = 0, R = G = B = 0 and FBLK = FBK bit of display control register on the whole strip,
 = 1, display of the characters.

CLU[3:0] : Active color selection at the beginning of the strip.

C[9:1] : Address of the first character code of the strip.

UEN : UDC enable
 0 : codes 240 to 254 (FOh to FEh) are read in ROM,
 1 : codes 240 to 255 (FOh to FFh) are read in RAM (UDC).

FUNCTIONAL DESCRIPTION (continued)

III - Code Format

The codes of STV9427/28/29 are all single byte codes. There are basically 3 kinds of code :

- The control codes from 0 to 27 (00h to 1Bh) and from 224 to 239 (E0h to EFh).
- The ROM character codes from 32 to 223 (20h to DFh) and from 240 to 255 (F0h to FFh).
- The user definables characters codes from 240 to 254 (F0h to FFh).

Each row must begin with a displayable character code followed by a NOP or any control code.

For code definition see Table 4.

III.1 - Control Codes

Control codes must be followed by a displayable code (from 32 to 223), except for RTN & EOL. They must not be used twice consecutively without a displayable code between them.

The control code CALL is preceded by an address byte.

The control codes are not displayed except if mentioned.

Code 0 (00h) : NOP : no operation and no display is performed, can be used to spare a location in RAM for an active control code.

Codes 1 to 7 (01h to 07h) : SYMETRIES :

- TSHS(01)* Top Side Horizontal Symetry code displays the top half side of the following displayable code symetrically to the bottom side.
- BSHS(02)* Bottom Side Horizontal Symetry code displays the bottom half side of the following displayable code symetrically to the top side.
- HFLIP(03)* Horizontal Flip code flips horizontally the following displayable code.
- LSVS(04)* Left Side Vertical Symetry code displays the left half side of the following displayable code symetrically to the right side.
- RSVS(05)* Right Side Vertical symetry code displays the right half side of the following displayable code symetrically to the left side.
- VFLIP(06)* Vertical Flip code flips vertically the following displayable code.
- HVFLIP(07)* Horizontal & Vertical Flip code flips horizontally and vertically the following displayable code.

Codes 8 (08h) (at odd @) : RTN : return to the CALL + 1 code location (see Note).

Code 09 to 14 (09h to 0Eh) : Reserved

Code 15 (0Fh) : EOL, end of line terminates the display of the current row.

Codes 16 to 23 (10h to 17h) : COL0 to COL7 codes select 1 byte among 8 within the CLUT in RAM. The block selection is fixed by CLU3 bit of the active character descriptor (see Table 1 and Table 2).

Codes 24 to 27 (18h to 19h) : CALL, these control codes switch the display of the next character to the code address given by the next byte as following :

| | | | | | | | | |
|-----------------------|---|---|---|---|---|---|---|----|
| CALL CODE (odd @) MSB | 0 | 0 | 0 | 1 | 1 | 0 | 0 | A9 |
|-----------------------|---|---|---|---|---|---|---|----|

| | | | | | | | | |
|---------------------------|----|----|----|----|----|----|----|----|
| ADDRESS BYTE (even @) LSB | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 |
|---------------------------|----|----|----|----|----|----|----|----|

A[9:1] : Address of the next code to be used (A0 = 0 only even addresses).

Notes :
 CALL and RTN code must be used twin. They cannot be nested.
 CALL and RTN codes are displayed as a SPACE character.
 CALL and RTN codes must be placed at odd addresses. They may be preceded by a NOP in order to place them at the right position.

Codes 28 to 31 (1Ch to 1Fh) : Reserved

Code 224 to 239 (E0h to EFh) : Accent shapes from 224 to 239 (E0h to EFh) are used combined with all other character codes 32 to 223 (10h to DFh) and placed before the target character.

The first set of accents, 224 to 231 (E0h to E7h) must be used with lower case letters. The 5 upper slices of the target character are replaced by the accent shape.

The second set of accents, 232 to 239 (E8h to EFh) must be used with the upper case letters (capital letters). The 3 upper slices of the target character are replaced by the accent shape. Accent code must always be followed by a displayable character or a space.

III.2 - ROM Character Codes

Codes 32 to 223 (20h to DFh) and Codes 240 to 254 (F0h to FEh) : ROM character shapes are described as 12x18 pixel matrix as shown in Table 5.

It comprises 60 logos dedicated for monitor application (Horizontal position, keystone, ...), 25 characters for horizontal bar-graph and additional shapes.

FUNCTIONAL DESCRIPTION (continued)

Table 4

| Code N° | MSB | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---------|-----|--------|------|-------|---|---|---|---|--------|-----|---------|--------|-------|-------|---------|--------|--------|
| LSB | HEX | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
| 0 | 0 | NOP | COL0 | Space | 0 | @ | P | ç | p | Ç | Cont1 | Hlin1 | Box0 | Bar5 | Bar21 | ' dn | R |
| 1 | 1 | TSHS | COL1 | ! | 1 | A | Q | a | q | ç | Cont2 | Hlin2 | Box1 | Bar6 | Bar22 | ' up | G |
| 2 | 2 | BSHS | COL2 | " | 2 | B | R | b | r | Æ | Bright | Kystn | Box2 | Bar7 | 10o | ^ dn | B |
| 3 | 3 | HFLIP | COL3 | # | 3 | C | S | c | s | æ | Color | Kybal1 | Box3 | Bar8 | 1o0 | x dn | 1 |
| 4 | 4 | LSVS | COL4 | \$ | 4 | D | T | d | t | Ø | Spkr | Kybal2 | Box4 | Bar9 | Indxrgt | ~ dn | 2 |
| 5 | 5 | RSVS | COL5 | % | 5 | E | U | e | u | ø | Mute | Pincus | Box5 | Bar10 | Indxup | ° up | clock0 |
| 6 | 6 | VFLIP | COL6 | & | 6 | F | V | f | v | ß | Dgaus | Pinbal | Box6 | Bar11 | rtn | dot dn | clock1 |
| 7 | 7 | HVFLIP | COL7 | ' | 7 | G | W | g | w | « | Balance | Tilt1 | Box7 | Bar12 | hbar0 | ~ dn | clock2 |
| 8 | 8 | RTN | CALL | (| 8 | H | X | h | x | 1/2 | Vfcus | Tilt2 | Box8 | Bar13 | hbar1 | ' up | A |
| 9 | 9 | - | CALL | ± | 9 | I | Y | i | y | 1/4 | Hfcus | Cornr0 | Box9 | Bar14 | vbar0 | ' up | E |
| 10 | A | - | - | * | : | J | Z | j | z | 3/4 | Vsz | Cornr1 | Box10 | Bar15 | vbar1 | ^ up | T |
| 11 | B | - | - | + | ; | K | [| k | { | ≈ | Vpos | Cornr2 | Bar0 | Bar16 | treble | x up | S |
| 12 | C | - | - | , | < | L | @ | l | | ≡ | Vlin | Cornr3 | Bar1 | Bar17 | bass | ~ up | Z |
| 13 | D | - | - | - | = | M | © | m | << | fh | Hsz | Cornr4 | Bar2 | Bar18 | mic | ° up | L |
| 14 | E | - | - | . | ÷ | N | ¥ | n | Arr lf | fv | Hpos1 | kh | Bar3 | Bar19 | upidx0 | dot up | D |
| 15 | F | EOL | - | / | ? | O | _ | o | Arr up | hz | Hpos2 | hz | Bar4 | Bar20 | upidx1 | ~ up | |

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FUNCTIONAL DESCRIPTION (continued)

III.3 - User Definable Character Codes (UDC)

Codes 240 to 254 (F0h to FEh) refer to character shape loaded in RAM.

The STV9427/28/29 allows the user to dynamically define character(s) for his own needs (for a special LOGO for example). Like the ROM characters, a UDC is made of a 12 pixels x 18 slices dot matrix.

In a UDC, each pixel is defined with a bit, 1 refers to foreground, and 0 to background color. Each slice of a UDC uses 2 bytes :

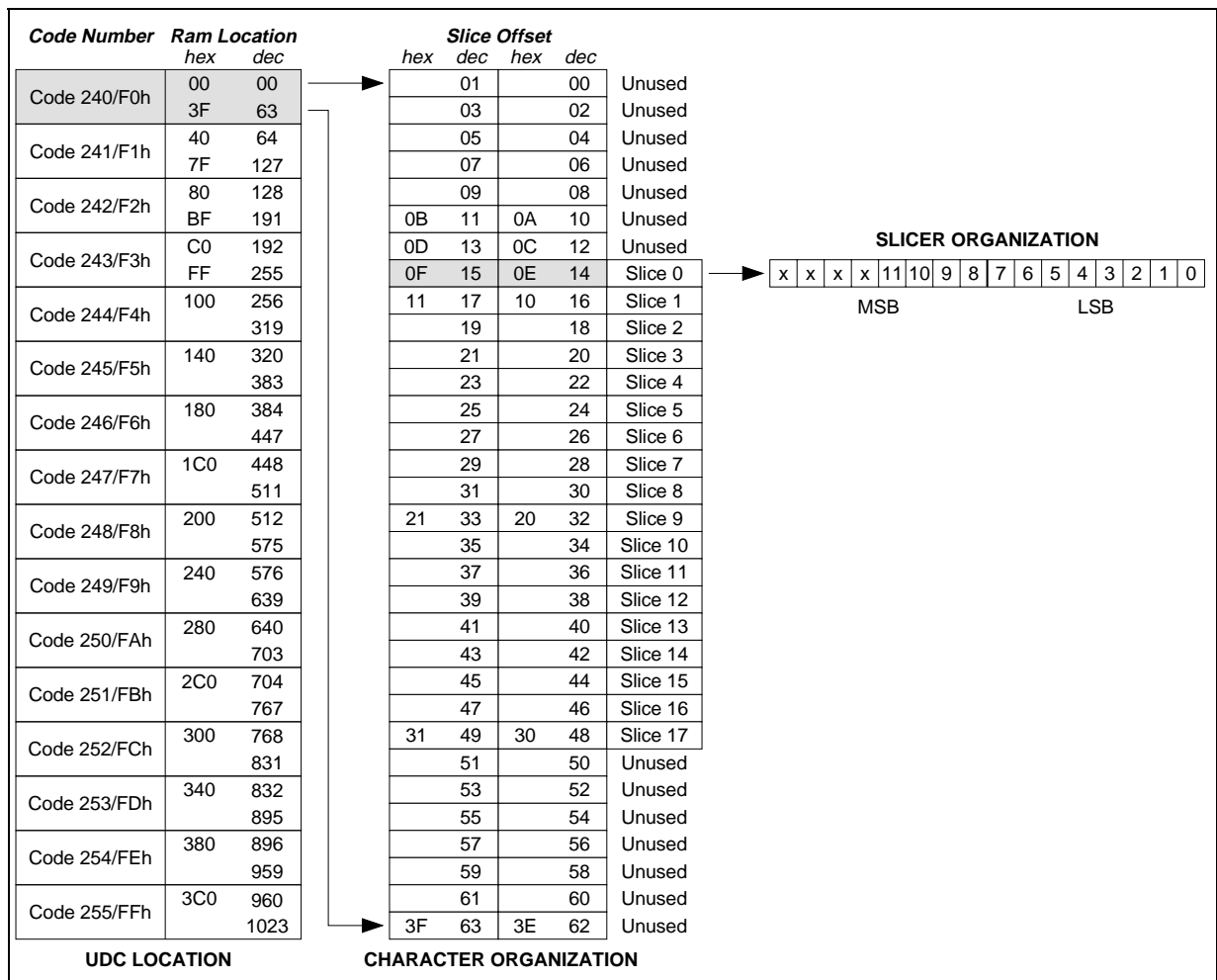
| | | | | | | | | |
|------------|-----|-----|-----|-----|------|------|-----|-----|
| add + 1 | - | - | - | - | PX11 | PX10 | PX9 | PX8 |
| add (even) | PX7 | PX6 | PX5 | PX4 | PX3 | PX2 | PX1 | PX0 |

PX11 is the left most pixel. Character slice address : SLICE ADDRESS = 64 (CHARACTER NUMBER - 240) + (SLICE NUMBER + 7) x 2.

Where :

- CHARACTER NUMBER is the number given by the character code.
- SLICE NUMBER is the number given by the slice interpolator (n° of the current slice of the strip : 1 <<18).

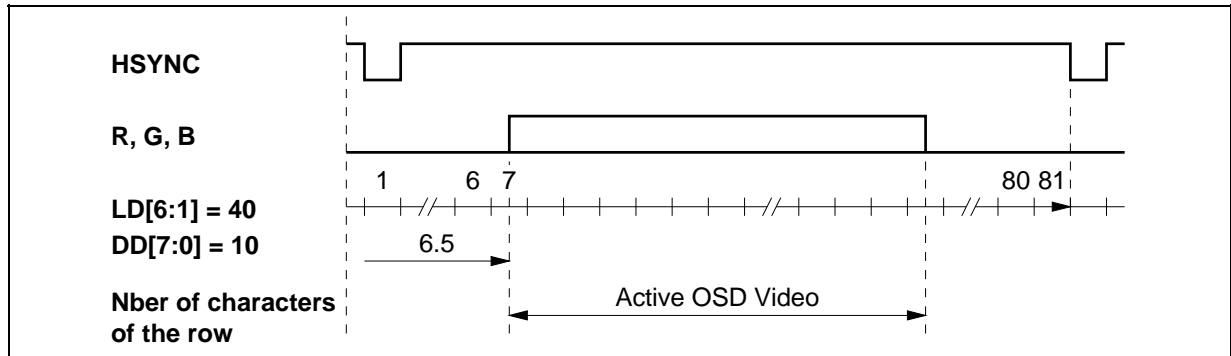
Figure 6 : User Definable Character Codes



9427-18.EPS

FUNCTIONAL DESCRIPTION (continued)

Figure 7 : Hozizontal Timing



IV - Clock and Timing

The whole timing is derived from the XTI and the horizontal SYNCHRO input frequencies. The XTI input frequency can be an external clock, crystal or a ceramic resonator signal thanks to XTI/XTO pins. The value of this frequency can be chosen between 6 and 15MHz is used by the PLL to generate a pixel clock locked on the horizontal synchro input signal.

IV.1 - Horizontal Timing (see Figure 7)

The number of pixel periods is given by the LINE DURATION register and is equal to :

$$[LD[6:1] \times 2 + 1] \times 12.$$

(LD[6:1] : value of the LINE DURATION register).

This value allows to define the horizontal size of the characters.

The horizontal left margin is given by the HORIZONTAL DELAY register and is equal to :

$$(DD[7:0] - 6) \times 6 + 54$$

(DD[7:0] : value of the DISPLAY DELAY register).

This value allows to define the horizontal position of the characters on the screen. Due to internal logic, minimum horizontal delay is fixed at 4.5 characters (54 pixel) when DD is even and lower or equal to 6, and it is fixed at 5 characters (60 pixel) when DD is odd and lower or equal to 7.

IV.2 - D to A Timing (STV9427)

The D/A converters of the STV9427 are pulse width modulator converter.

The frequency of the output signal is : $\frac{f_{XTAL}}{256 \times 6}$ and

the duty cycle is : $\frac{Vi[7:0]}{256 \times 6}$ per cent.

After a low pass filter, the average value of the

$$\text{output is : } \frac{Vi[7:0]}{256 \times 6} \cdot V_{DD}$$

V - Display Control

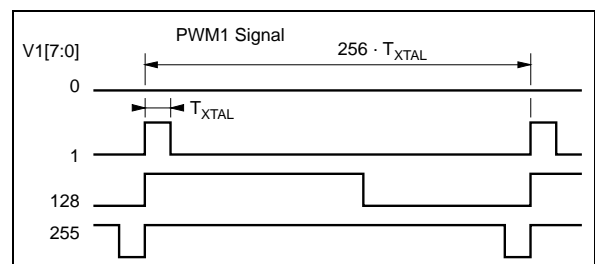
A screen is composed of successive scanlines gath-

ered in several strips. Each strip is defined by a descriptor stored in memory. A table of descriptors allows screen composition and different tables can be stored in memory at the page addresses (16 possible \neq addresses). Two types of strips are available :

- Spacing strip : its descriptor (see II) gives the number of black (FBK = 1 in DISPLAY CONTROL register) or transparent (FBK = 0) lines.
- Character strip : its descriptor gives the memory address of the character codes corresponding to the 1st displayed character. The characters and attributes (see code format III) are defined by a succession of codes stored in the RAM at addresses starting from the 1st one given by the descriptor. A character strip can be displayed or not by using the DE bit of its descriptor.

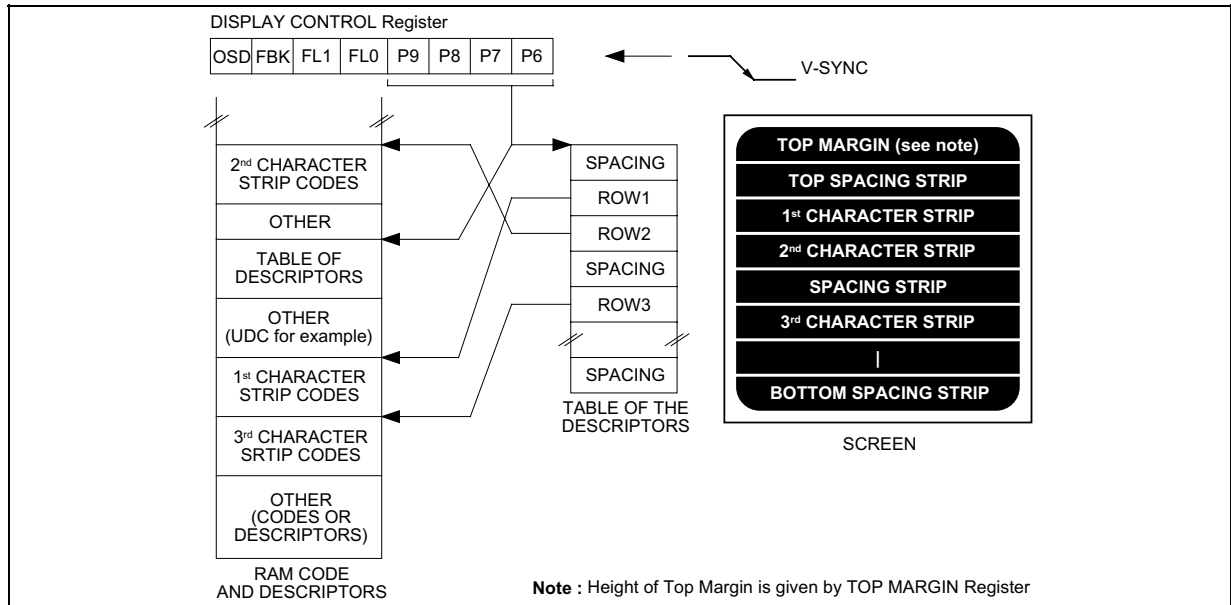
After the VSYNC edge, the first strip descriptor is read at the top of the current table of descriptors at the address given by P[9:0] (see DISPLAY CONTROL register) ; if it is a spacing strip, SL[7:0] black or transparent scan lines are displayed ; if it is a character strip, during CH[5:0] scan lines (CH[5:0] given by the CHARACTER HEIGHT register), the character codes are read at the addresses starting from the 1st one given by the descriptor until a end of line character or the end of the scan line ; the next descriptor is then read and the same process is repeated until the next edge of VSYNC.

Figure 8 : PWM Timing



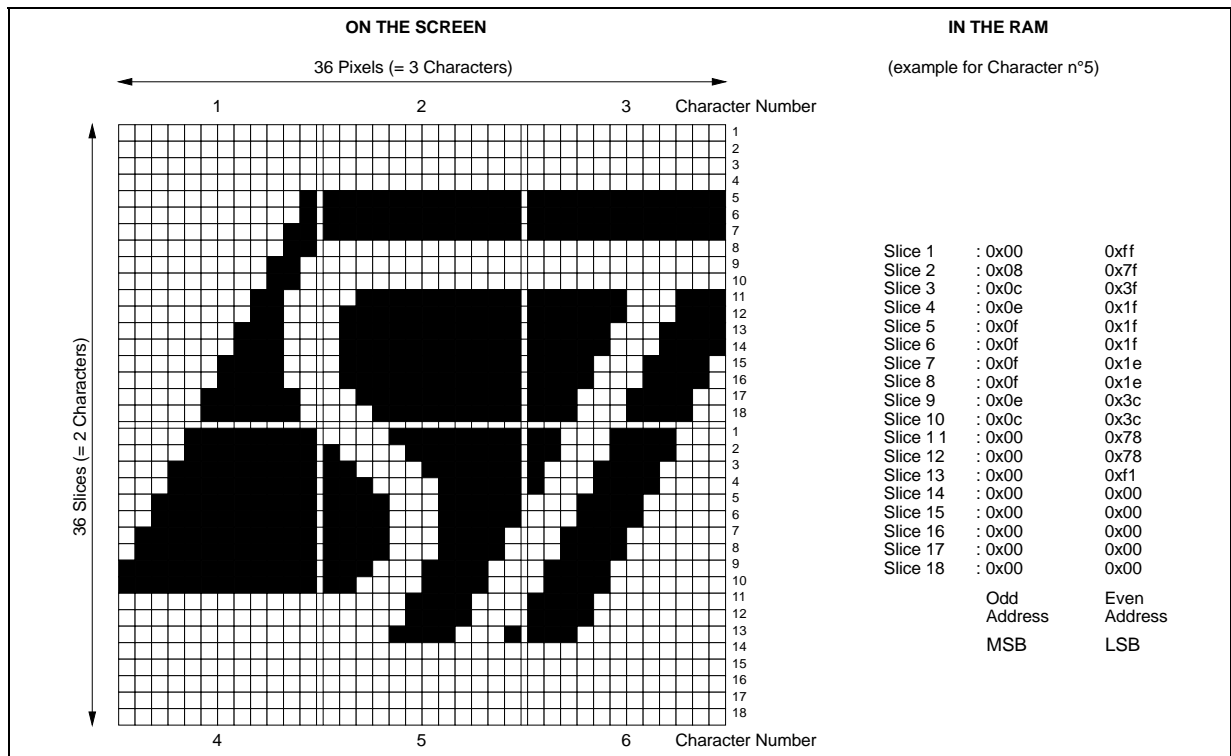
FUNCTIONAL DESCRIPTION (continued)

Figure 9 : Relation between Screen/Address Page/Character Code in RAM



9427-09.EPS

Figure 10 : User Definable Character



9427-10.EPS

FUNCTIONAL DESCRIPTION (continued)

Table 5 : ROM Character Generator

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ! | 0 | ® | P | ø | ð | Ð | Č | Č | Ť | Ť | Ť | Ť | Ť |
| 1 | ! | 1 | A | Q | a | q | ç | ◀ | D | — | Ť | Ť | Ť | Ť |
| 2 | Ť | 2 | B | R | b | r | Æ | × | C | | Ť | Ť | Ť | Ť |
| 3 | # | 3 | C | S | c | s | æ | € | Č | Ť | Ť | Ť | Ť | Ť |
| 4 | \$ | 4 | D | T | d | t | ø | ◀ | D | | Ť | Ť | Ť | Ť |
| 5 | % | 5 | E | U | e | u | ø | ◀ | E | | Ť | Ť | Ť | Ť |
| 6 | & | 6 | F | V | f | v | ß | À | D | | Ť | Ť | Ť | Ť |
| 7 | Ť | 7 | G | W | g | w | ◀ | ◀ | C | | Ť | Ť | Ť | Ť |
| 8 | Ť | 8 | H | X | h | x | ¼ | € | D | | Ť | Ť | Ť | Ť |
| 9 | ± | 9 | I | Y | i | y | ¼ | € | C | | Ť | Ť | Ť | Ť |
| A | * | * | J | Z | j | z | ¼ | € | C | | Ť | Ť | Ť | Ť |
| B | + | ; | K | I | k | ı | ¼ | € | C | | Ť | Ť | Ť | Ť |
| C | . | < | L | ® | l | ı | ¼ | € | D | | Ť | Ť | Ť | Ť |
| D | — | = | M | ® | m | ı | ¼ | € | D | | Ť | Ť | Ť | Ť |
| E | . | = | N | ® | n | ı | ¼ | € | C | | Ť | Ť | Ť | Ť |
| F | / | ? | O | ® | o | ı | ¼ | € | D | | Ť | Ť | Ť | Ť |

9427-11A.EPS / 9427-11B.EPS

FUNCTIONAL DESCRIPTION (continued)

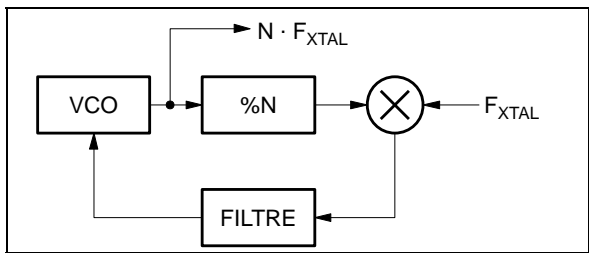
VI - PLL

The PLL function of the STV9427/28/29 provides the internal pixel clock locked on the horizontal synchro signal and used by the display processor to generate the R, G, B and fast blanking signals. It is made of 2 PLLs. The first one analogic (see Figure 11), provides a high frequency signal locked on the crystal frequency. The frequency multiplier is given by :

$$N = 2 \cdot (FM[3:0] + 3)$$

Where FM[3:0] is the value of the FREQUENCY MULTIPLIER register.

Figure 11 : Analogic PLL

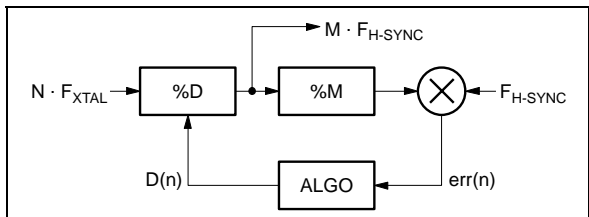


The second PLL, full digital (see Figure 12), provides a pixel frequency locked on the horizontal synchro signal. The ratio between the frequencies of these 2 signals is :

$$M = 12 \times (LD[6:1] \times 2 + 1)$$

Where LD[6:1] is the value of the LINE DURATION register.

Figure 12 : Digital PLL



VI.1 - Programming of the PLL Registers

Frequency Multiplier (@3FF8)

This register gives the ratio between the crystal frequency and the high frequency of the signal used by the 2nd PLL to provide, by division, the pixel clock. The value of this high frequency must be near to 200MHz (for example if the crystal is a 8MHz, the value of FM must be equal to 10) and greater than 2.5 x (pixel frequency). The frequency of VCO must stand within limits given below :

$$F_{pxlmin} \times 16 \geq F_{VCO} \geq F_{pxlmax} \times 2.5$$

Initial Pixel Period (@3FF7)

This register allows to increase the speed of the convergence of the PLL when the horizontal frequency changes (new graphic standart). The relationship between FM[3:0], PP[7:0], LD[6:1], f_{H-SYNC} and f_{X-TAL} is :

$$PP[7:0] = \text{round} \left(8 \cdot \frac{2 \cdot (FM[3:0] + 3) \cdot F_{XTAL}}{6 \cdot (LD[6:1] \cdot 2 + 1) \cdot F_{HSYNC}} - 24 \right)$$

Locking Condition Time Constant (@ 3FF5)

This register gives the constants AS[2:0] and BS[2:0] used by the algo part of the PLL (see Figure 11) to calculate, from the phase error, err(n), the new value, D(n), of the division of the high frequency signal to provide the pixel clock. These two constants are used only in locking condition, which is true, if the phase error is less than a fixed value during at least, 4 scan lines. If the phase error becomes greater than the fixed value, the PLL is not in locking condition but in capture process. In this case, the algo part of the PLL used the other constants, AF[2:0] and BF[2:0], given by the next register.

Capture Process Time Constant (@ 3FF6)

The choice between these two time constants (locking condition or capture process) allows to decrease the capture process time by changing the time response of the PLL.

FUNCTIONAL DESCRIPTION (continued)

VI.2 - How to choose the value of the time constant ?

The time response of the PLL is given by its characteristic equation which is :

$$(x - 1)^2 + (\alpha + \beta) \cdot (x - 1) + \beta = 0.$$

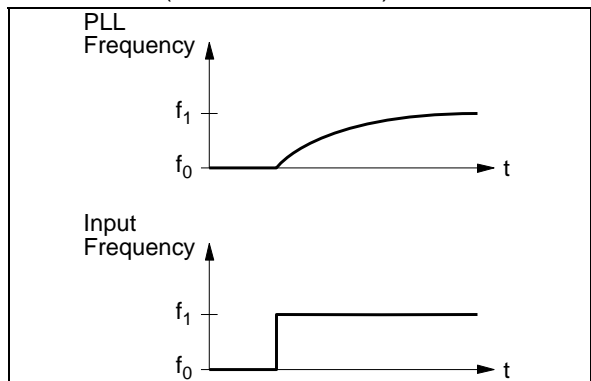
Where :

$\alpha = 3 \cdot LD[6:1] \cdot 2^{A-11}$ and $\beta = 3 \cdot LD[6:1] \cdot 2^{B-19}$.
 (LD[6:1] = value of the LINE DURATION register, A = value of the 1st time constant, AF or AS and B = value of the 2^d time constant, BF or BS).

As you can see, the solution depend only on the LINE DURATION and the TIME CONSTANTS given by the I²C registers.

If $(\alpha + \beta)^2 - 4\beta \geq 0$ and $2\alpha - \beta < 4$, the PLL is stable and its response is like this presented on Figure 13.

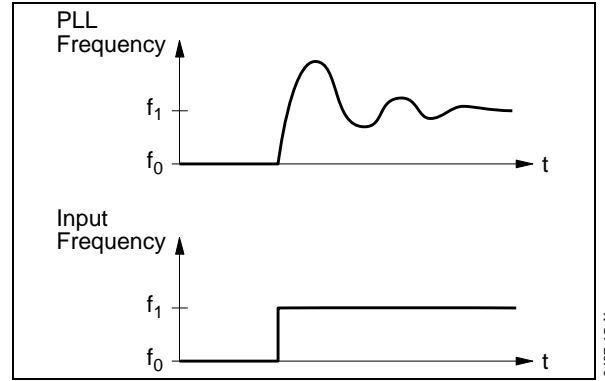
Figure 13 : Time Response of the PLL/Characteristic Equation Solutions (with real solutions)



If $(\alpha + \beta)^2 - 4\beta \leq 0$, the response of the PLL is like this presented on Figure 14.

In this case the PLL is stable if $\tau > 0.7$ damping coefficient).

Figure 14 : Time Response of the PLL/Characteristic Equation Solutions (with Complex Solutions)



The Table 6 gives some good values for A and B constants for different values of the LINE DURATION.

Summary

For a good working of the PLL :

- A and B time constants must be chosen among values for which the PLL is stable,
- B must be equal or greater than A and the difference between them must be less than 3,
- The greater (A, B) are, the faster the capture is.

An optimal choice for the most of applications might be :

- For locking condition : AS = 0 and BS = 1,
- For capture process : AF = 2 and BF = 4.

But for each application the time constants can be calculated by solving the characteristic equation and choosing the best response.

Table 6 : Valid Time Constants Examples

| B \ A | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|-------|------|---------------------|------|------|------|------|------|
| 0 | YYYY | YYYY | YYYY | YYYN | YNNN | NNNN | NNNN |
| 1 | YYYY | YYYY | YYYY | YYYN | YNNN | NNNN | NNNN |
| 2 | NYYY | YYYY | YYYY | YYYN | YNNN | NNNN | NNNN |
| 3 | NNNY | YYYY | YYYY | YYYN | YNNN | NNNN | NNNN |
| 4 | NNNN | NYYY ⁽¹⁾ | YYYY | YYYN | YNNN | NNNN | NNNN |
| 5 | NNNN | NNNY | YYYY | YYYN | YNNN | NNNN | NNNN |
| 6 | NNNN | NNNN | NYYY | YYYN | YNNN | NNNN | NNNN |
| 7 | NNNN | NNNN | NNNY | YYYN | YNNN | NNNN | NNNN |

Note 1 : Case of A[2:0] = 1 (001) and B[2:0] = 4 (100) :

| LD | 16 | 32 | 48 | 64 |
|----------------------|----|----|----|----|
| Valid Time Constants | N | Y | Y | Y |

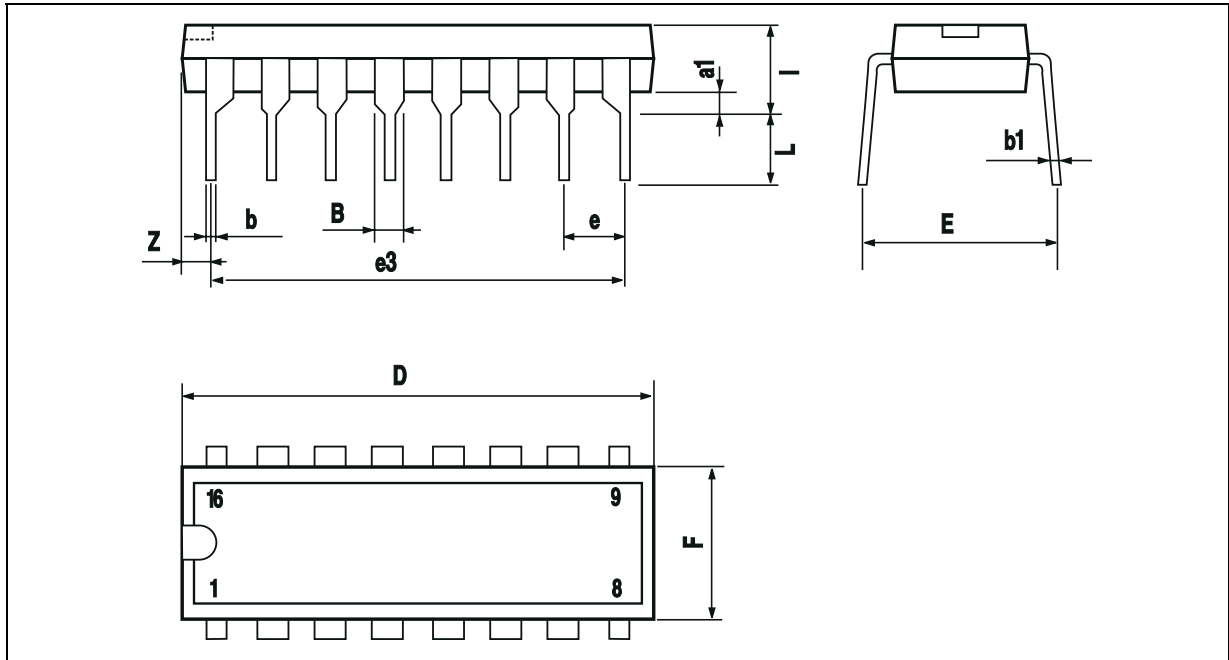
Value of LINE DURATION Register (@ 3FF0) :

LD = 16 : LD[6:0] = 0010000, LD[6:1] = 001000
 LD = 32 : LD[6:0] = 0100000
 LD = 48 : LD[6:0] = 0110000
 LD = 64 : LD[6:0] = 1000000, LD[6:1] = 100000.

Table meaning : N = No possible capture - No stability
 Y = PLL can lock

STV9427 - STV9428 - STV9429

PACKAGE MECHANICAL DATA (STV9427)
 16 PINS - PLASTIC DIP

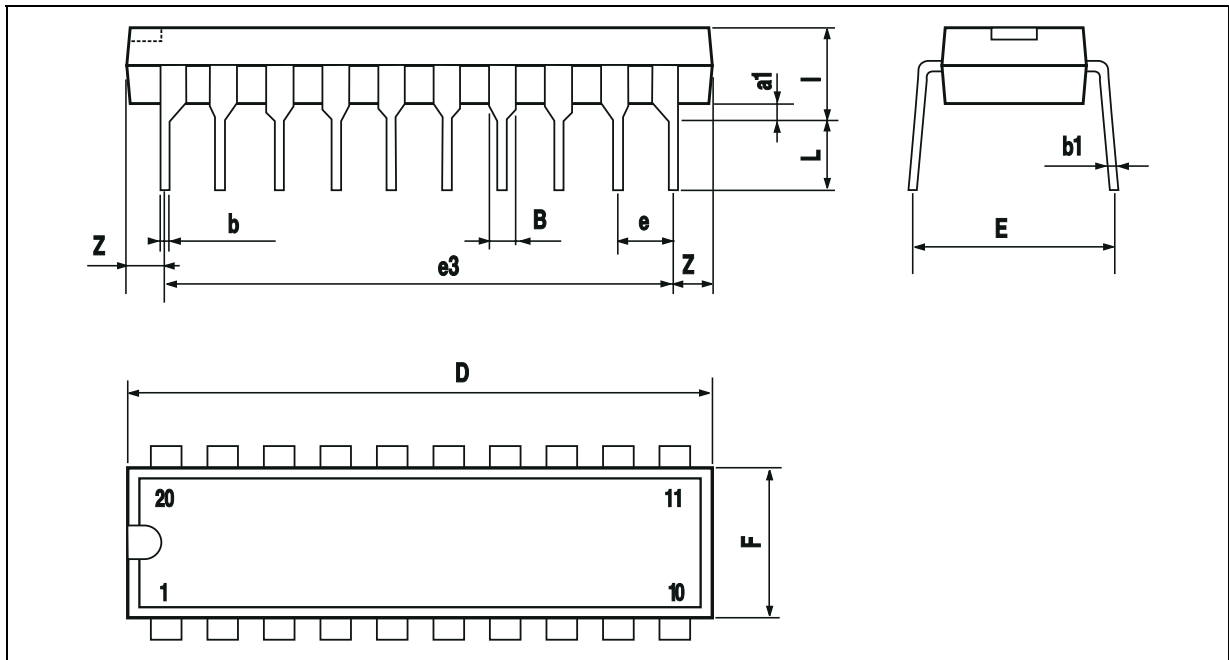


PM-DIP16EFS

| Dimensions | Millimeters | | | Inches | | |
|------------|-------------|-------|------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| a1 | 0.51 | | | 0.020 | | |
| B | 0.77 | | 1.65 | 0.030 | | 0.065 |
| b | | 0.5 | | | 0.020 | |
| b1 | | 0.25 | | | 0.010 | |
| D | | | 20 | | | 0.787 |
| E | | 8.5 | | | 0.335 | |
| e | | 2.54 | | | 0.100 | |
| e3 | | 17.78 | | | 0.700 | |
| F | | | 7.1 | | | 0.280 |
| l | | | 5.1 | | | 0.201 |
| L | | 3.3 | | | 0.130 | |
| Z | | | 1.27 | | | 0.050 |

DIP16.TBL

PACKAGE MECHANICAL DATA (STV9428)
 20 PINS - PLASTIC DIP



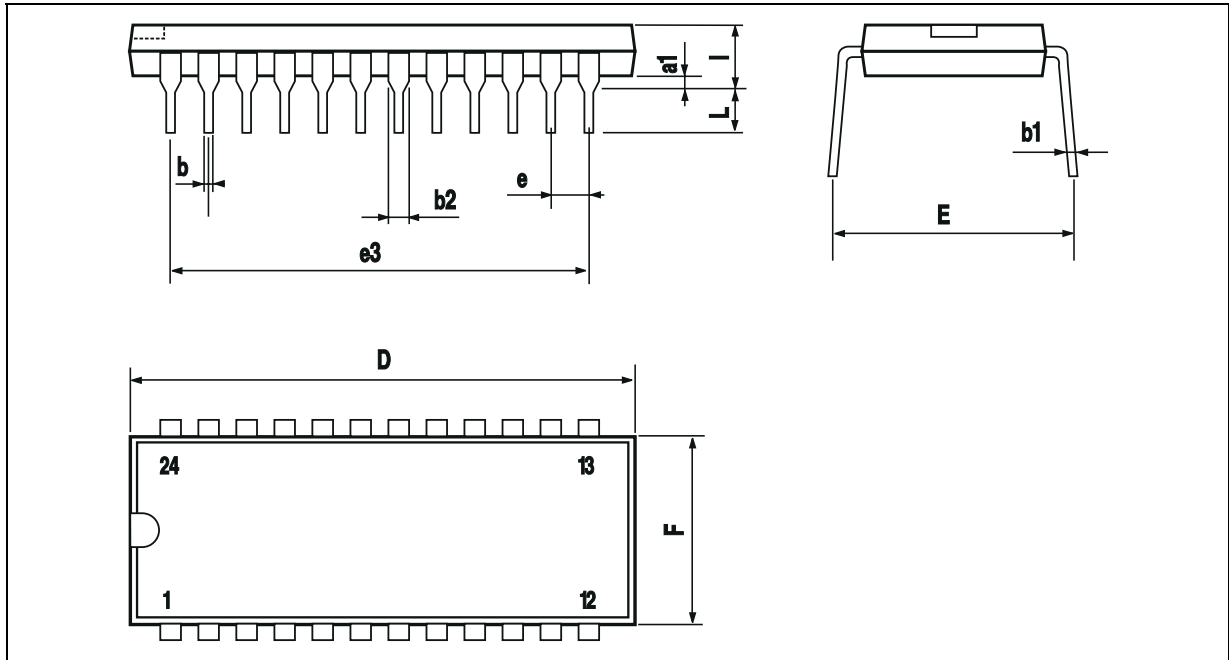
PM-DIP20.EPS

| Dimensions | Millimeters | | | Inches | | |
|------------|-------------|-------|------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| a1 | 0.254 | | | 0.010 | | |
| B | 1.39 | | 1.65 | 0.055 | | 0.065 |
| b | | 0.45 | | | 0.018 | |
| b1 | | 0.25 | | | 0.010 | |
| D | | | 25.4 | | | 1.000 |
| E | | 8.5 | | | 0.335 | |
| e | | 2.54 | | | 0.100 | |
| e3 | | 22.86 | | | 0.900 | |
| F | | | 7.1 | | | 0.280 |
| l | | | 3.93 | | | 0.155 |
| L | | 3.3 | | | 0.130 | |
| Z | | | 1.34 | | | 0.053 |

DIP20.TBL

STV9427 - STV9428 - STV9429

PACKAGE MECHANICAL DATA (STV9429) 24 PINS - PLASTIC DIP



PM-DIP24.EPS

| Dimensions | Millimeters | | | Inches | | |
|------------|-------------|-------|-------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| a1 | | 0.63 | | | 0.025 | |
| b | | 0.45 | | | 0.018 | |
| b1 | 0.23 | | 0.31 | 0.009 | | 0.012 |
| b2 | | 1.27 | | | 0.050 | |
| D | | | 32.2 | | | 1.268 |
| E | 15.2 | | 16.68 | 0.598 | | 0.657 |
| e | | 2.54 | | | 0.100 | |
| e3 | | 27.94 | | | 1.100 | |
| F | | | 14.1 | | | 0.555 |
| l | | 4.445 | | | 0.175 | |
| L | | 3.3 | | | 0.130 | |

DIP24.TBL

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