



#### FEATURES

- 4:2:2 to over-sampled RGB or  $YC_B C_R$  conversion in a single device
- single 10 bit 4:2:2 input
- internal 4:2:2 de-multiplexer
- 4:2:2 to 8:8:8 interpolation filters
- internal  $YC_B C_R$  to RGB color space conversion
- optional  $YC_B C_R$  (8:8:8) output mode
- setup insertion in Luminance channel under user control
- user selectable digital SIN X/X correction
- rounding to 10/8 bit resolution per output channel
- 40 MHz maximum clock rate
- single +5 V power supply

#### APPLICATIONS

- Over-Sampling 4:2:2 to Analog RGB Conversions for video monitoring
- Over-Sampling 4:2:2 to Analog  $YC_B C_R$  Conversions for video monitoring

#### ORDERING INFORMATION

Part Number	Package	Temperature Range
GF9103-CPS	68 pin PLCC	0° to 70°C
GF9103-CTS	68 pin PLCC Tape	0° to 70°C

#### DEVICE DESCRIPTION

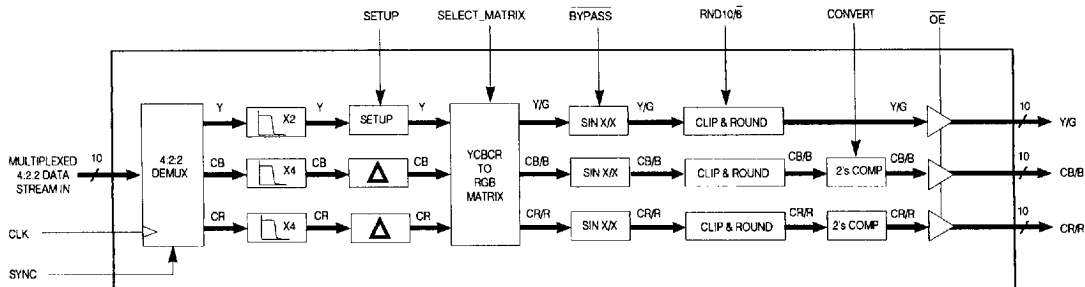
The GF9103 is specifically designed to simplify conversions from 4:2:2 component digital video to analog RGB or analog  $YC_B C_R$  component video. The GF9103 simplifies this process by performing 4:2:2 to 8:8:8 interpolation, digital color space conversion and digital SIN X/X correction in a single device. Immediately following the GF9103, three over-sampled channels of RGB or  $YC_B C_R$  data may be passed through Digital to Analog converters and simplified analog reconstruction filters.

The GF9103 accepts a single 10 bit stream of 4:2:2 data and internally de-multiplexes it into three 10 bit channels of  $YC_B C_R$  data. The  $YC_B C_R$  data is then passed through three linear phase FIR filters that over-sample the Y data by a factor of 2 and the  $C_B$  and  $C_R$  data by a factor of 4.

While operating in an over-sampled RGB output mode, the interpolated  $YC_B C_R$  data is passed through the internal color space converter to convert the  $YC_B C_R$  data to RGB data according to CCIR-601. Alternatively, the color space converter may be bypassed to obtain over-sampled  $YC_B C_R$  (8:8:8) output data. While operating in  $YC_B C_R$  output mode, setup may be dynamically inserted into the Luminance channel.

Prior to output rounding, over-sampled  $YC_B C_R$  or RGB data may be corrected for SIN X/X characteristics of D/A conversion. Output data may be rounded to 10 or 8 bit resolution per channel.  $C_B$  and  $C_R$  may be presented as signed or unsigned data.

The GF9103 is packaged in a 68 pin PLCC package, operates with a single +5 V power supply and typically consumes only 85 mA of current when operated at 27 MHz.



#### FUNCTIONAL BLOCK DIAGRAM

Revision Date August 1997

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# PIN DESCRIPTION

PIN NO.	SYMBOL	DESCRIPTION
10, 18, 27, 36 44, 52, 61, 68	$V_{DD}$	+5 V $\pm$ 5% power supply.
1, 6, 7, 9, 26, 30 35, 40, 43, 60, 64	GND	Ground.
3	SCAN_EN	Set Low.
8, 11-17, 19, 20	$SI_{9,0}$	<b>Input Data Port:</b> Input data port with internal pull-downs. Input data is assumed to be a multiplexed stream of $C_B Y C_R [Y] C_B \dots$ , where [Y] denotes an isolated Luminance sample. $SI_9$ is the Most Significant Bit and $SI_0$ is the Least Significant Bit.
4	OE	<b>Output Enable:</b> Active low input with internal pull-up. When OE is high, the output data ports are in high impedance state.
59-53, 51-49	$SOA_{9,0}$	<b>Output Data Port A:</b> Depending on device configuration, $SOA_{9,0}$ may output over-sampled Y or G video. $SOA_9$ is the Most Significant Bit and $SOA_0$ is the Least Significant Bit.
48-45, 42, 41, 39-37, 34	$SOB_{9,0}$	<b>Output Data Port B:</b> Depending on device configuration, $SOB_{9,0}$ may output over-sampled $C_B$ or B video. $SOB_9$ is the Most Significant Bit and $SOB_0$ is the Least Significant Bit.
33-31, 29, 28 25-21	$SOC_{9,0}$	<b>Output Data Port C:</b> Depending on device configuration, $SOC_{9,0}$ may output over-sampled $C_R$ or R video. $SOC_9$ is the Most Significant Bit and $SOC_0$ is the Least Significant Bit.
2	CLK	<b>System Clock:</b> All timing information relative to rising edge of clock.
5	SYNC	<b>Synchronization:</b> Control signal input with internal pull-up. This input is used to synchronize the incoming data by holding SYNC high on clock period N and low on clock period N+1 when the first $C_B$ sample is presented to the $SI_{9,0}$ inputs. SYNC may be held low until re-synchronization is desired or may be toggled at every occurrence of a $C_B$ sample.
65	SELECT_MATRIX	<b>Select Color Space Conversion:</b> Control signal input with internal pull-down. SELECT_MATRIX is used to enable and disable the internal $YC_B C_R$ to RGB color space converter. Color space conversion is enabled while SELECT_MATRIX is high and is disabled while SELECT_MATRIX is low.
66	BYPASS	<b>Bypass SIN X/X Correction:</b> Control signal input with internal pull-up. When BYPASS is high, SIN X/X correction for the three output channels is enabled. While BYPASS is low, SIN X/X correction is bypassed.
63	SETUP	<b>Setup:</b> Control signal input with internal pull-down. SETUP is used to enable and disable setup insertion in the Luminance channel.
62	CONVERT	<b>Two's Complement Conversion:</b> Control signal input with internal pull-up. While CONVERT is high, $SOB_{9,0}$ and $SOC_{9,0}$ output signed (two's complement) digital data. While CONVERT is low, $SOB_{9,0}$ and $SOC_{9,0}$ output unsigned (offset binary) data. When operating in RGB output mode, the CONVERT pin is over-ridden and both $SOB_{9,0}$ and $SOC_{9,0}$ output unsigned digital data. $SOA_{9,0}$ outputs unsigned digital data in all operating modes.
67	RND10/8	<b>Output Rounding:</b> Control signal input with internal pull-up. RND10/8 selects rounding to 10 bit resolution per channel when high and rounding to 8 bit resolution per channel when low.

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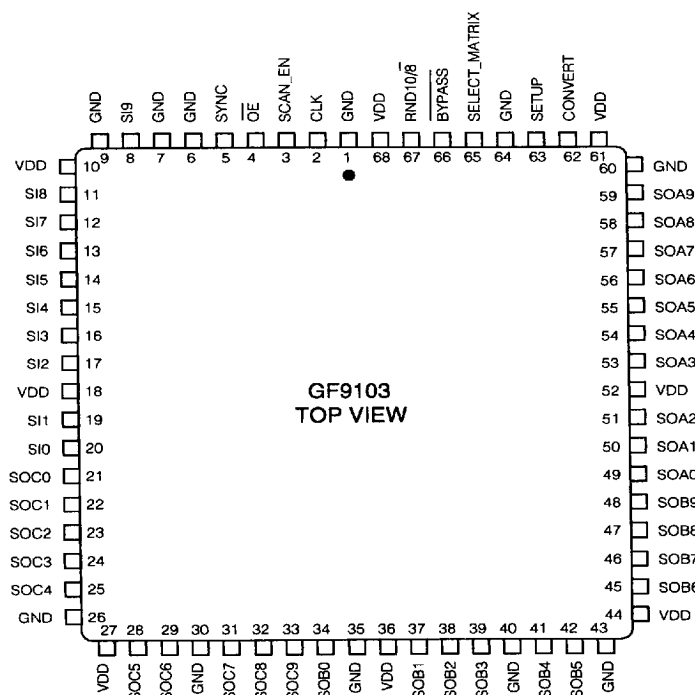


Fig. 1 GF9103 Pin Connections

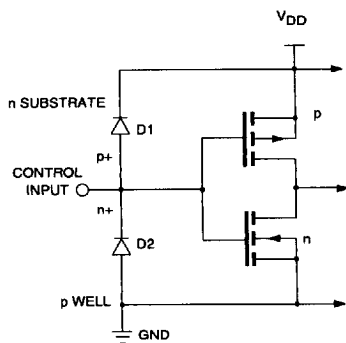


Fig. 2a Equivalent Input Circuit

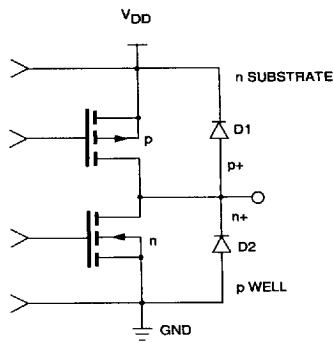


Fig. 2b Equivalent Output Circuit

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## DEVICE DESCRIPTION

The GF9103 is composed of five main sections:

- 1) 4:2:2 De-Multiplexer
- 2) FIR Filtering and Setup Insertion
- 3) Color Space Conversion
- 4) Digital SIN X/X Correction
- 5) Output Processing

### 4:2:2 DE-MULTIPLEXER

The de-multiplexer accepts data multiplexed in a SMPTE 125M compliant format from the  $SI_{9,0}$  input data port.  $SI_9$  is the Most Significant Bit and  $SI_0$  is the Least Significant Bit. The input data stream is assumed to be a multiplexed stream of  $C_B Y C_R [Y] C_B \dots$ , where the three words  $C_B Y C_R$  refer to cosited samples and where  $[Y]$  refers to an isolated Luminance sample. When operating the GF9103 with 8 bit input data,  $SI_{9,2}$  should be used to present data to the device and  $SI_{1,0}$  should be set low.

At least once during a power cycle, the GF9103 must be synchronized to the incoming data stream. The GF9103 is synchronized by holding SYNC high on clock period N and low on clock period N+1 when the first  $C_B$  sample is presented to the  $SI_{9,0}$  inputs. SYNC may be held low until re-synchronization is desired, or it may be toggled at every occurrence of a  $C_B$  sample. Refer to the timing diagram in Figure 9 for required operation of the SYNC control signal.

The internal de-multiplexer will de-multiplex all data in the input data stream including any ancillary, EDH, VITC, and EAV/ SAV ... signals that may be present. Since this data is passed directly to the interpolation filters in the same way that active video would be, it is recommended that such data be replaced with appropriate blanking levels prior to entering the GF9103.

The output of the 4:2:2 de-multiplexer consists of three 10 bit channels of  $YC_B C_R$  data. All three channels are then fed to their respective interpolation filter.

### INTERPOLATION FILTERS

Within the interpolation stage, the Luminance data is over-sampled by a factor of two and the  $C_B$  and  $C_R$  data is over-sampled by a factor of four so that the 4:2:2 data is converted to 8:8:8 data. By over-sampling the 4:2:2 data to 8:8:8 data, the size, cost and complexity of the analog reconstruction filters following Digital to Analog converters are reduced.

The Luminance data is over-sampled by a linear phase FIR filter providing 0.0 dB DC gain, +0.038/-0.025 pass-band ripple [0.0 fs to 0.21 fs], 6 dB attenuation at fs/4, and 47 dB stopband attenuation [0.30 fs to 0.50 fs]. Figure 3 and Figure 4 present the frequency response of the Luminance interpolation filter.

The  $C_B$  and  $C_R$  data is over-sampled by a linear phase FIR filter providing 0.0 dB DC gain, passband ripple of +0.2 dB/-0.2 dB [0.0 to 0.07 fs], 6 dB attenuation at fs/8 and a stopband attenuation of 28 dB [0.17 fs to 0.50 fs].

Figure 5 and Figure 6 present the frequency response of the  $C_B$  and  $C_R$  interpolation filters.

Following the interpolation process, a DC offset may be introduced into the Luminance channel. Setup insertion is enabled and disabled by the SETUP control signal. While SETUP is high, the Luminance data is scaled by a factor of +947/1024 and an offset of +71 (decimal) is added. While SETUP is low, no scaling or offset is applied and the data passes through the stage unmodified. The timing diagram in Figure 10 demonstrates the operation of the SETUP control signal.

### COLOR SPACE CONVERSION

Two operating modes exist for the color space converter section. These two modes are controlled by the SELECT\_MATRIX control signal. While SELECT\_MATRIX is low, the de-matrixing 3x3 multiplier is bypassed so that over-sampled  $YC_B C_R$  data is passed through the stage unmodified. While SELECT\_MATRIX is high, the 3x3 multiplier implements the following color space conversion:

$$\begin{bmatrix} G \\ B \\ R \end{bmatrix} = \begin{bmatrix} 1 & -689/2048 & -1430/2048 \\ 1 & 3548/2048 & 0 \\ 1 & 0 & 2807/2048 \end{bmatrix} \begin{bmatrix} Y \\ C_B \\ C_R \end{bmatrix}$$

### SIN X/X Correction

While BYPASS is high, SIN X/X correction is enabled on each of the three output channels. SIN X/X correction is implemented by passing the data through a FIR filter with the frequency response shown in Figure 7. While BYPASS is low, the FIR filter is bypassed and each channel is passed directly to the output processing section. Total latency through the device is 22 clock cycles when BYPASS is low and 24 clock cycles when BYPASS is high.

### OUTPUT PROCESSING

Output data may be rounded to 10 or 8 bit accuracy. RND10/8 should be set high for 10 bit output rounding and set low for 8 bit output rounding. Rounding to 8 bit accuracy is accomplished by adding a rounding bit to  $SO_1$  and then zeroing both  $SO_0$  and  $SO_1$ .

$C_B$  and  $C_R$  data may be output as signed (two's complement) or unsigned (offset binary) data depending on the state of the CONVERT control signal. When CONVERT is set high, the  $C_B$  and  $C_R$  channels are output as signed (two's complement) data. When CONVERT is set low,  $C_B$  and  $C_R$  are output as unsigned (offset binary) data, obtained by inverting the sign bit of the two's complement number. When operating in RGB output mode, the CONVERT pin is over-ridden and RGB data is always output as unsigned (offset binary) data.

CONTROL SIGNAL/OPERATING MODE SUMMARY

SYNC

The SYNC control signal provides synchronization for the internal 4:2:2 de-multiplexer. SYNC should be held high on clock period N and low on clock period N+1 when the first C<sub>B</sub> sample is presented to the SI<sub>9,0</sub> inputs. SYNC may be held low until re-synchronization is desired or may be toggled at every occurrence of a C<sub>B</sub> sample.

SELECT\_MATRIX AND SETUP

SELECT\_MATRIX and SETUP select the color space conversion and offset insertions which the GF9103 is to perform. The following chart presents the available color space conversions and the corresponding states of the SELECT\_MATRIX and SETUP control pins. SETUP is a dynamic pin that may be modified every clock cycle.

SELECT_MATRIX	SETUP	DESCRIPTION
0	0	Selects output to be over-sampled YC <sub>B</sub> C <sub>R</sub> with no setup in Y channel.
0	1	Selects output to be over-sampled YC <sub>B</sub> C <sub>R</sub> with a scaling factor of +947/1024 and an offset of +71 (decimal) applied to the Y channel.
1	X	Selects output to be over-sampled RGB with no setup.

SIN X/X CORRECTION

BYPASS	DESCRIPTION
1	SIN X/X correction enabled on all output data channels. Latency through the device is 24 clock cycles.
0	SIN X/X correction disabled. Latency through the device is 22 clock cycles.

OUTPUT ROUNDING

RND10/8	DESCRIPTION
1	Output data rounded to 10 bit resolution per channel.
0	Output data rounded to 8 bit resolution per channel.

TWO'S COMPLEMENT OUTPUT CONVERSION

CONVERT	SELECT_MATRIX	DESCRIPTION
1	0	SOB <sub>9,0</sub> and SOC <sub>9,0</sub> output signed (two's complement) C <sub>B</sub> and C <sub>R</sub> data.
0	0	SOB <sub>9,0</sub> and SOC <sub>9,0</sub> output unsigned (offset binary) C <sub>B</sub> and C <sub>R</sub> data.
X	1	SOB <sub>9,0</sub> and SOC <sub>9,0</sub> output unsigned B and R data.

OUTPUT ENABLE

OE	DESCRIPTION
0	All output data ports are enabled.
1	All output data ports are in high impedance state.

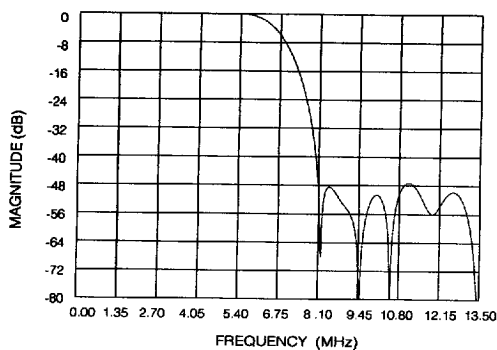


Fig. 3 Frequency Response of Luminance Interpolation Filter (Sampling at  $f_s = 27$  MHz)

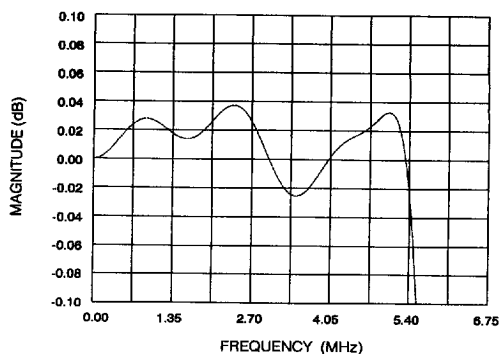


Fig. 4 Frequency Response of Luminance Interpolation Filter (Sampling at  $f_s = 27$  MHz)

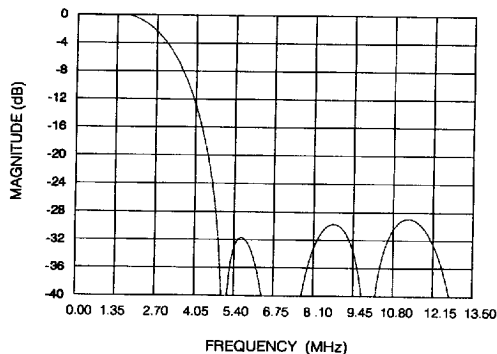


Fig. 5 Frequency Response of Chrominance Interpolation Filter (Sampling at  $f_s = 27$  MHz)

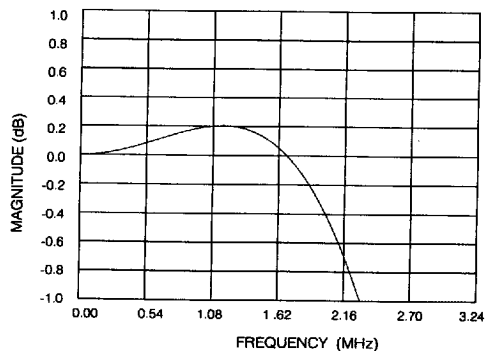


Fig. 6 Frequency Response of Chrominance Interpolation Filter (Sampling at  $f_s = 27$  MHz)

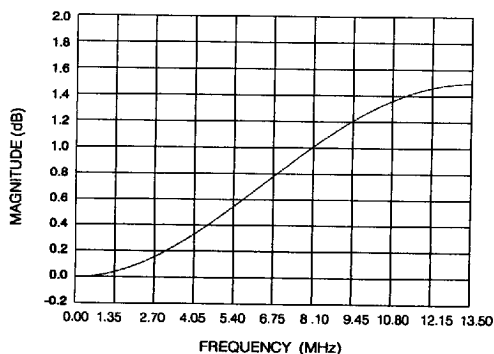


Fig. 7 SIN X/X Compensation Filter Frequency Response (Sampling at  $f_s = 27$  MHz)

PARAMETER	LUMINANCE FILTER	CHROMINANCE FILTER
Filter Order	31	15
Pass Band Ripple	+0.038/-0.025 dB (0.0 $f_s$ to 0.21 $f_s$ )	+0.2/-0.2 dB (0.0 $f_s$ to 0.07 $f_s$ )
DC Gain	0.0 dB	0.0 dB
Attenuation	-6.00 dB (at $f_g/4$ )	-6.00 dB (at $f_g/8$ )
Stop Band Attenuation	-47 dB (0.30 $f_s$ to 0.50 $f_s$ )	-28 dB (0.17 $f_s$ to 0.50 $f_s$ )


Fig. 8 Luminance and Chrominance Filter Characteristics

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# ABSOLUTE MAXIMUM RATINGS

PARAMETER	VALUE
Supply Voltage	-0.3 to +7.0 V
Input Voltage Range (any input)	+0.5 to ( $V_{DD} + 0.5$ ) V
Operating Temperature Range	0°C ≤ T <sub>A</sub> ≤ 70°C
Storage Temperature Range	-65°C ≤ T <sub>S</sub> ≤ 150°C
Lead Temperature (soldering 10 seconds)	260°C

**CAUTION**  
ELECTROSTATIC  
SENSITIVE DEVICES  
DO NOT OPEN PACKAGES OR HANDLE  
EXCEPT AT A STATIC-FREE WORKSTATION



## ELECTRICAL CHARACTERISTICS

V<sub>DD</sub> = 5 V, T<sub>A</sub> = 0° to 70°C, R<sub>L</sub> = 150 Ω to GND and 144 Ω AC coupled unless otherwise shown.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V <sub>DD</sub>		4.75	5	5.25	V
Supply Current Quiescent	I <sub>DDQ</sub>	V <sub>DD</sub> = Max, V <sub>IN</sub> = 0V	-	5	9	mA
Supply Current Unloaded	I <sub>DDU</sub>	V <sub>DD</sub> = Max, OE = V <sub>DD</sub> , f = 27 MHz	-	85	150	mA
Input Voltage, Logic Low	V <sub>IL</sub>		-	-	0.2V <sub>DD</sub>	V
Input Voltage, Logic High	V <sub>IH</sub>		0.7V <sub>DD</sub>	-	-	V
Switching Threshold	V <sub>T</sub>	CMOS	-	2.5	-	V
Input Current: (CMOS Inputs)	I <sub>IN</sub>	V <sub>IN</sub> = V <sub>DD</sub> or GND	-10	±1	10	μA
Inputs with Pulldown Resistors		V <sub>IN</sub> = V <sub>DD</sub>	35	115	222	μA
Inputs with Pullup Resistors		V <sub>IN</sub> = GND	-35	-115	-214	μA
Output Voltage, Logic Low	V <sub>OL</sub>	V <sub>DD</sub> = Min, I <sub>OL</sub> = 4mA	-	0.2	0.4	V
Output Voltage, Logic High	V <sub>OH</sub>	V <sub>DD</sub> = Min, I <sub>OH</sub> = -4mA	2.4	4.5	-	V
Hi-Z Output Leakage Current	I <sub>OZ</sub>	V <sub>DD</sub> = Max, OE = 1	-10	±1	10	μA
Short Circuit Output Current	I <sub>OS</sub>	V <sub>DD</sub> = Max, output high one pin to ground, one second duration max	-	-	140	mA
Input Capacitance	C <sub>IN</sub>	T <sub>A</sub> = 25°C, f = 1MHz	-	-	10	pF
Output Capacitance	C <sub>OUT</sub>	T <sub>A</sub> = 25°C, f = 1MHz	-	-	10	pF

## SWITCHING CHARACTERISTICS, T<sub>A</sub> from 0°C to 70°C unless otherwise specified.

NAME	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
t <sub>D</sub>	Output delay	V <sub>DD</sub> = Min, C <sub>L</sub> = 25 pF	8	9	10	ns
t <sub>OH</sub>	Output hold time	V <sub>DD</sub> = Max, C <sub>L</sub> = 25 pF	1	-	-	ns
t <sub>EN</sub>	Output enable	V <sub>DD</sub> = Min, C <sub>L</sub> = 25 pF	-	-	8	ns
t <sub>DIS</sub>	Output disable	V <sub>DD</sub> = Min, C <sub>L</sub> = 25 pF	-	-	8	ns
t <sub>CV</sub>	Cycle time		25	-	-	ns
t <sub>PWL</sub>	Clock pulse width low		10	-	-	ns
t <sub>PWH</sub>	Clock pulse width high		10	-	-	ns
t <sub>S</sub>	Input setup time		8	-	-	ns
t <sub>H</sub>	Input hold time		1	-	-	ns

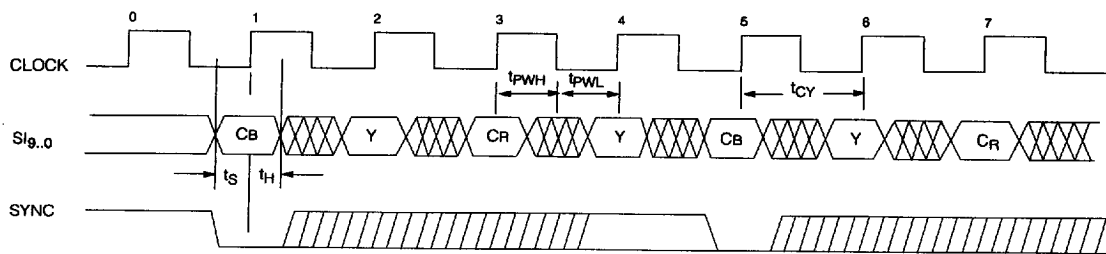


Fig. 9 Operation of SYNC Control Signal

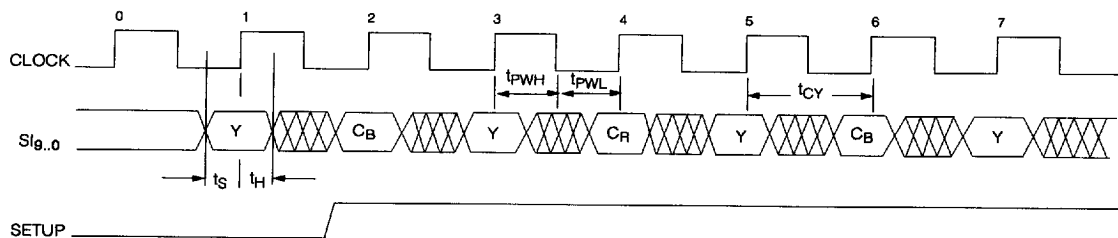


Fig. 10 Operation of SETUP Control Signal

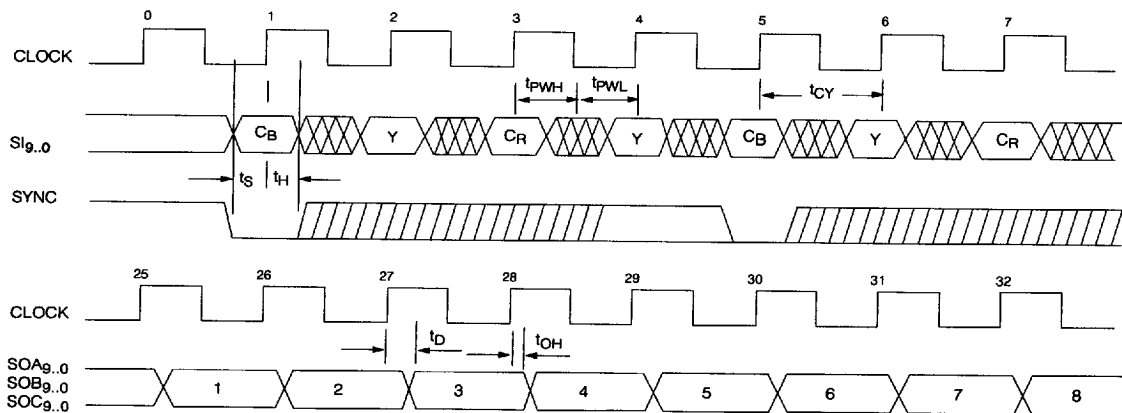
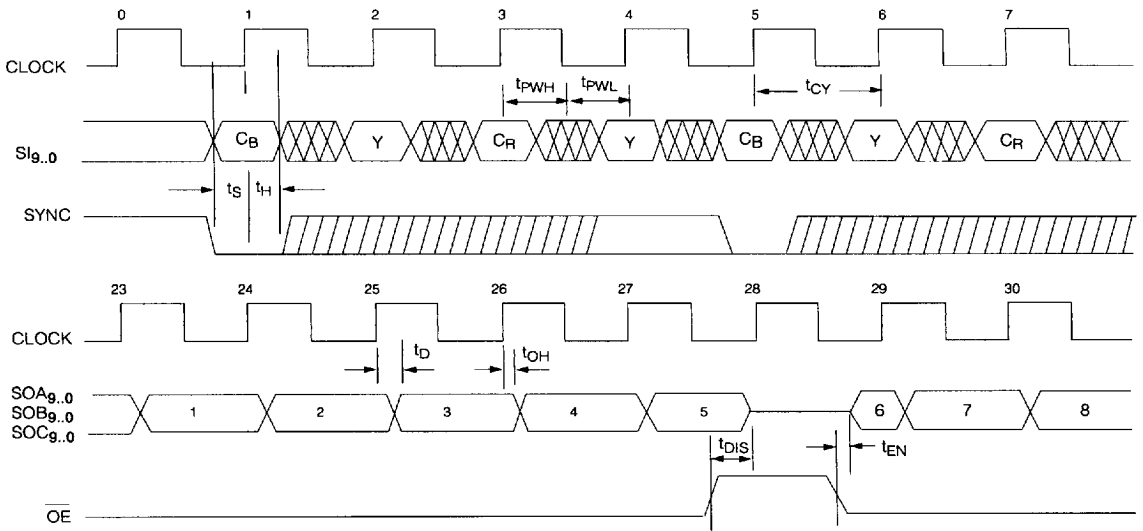


Fig. 11 Input/Output Timing.  $\overline{\text{BYPASS}} = 1$ .

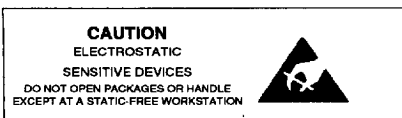
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GF9103

Fig. 12 Input/Output Timing. BYPASS = 0.



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