

## NTSC/PAL Digital Video Encoder

### Features

- Six DACs providing simultaneous composite, S-video, and RGB or Component YUV outputs
- Programmable DAC output currents for low impedance (37.5  $\Omega$ ) and high impedance (150  $\Omega$ ) loads
- Multi-standard support for NTSC-M, NTSC-JAPAN, PAL (B, D, G, H, I, M, N, Combination N)
- ITU R.BT656 input mode supporting EAV/SAV codes and CCIR601 Master/Slave input modes
- Programmable HSYNC and VSYNC timing
- Multistandard Teletext (Europe, NABTS, WST) support
- VBI encoding support
- Wide-Screen Signaling (WSS) support, EIA-J CPX1204
- NTSC closed caption encoder with interrupt
- CS4955 supports Macrovision copy protection Version 7
- Host interface configurable for parallel or I<sup>2</sup>C® compatible operation
- On-chip voltage reference generator
- +3.3 V or +5 V operation, CMOS, low-power modes, three-state DACs

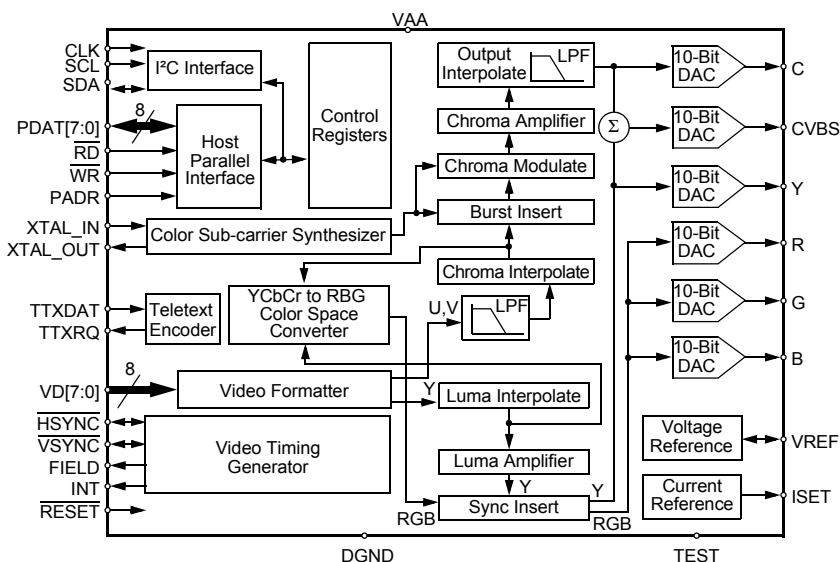
### Description

The CS4954/5 provides full conversion from digital video formats YCbCr or YUV to NTSC and PAL Composite, Y/C (S-video) and RGB, or YUV analog video. Input formats can be 27 MHz 8-bit YUV, 8-bit YCbCr, or ITU R.BT656 with support for EAV/SAV codes. Video output can be formatted to be compatible with NTSC-M, NTSC-J, PAL-B,D,G,H,I,M,N, and Combination N systems. Closed Caption is supported in NTSC. Teletext is supported for NTSC and PAL.

Six 10-bit DACs provide two channels for an S-Video output port, one or two composite video outputs, and three RGB or YUV outputs. Two-times oversampling reduces the output filter requirements and guarantees no DAC-related modulation components within the specified bandwidth of any of the supported video standards.

Parallel or high-speed I<sup>2</sup>C compatible control interfaces are provided for flexibility in system design. The parallel interface doubles as a general purpose I/O port when the CS4954/5 is in I<sup>2</sup>C mode to help conserve valuable board area.

The CS4954 and CS4955 are available in a 48-pin TQFP and operate in -40 to +85°C ambient temperature. The CDB4954/55 Customer Demonstration board is also available. Please refer to [“Ordering Information”](#) on page 2.



**ORDERING INFORMATION**

| Product    | Description                    | Package | Pb-Free | Grade      | Temp Range    | Container | Order#       |
|------------|--------------------------------|---------|---------|------------|---------------|-----------|--------------|
| CS4954     | NTSC/PAL Digital Video Encoder | 48-TQFP | Yes     | Commercial | -40° to +85°C | Rail      | CS4954-CQZ   |
| CS4955     |                                |         |         |            |               |           | CS4955-CQZ   |
| CDB4954/55 | CS4954/55 Evaluation Board     |         | No      | -          | -             | -         | CDB4954A/55A |

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## 1. CHARACTERISTICS AND SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

### AC & DC PARAMETRIC SPECIFICATIONS (AGND,DGND = 0 V, all voltages with respect to 0 V)

| Parameter                                   | Symbol  | Min  | Max       | Units |
|---------------------------------------------|---------|------|-----------|-------|
| Power Supply                                | VAA/VDD | -0.3 | 6.0       | V     |
| Input Current Per Pin (Except Supply Pins)  |         | -10  | 10        | mA    |
| Output Current Per Pin (Except Supply Pins) |         | -50  | +50       | mA    |
| Analog Input Voltage                        |         | -0.3 | VAA + 0.3 | V     |
| Digital Input Voltage                       |         | -0.3 | VDD + 0.3 | V     |
| Ambient Temperature Power Applied           |         | -55  | + 125     | °C    |
| Storage Temperature                         |         | -65  | + 150     | °C    |

WARNING: Operating beyond these limits can result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

### RECOMMENDED Operating Conditions (AGND,DGND = 0 V, all voltages with respect to 0 V.)

| Parameter                      | Symbol  | Min          | Typ        | Max          | Units |
|--------------------------------|---------|--------------|------------|--------------|-------|
| Power Supplies: Digital Analog | VAA/VDD | 3.15<br>4.75 | 3.3<br>5.0 | 3.45<br>5.25 | V     |
| Operating Ambient Temperature  | TA      | -40          | +25        | +85          | °C    |

Note: Operation outside the ranges is not recommended.

## THERMAL CHARACTERISTICS

| Parameters                            | Symbol           | Min | Typ | Max | Units |
|---------------------------------------|------------------|-----|-----|-----|-------|
| Allowable Junction Temperature        |                  | -   | -   | 150 | °C    |
| Junction to Ambient Thermal Impedance |                  | -   | -   | -   |       |
| (Four-layer PCB) TQFP                 | $\theta_{JA-TM}$ | -   | 45  | -   | °C/W  |
| (Two-layer PCB) TQFP                  | $\theta_{JA-TS}$ | -   | 65  | -   |       |

Note: Four-layer PCB recommended for operation in environments where TA > 70° C.

### DC CHARACTERISTICS (TA = 25° C; VAA, VDD = 5 V; GNDA, GNDD = 0 V.)

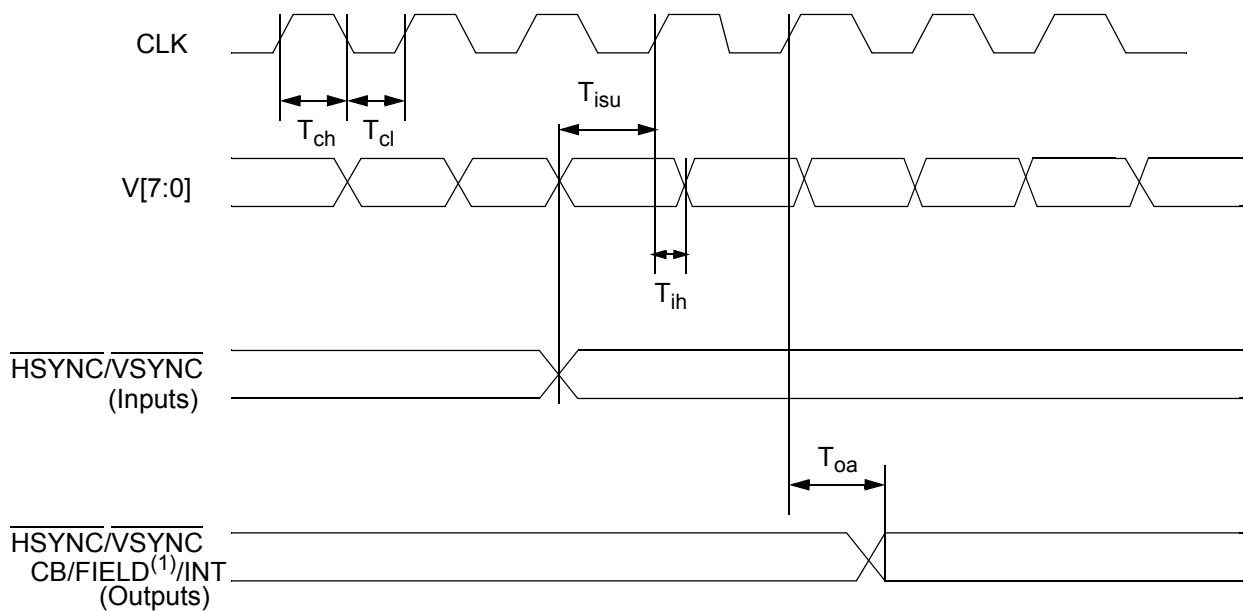
| Parameter                                                          | Symbol | Min     | Typ | Max     | Units |
|--------------------------------------------------------------------|--------|---------|-----|---------|-------|
| <b>Digital Inputs</b>                                              |        |         |     |         |       |
| High level Input Voltage<br>V [7:0], PDAT [7:0], Hsync/Vsync/CLKIN | VIH    | 2.2     | -   | VDD+0.3 | V     |
| High Level Input Voltage I <sup>2</sup> C                          | VIH    | 0.7 VDD | -   | -       | V     |
| Low level Input Voltage All Inputs                                 | -      | -0.3    | -   | 0.8     | V     |
| Input Leakage Current                                              | -      | -10     | -   | +10     | μA    |
| <b>Digital Outputs</b>                                             |        |         |     |         |       |
| High Level Output Voltage Io = -4 mA                               | VOH    | 2.4     | -   | VDD     | V     |
| Low level Output Voltage Io = 4 mA                                 | VOL    | -       | -   | 0.4     | V     |

| Parameter                                                 | Symbol   | Min          | Typ        | Max          | Units            |
|-----------------------------------------------------------|----------|--------------|------------|--------------|------------------|
| Low Level Output Voltage SDA pin only, $I_o = 6\text{mA}$ | VOL      | -            | -          | 0.4          | V                |
| Output Leakage Current High-Z Digital Outputs             | -        | -10          | -          | +10          | $\mu\text{A}$    |
| <b>Analog Outputs</b>                                     |          |              |            |              |                  |
| Full Scale Output Current CVBS/Y/C/R/G/B (Notes 1, 2, 3)  | IO       | 32.9         | 34.7       | 36.5         | mA               |
| Full Scale Output Current CVBS/Y/C/R/G/B (Notes 1, 2, 4)  | IO       | 8.22         | 8.68       | 9.13         | mA               |
| LSB Current CVBS/Y/C/R/G/B (Notes 1, 2, 3)                | IB       | 32.2         | 33.9       | 35.7         | $\mu\text{A}$    |
| LSB Current CVBS/Y/C/R/G/B (Notes 1, 2, 4)                | IB       | 8.04         | 8.48       | 8.92         | $\mu\text{A}$    |
| DAC-to-DAC Matching (Note 1)                              | MAT      | -            | 2          | 4            | %                |
| Output Compliance (Note 1)                                | VOC      | 0            | -          | + 1.4        | V                |
| Output Impedance (Note 1)                                 | ROUT     | -            | 15         | -            | $\text{k}\Omega$ |
| Output Capacitance (Note 1)                               | COUT     | -            | -          | 30           | pF               |
| DAC Output Delay (Note 1)                                 | ODEL     | -            | 4          | 12           | ns               |
| DAC Rise/Fall Time (Note 1, 5)                            | TRF      | -            | 2.5        | 5            | ns               |
| <b>Voltage Reference</b>                                  |          |              |            |              |                  |
| Reference Voltage Output                                  | VOV      | 1.170        | 1.232      | 1.294        | V                |
| Reference Input Current (Note 1)                          | UVC      | -            | -          | 10           | $\mu\text{A}$    |
| <b>Power Supply</b>                                       |          |              |            |              |                  |
| Supply Voltage                                            | VAA, VDD | 3.15<br>4.75 | 3.3<br>5.0 | 3.45<br>5.25 | V                |
| Digital Supply Current                                    | IAA1     | -            | 70         | 150          | mA               |
| Analog Supply Low-Z (Note 6)                              | IAA2     | -            | 100        | 150          | mA               |
| Analog Supply High-Z (Note 7)                             | IAA3     | -            | 60         | 100          | mA               |
| Power Supply Rejection Ratio                              | PSRR     |              | 0.02       | 0.05         | V / V            |
| <b>Static Performance</b>                                 |          |              |            |              |                  |
| DAC Resolution (Note 1)                                   |          | -            | -          | 10           | Bits             |
| Differential Non-Linearity (Note 1)                       | DNL      | -1           | $\pm 0.5$  | + 1          | LSB              |
| Integral Non-Linearity (Note 1)                           | INL      | - 2          | $\pm 1$    | + 2          | LSB              |
| <b>Dynamic Performance</b>                                |          |              |            |              |                  |
| Differential Gain (Note 1)                                | DG       | -            | 2          | 5            | %                |
| Differential Phase (Note 1)                               | DP       | -            | $\pm 0.5$  | $\pm 2$      | °                |
| Hue Accuracy (Note 1)                                     | HA       | -            | -          | 2            | °                |
| Signal to Noise Ratio                                     | SNR      | 70           | -          | -            | dB               |
| Saturation Accuracy (Note 1)                              | SAT      | -            | 1          | 2            | %                |

- Notes:
1. Values are by characterization only
  2. Output current levels with  $I_{SET} = 4\text{ k}\Omega$ ,  $V_{REF} = 1.232\text{ V}$ .
  3. DACs are set to low impedance mode
  4. DACs are set to high impedance mode
  5. Times for black-to-white-level and white-to-black-level transitions.
  6. Low-Z, 3 DACs on
  7. High-Z, 6 DACs on

## AC CHARACTERISTICS

| Parameter                                      | Symbol           | Min   | Typ   | Max   | Units |
|------------------------------------------------|------------------|-------|-------|-------|-------|
| <b>Pixel Input and Control Port (Figure 1)</b> |                  |       |       |       |       |
| Clock Pulse High Time                          | T <sub>ch</sub>  | 14.82 | 18.52 | 22.58 | ns    |
| Clock Pulse Low Time                           | T <sub>cl</sub>  | 14.82 | 18.52 | 22.58 | ns    |
| Clock to Data Set-up Time                      | T <sub>isu</sub> | 6     | -     | -     | ns    |
| Clock to Data Hold Time                        | T <sub>ih</sub>  | 0     | -     | -     | ns    |
| Clock to Data Output Delay                     | T <sub>oa</sub>  | -     | -     | 17    | ns    |



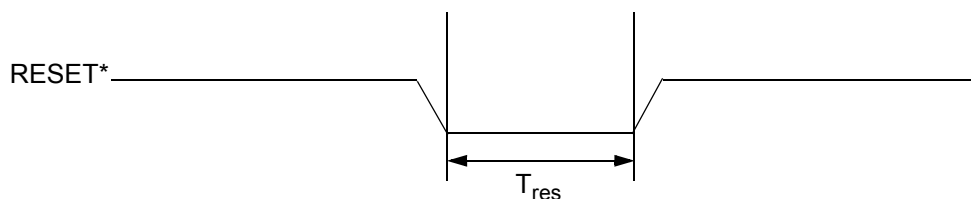
**Figure 1.** Video Pixel Data and Control Port Timing

| Parameter                                         | Symbol | Min | Typ | Max  | Units |
|---------------------------------------------------|--------|-----|-----|------|-------|
| <b>I<sup>2</sup>C Host Port Timing (Figure 2)</b> |        |     |     |      |       |
| SCL Frequency                                     | Fclk   |     |     | 1000 | kHz   |
| Clock Pulse High Time                             | Tsph   | 0.1 |     |      | μs    |
| Clock Pulse Low Time                              | Tspl   | 0.7 |     |      | μs    |
| Hold Time (Start Cond.)                           | Tsh    | 100 |     |      | ns    |
| Setup Time (Start Cond.)                          | Tssu   | 100 |     |      | ns    |
| Data Setup Time                                   | Tsds   | 50  |     |      | ns    |
| Rise Time                                         | Tsr    |     |     | 1    | μs    |
| Fall Time                                         | Tsf    |     |     | 0.3  | μs    |
| Setup Time (Stop Cond.)                           | Tss    | 100 |     |      | ns    |
| Bus Free Time                                     | Tbuf   | 100 |     |      | ns    |
| Data Hold Time                                    | Tdh    | 0   |     |      | ns    |
| SCL Low to Data Out Valid                         | Tvdo   |     |     | 600  | ns    |



**TIMING CHARACTERISTICS**(Continued)

| <b>Parallel Host Port Timing (Figure 27, 28, 29)</b> | <b>Symbol</b> | <b>Min</b> | <b>Typ</b> | <b>Max</b> | <b>Units</b> |
|------------------------------------------------------|---------------|------------|------------|------------|--------------|
| Read Cycle Time                                      | Trd           | 60         | -          | -          | ns           |
| Read Pulse Width                                     | Trpw          | 30         | -          | -          | ns           |
| Address Setup Time                                   | Tas           | 3          | -          | -          | ns           |
| Read Address Hold Time                               | Trah          | 10         | -          | -          | ns           |
| Read Data Access Time                                | Trda          | -          | -          | 40         | ns           |
| Read Data Hold Time                                  | Trdh          | 10         | -          | 50         | ns           |
| Write Recovery Time                                  | Twr           | 60         | -          | -          | ns           |
| Write Pulse Width                                    | Twpw          | 40         | -          | -          | ns           |
| Write Data Setup Time                                | Twds          | 8          | -          | -          | ns           |
| Write Data Hold Time                                 | Twdh          | 3          | -          | -          | ns           |
| Write-Read/Read-Write Recovery Time                  | Trec          | 50         | -          | -          | ns           |
| Address from Write Hold Time                         | Twac          | 0          | -          | -          | ns           |
| <b>Reset Timing (Figure 3)</b>                       |               |            |            |            |              |
| Reset Pulse Width                                    | Tres          | 100        |            |            | ns           |


**Figure 3.** Reset Timing

## 2. ADDITIONAL CS4954/5 FEATURES

- Five programmable DAC output combinations, including YUV and second composite
- Optional pseudo-progressive scan @ MPEG2 field rates
- Stable color subcarrier for MPEG2 systems
- General purpose input and output pins
- Individual DAC power-down capability
- On-chip color bar generator
- Supports RS170A and ITU R.BT601 composite output timing
- HSYNC and VSYNC output in ITU R.BT656 mode
- Teletext encoding selectable on two composite and S-video signals
- Programmable saturation, SCH Phase, hue, brightness and contrast
- Device power-down capability
- Super White and Super Black support

## 3. CS4954 INTRODUCTION

The CS4954/5 is a complete multi-standard digital video encoder implemented in current CMOS technology. The device can operate at 5 V as well as at 3.3 V. ITU R.BT601- or ITU R.BT656-compliant digital video input is converted into NTSC-M, NTSC-J, PAL-B, PAL-D, PAL-G, PAL-H, PAL-I, PAL-M, PAL-N, or PAL-N Argentina-compatible analog video. The CS4954/5 is designed to connect, without glue logic, to MPEG1 and MPEG2 digital video decoders.

Two 10-bit DAC outputs provide high quality S-Video analog output while another 10-bit DAC simultaneously generates composite analog video. In addition, there are three more DACs to provide simultaneous analog RGB or analog YUV outputs. The CS4954/5 will accept 8-bit YCbCr or 8-bit YUV input data.

The CS4954/5 is completely configured and controlled via an 8-bit host interface port or an I<sup>2</sup>C compatible serial interface. This host port provides access and control of all CS4954/5 options and features, such as closed caption insertion, interrupts, etc.

In order to lower overall system costs, the CS4954/5 provides an internal voltage reference that eliminates the requirement for an external, discrete, three-pin voltage reference.

In ISO MPEG-2 system configurations, the CS4954/5 can be augmented with a common color-burst crystal to provide a stable color subcarrier given an unstable 27 MHz clock input. The use of the crystal is optional, but the facility to connect one is provided for MPEG-2 environments in which the system clock frequency variability is too wide for accurate color sub-carrier generation.

## 4. FUNCTIONAL DESCRIPTION

In the following subsections, the functions of the CS4954/5 will be described. The descriptions refer to the device elements shown in the block diagram on the cover page.

### 4.1 Video Timing Generator

All timing generation is accomplished via a 27 MHz input applied to the CLK pin. The CS4954/5 can also accept a signal from an optional color burst crystal on the XTAL\_IN & XTAL\_OUT pins. See the section, Color Subcarrier Synthesizer, for further details.

The Video Timing Generator is responsible for orchestrating most of the other modules in the device. It operates in harmony with external sync input timing, or it can provide external sync timing outputs. It automatically disables color burst on appropriate scan lines and automatically generates serration and equalization pulses on appropriate scan lines.

The CS4954/5 is designed to function as a video timing master or video timing slave. In both Master and Slave Modes, all timing is sampled and asserted with the rising edge of the CLK pin.

In most cases, the CS4954/5 will serve as the video timing master.  $\overline{\text{HSYNC}}$ ,  $\overline{\text{VSYNC}}$ , and  $\text{FIELD}^{(1)}$  are configured as outputs in Master Mode.  $\overline{\text{HSYNC}}$  or  $\text{FIELD}$  can also be defined as a composite blanking output signal in Master Mode. In Master Mode, the timing of  $\overline{\text{HSYNC}}$ ,  $\overline{\text{VSYNC}}$ ,  $\text{FIELD}$  and Composite Blank (CB) signals is programmable. Exact horizontal and vertical display timing is addressed in the Operational Description section.

In Slave Mode,  $\overline{\text{HSYNC}}$  and  $\overline{\text{VSYNC}}$  are typically configured as input pins and are used to initialize independent vertical and horizontal timing generators upon their respective falling edges.  $\overline{\text{HSYNC}}$  and  $\overline{\text{VSYNC}}$  timing must conform to the ITU-R BT.601 specifications.

The CS4954/5 also provides a ITU R.BT656 Slave Mode in which the video input stream contains EAV and SAV codes. In this case, proper  $\overline{\text{HSYNC}}$  and  $\overline{\text{VSYNC}}$  timing is extracted automatically without any inputs other than the V [7:0]. ITU R.BT656 input data that is sampled with the leading edge of CLK.

In addition, it is also possible to output HSYNC and VSYNC signals when in ITU R.BT656 Slave Mode.

## 4.2 Video Input Formatter

The Video Input Formatter translates YCbCr input data into YUV information, when necessary, and splits the luma and chroma information for filtering, scaling, and modulation.

## 4.3 Color Subcarrier Synthesizer

The subcarrier synthesizer is a digital frequency synthesizer that produces the appropriate subcarrier frequency for NTSC or PAL. The CS4954/5

generates the color burst frequency based on the CLK input (27 MHz). Color burst accuracy and stability are limited by the accuracy of the 27 MHz input. If the frequency varies, then the color burst frequency will also vary accordingly.

For environments in which the CLK input varies or jitters unacceptably, a local crystal frequency reference can be used on the XTAL\_IN and XTAL\_OUT pins. In this instance, the input CLK is continuously compared with the external crystal reference input and the internal timing of the CS4954/5 is automatically adjusted so that the color burst frequency remains within tolerance.

Controls are provided for phase adjustment of the burst to permit color adjustment and phase compensation. Chroma hue control is provided by the CS4954/5 via a 10-bit Hue Control Register (HUE\_LSB and H\_MSB). Burst amplitude control is also made available to the host via the 8-bit burst amplitude register (SC\_AMP).

## 4.4 Chroma Path

The Video Input Formatter delivers 4:2:2 YUV outputs to separate chroma and luma data paths.

The chroma output of the Video Input Formatter is directed to a chroma low-pass 19-tap FIR filter. The filter bandwidth is selected (or the filter can be bypassed) via the CONTROL\_1 Register. The passband of the filter is either 650 kHz or 1.3 MHz and the passband ripple is less than or equal to 0.05 dB. The stopband for the 1.3 MHz selection begins at 3 MHz with an attenuation of greater than 35 dB. The stopband for the 650 kHz selection begins around 1.1 MHz with an attenuation of greater than 20 dB.

The output of the chroma low-pass filter is connected to the chroma interpolation filter in which up-sampling from 4:2:2 to 4:4:4 is accomplished. Following the interpolation filter, the U and V chroma signals pass through two independent vari-

NOTE 1. The FIELD pin (pin 9) remains an output pin in SLAVE mode. However, the FIELD pin state does not toggle in SLAVE mode and its output state should be considered random.

able gain amplifiers in which the chroma amplitude can be varied via the U\_AMP and V\_AMP 8-bit host addressable registers.

The U and V chroma signals are fed to a quadrature modulator in which they are combined with the output from the subcarrier synthesizer to produce the proper modulated chrominance signal.

The chroma is then interpolated by a factor of two in order to operate the output DACs at twice the pixel rate. The interpolation filters enable running the DACs at twice the pixel rate which helps reduce the  $\sin x/x$  roll-off for higher frequencies and reduces the complexity of the external analog low pass filters.

#### 4.5 Luma Path

Along with the chroma output path, the CS4954/5 Video Input Formatter has a parallel luma data output to a digital delay line. The delay line is a digital FIFO. The FIFO depth matches the clock period delay associated with the more complex chroma path. Brightness adjustment is also provided via the 8-bit BRIGHTNESS\_OFFSET Register.

Following the luma delay, the data is passed through an interpolation filter that has a programmable bandwidth, followed by a variable gain amplifier. The amplifier DC luma gain can be changed using the the Y\_AMP Register.

The output of the luma amplifier connects to the sync insertion block. Sync insertion is accomplished by multiplexing, into the luma data path, the different sync DC values at the appropriate times. The digital sync generator takes horizontal sync and vertical sync timing signals and generates the appropriate composite sync timing (including vertical equalization and serration pulses), blanking information, and burst flag. The sync edge rates conform to RS-170A or ITU R.BT601 and ITU R.BT470 specifications.

It is also possible to delay the luminance signal, with respect to the chrominance signal, by up to

three pixel clocks. This variable delay is useful to offset different propagation delays of the luma baseband and modulated chroma signals. This adjustable luma delay is available only on the CVBS\_1 output.

#### 4.6 RGB Path and Component YUV Path

The RGB datapath has the same latency as the luma and chroma path. Therefore all six simultaneous analog outputs are synchronized. The 4:2:2 YCbCr data is first interpolated to 4:4:4 and then interpolated to 27 MHz. The color space conversion is performed at 27 MHz. The coefficients for the color space conversion conform to the ITU R.BT601 specifications.

After color space conversion, the amplitude of each component can be independently adjusted via the R\_AMP, G\_AMP, and B\_AMP 8-bit host addressable registers. A synchronization signal can be added to either one, two or all of the RGB signals. The synchronization signal conforms to NTSC or PAL specifications.

Some applications (e.g., projection TVs) require analog component YUV signals. The chip provides a programmable mode that outputs component YUV data. Sync can be added to the luminance signal. Independent gain adjustment of the three components is provided as well.

#### 4.7 Digital to Analog Converters

The CS4954/5 provides six discrete 27 MHz DACs for analog video. The default configuration is one 10-bit DAC for S-video chrominance, one 10-bit DAC for S-Video luminance, one 10-bit DAC for composite output, and three 10-bit DACs for RGB outputs. All six DACs are designed for driving either low-impedance loads (double terminated 75  $\Omega$ ) or high-impedance loads (double terminated 300  $\Omega$ ). There are five different DAC configurations to choose from (see Table 1, below).

The DACs can be put into high-impedance mode via host-addressable control register bits. Each of

| DAC  | Pin # | Mode 1 | Mode 2 | Mode 3 | Mode 4 | Mode 5 |
|------|-------|--------|--------|--------|--------|--------|
| Y    | 48    | Y      | Y      | Y      | CVBS_2 | CVBS_2 |
| C    | 47    | C      | C      | C      | -      | -      |
| CVBS | 44    | CVBS_1 | CVBS_1 | CVBS_1 | CVBS_1 | CVBS_1 |
| R    | 39    | R      | Cr (V) | -      | R      | Cr (V) |
| G    | 40    | G      | Y      | CVBS_2 | G      | Y      |
| B    | 43    | B      | Cb (U) | -      | B      | Cb (U) |

**Table 1.** DAC configuration Modes

the six DACs has its own associated DAC enable bit. In the Disable Mode, the 10-bit DACs source (or sink) zero current.

When running the DACs with a low-impedance load, a minimum of three DACs must be powered down. When running the DACs with a high-impedance load, all the DACs can be enabled simultaneously.

For lower power standby scenarios, the CS4954/5 also provides power shut-off control for the DACs. Each DAC has an associated DAC shut-off bit.

## 4.8 Voltage Reference

The CS4954/5 is equipped with an on-board voltage reference generator (1.232 V) that is used by the DACs. The internal reference voltage is accurate enough to guarantee a maximum of 3% overall gain error on the analog outputs. However, it is possible to override the internal reference voltage by applying an external voltage source to the VREF pin.

## 4.9 Current Reference

The DAC output current-per-bit is derived in the current reference block. The current step is specified by the size of resistor placed between the ISET current reference pin and electrical ground.

A 4 k $\Omega$  resistor needs to be connected between ISET pin and GNDA. The DAC output currents are optimized to drive either a doubly terminated 75  $\Omega$  load (low impedance mode) or a double terminated 300  $\Omega$  load (high impedance mode). The 2 output

current modes are software selectable via a register bit.

## 4.10 Host Interface

The CS4954/5 provides a parallel 8-bit data interface for overall configuration and control. The host interface uses active-low read and write strobes, along with an active-low address enable signal, to provide microprocessor-compatible read and write cycles. Indirect host addressing to the CS4954/5 internal registers is accomplished via an internal address register that is uniquely accessible via bus write cycles for the device when the host address enable signal is asserted.

The CS4954/5 also provides an I<sup>2</sup>C-compatible serial interface for device configuration and control. This port can operate in standard (up to 100 kb/sec) or fast (up to 400 kb/sec) modes. When in I<sup>2</sup>C mode, the parallel data interface pins, PDAT [7:0], can be used as a general purpose I/O port controlled by the I<sup>2</sup>C interface.

## 4.11 Closed Caption Services

The CS4954/5 supports the generation of NTSC Closed Caption services. Line 21 and Line 284 captioning can be generated and enabled independently via a set of control registers. When enabled, clock run-in, start bit, and data bytes are automatically inserted at the appropriate video lines. A convenient interrupt protocol simplifies the software interface between the host processor and the CS4954/5.

#### 4.12 Teletext Services

The CS4954/5 encodes the most common teletext formats, such as European Teletext, World Standard Teletext (PAL and NTSC), and North American Teletext (NABTS).

Teletext data can be inserted in any of the TV lines (blanking lines as well as active lines). In addition the blanking lines can be individually allocated for Teletext instantiation.

The input timing for teletext data is user programmable. See the section *Teletext Services* for further details.

Teletext data can be independently inserted on either one or all of the CVBS\_1, CVBS\_2, or S-video signals.

#### 4.13 Wide-Screen Signaling Support and CGMS

Insertion of wide-screen signal encoding for PAL and NTSC standards is supported and CGMS (Copy Generation Management System) for NTSC in Japan. Wide-screen signals are inserted in lines 23 and 336 for PAL, and lines 20 and 283 for NTSC.

#### 4.14 VBI Encoding

This chip supports the transmission of control signals in the vertical blanking time interval according to SMPTE RP 188 recommendations. VBI encoded data can be independently inserted into any or all of CVBS\_1, CVBS\_2 or S-video signals.

#### 4.15 Control Registers

The control and configuration of the CS4954/5 is accomplished primarily through the control register block. All of the control registers are uniquely addressable via the internal address register. The control register bits are initialized during device RESET.

See the Programming section of this data sheet for the individual register bit allocations, bit operational descriptions, and initialization states.

#### 4.16 Testability

The digital circuits are completely scanned by an internal scan chain, thus providing close to 100% fault coverage.

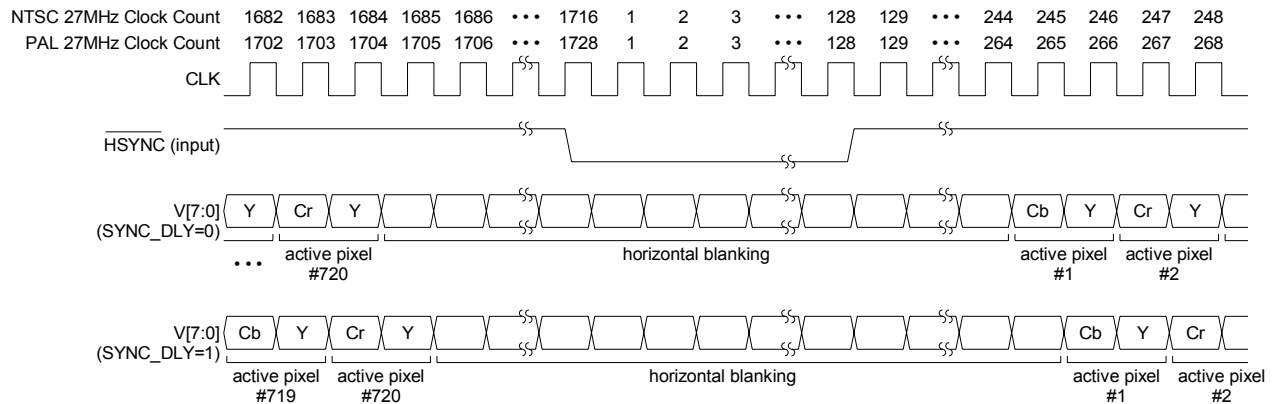
### 5. OPERATIONAL DESCRIPTION

#### 5.1 Reset Hierarchy

The CS4954/5 is equipped with an active low asynchronous reset input pin,  $\overline{\text{RESET}}$ .  $\overline{\text{RESET}}$  is used to initialize the internal registers and the internal state machines for subsequent default operation. See the electrical and timing specification section of this data sheet for specific CS4954/5 device RESET and power-on signal timing requirements and restrictions.

While the  $\overline{\text{RESET}}$  pin is held low, the host interface in the CS4954/5 is disabled and will not respond to host-initiated bus cycles. All outputs are valid after a time period following  $\overline{\text{RESET}}$  pin low.

A device RESET initializes the CS4954/5 internal registers to their default values as described by Table 9, Control Registers. In the default state, the CS4954/5 video DACs are disabled and the device is internally configured to provide blue field video data to the DACs (any input data present on the V [7:0] pins is ignored at this time). Otherwise, the CS4954/5 registers are configured for NTSC-M output and ITU R.BT601 output timing operation. At a minimum, the DAC Registers (0x04 and 0x05) must be written (to enable the DACs) and the IN\_MODE bit of the CONTROL\_0 Register (0x01) must be set (to enable ITU R.BT601 data input on V [7:0]) for the CS4954/5 to become operational after RESET.



**Figure 4.** ITU R.BT601 Input Slave Mode Horizontal Timing

## 5.2 Video Timing

### 5.2.1 Slave Mode Input Interface

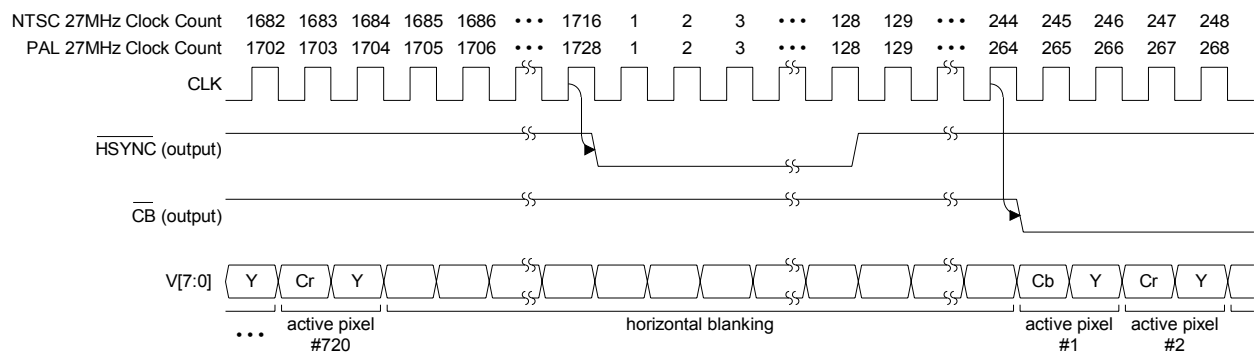
In Slave ITU R.BT601 (not ITU-R.BT656 input) Mode, the CS4954/5 receives signals on  $\overline{\text{VSYNC}}$  and  $\overline{\text{HSYNC}}$  as inputs. Slave Mode is the default following RESET and is changed to Master Mode via a control register bit (CONTROL\_0 [4]). The CS4954/5 is limited to ITU R.BT601 horizontal and vertical input timing. All clocking in the CS4954/5 is generated from the CLK pin. In Slave Mode, the Sync Generator uses externally provided horizontal and vertical sync signals to synchronize the internal timing of the CS4954/5. Video data that is sent to the CS4954/5 must be synchronized to the horizontal and vertical sync signals. Figure 4 illustrates horizontal timing for ITU R.BT601 input in Slave Mode. Note that the CS4954/5 expects to receive the first active pixel data on clock cycle 245

(NTSC) when CONTROL\_2 Register (0x02) bit SYNC\_DLY = 0. When SYNC\_DLY = 1, it expects the first active pixel data on clock cycle 246 (NTSC).

### 5.2.2 Master Mode Input Interface

The CS4954/5 defaults to Slave Mode following RESET high but can be switched into Master Mode via the MSTR bit in the CONTROL\_0 Register (0x00). In Master Mode, the CS4954/5 uses the  $\overline{\text{VSYNC}}$ ,  $\overline{\text{HSYNC}}$  and FIELD device pins as outputs to schedule the proper external delivery of digital video into the V [7:0] pins. Figure 5 illustrates horizontal timing for the CCIR601 input in Master Mode.

The timing of the  $\overline{\text{HSYNC}}$  output is selectable in the PROG\_HS Registers (0x0D, 0x0E).  $\overline{\text{HSYNC}}$  can be delayed by one full line cycle. The timing of the  $\overline{\text{VSYNC}}$  output is also selectable in the



**Figure 5.** ITU R.BT601 Input Master Mode Horizontal Timing

PROG\_VS Register (0x0D).  $\overline{\text{VSYNC}}$  can be delayed by thirteen lines or advanced by eighteen lines.

### 5.2.3 Vertical Timing

The CS4954/5 can be configured to operate in any of four different timing modes: PAL, which is 625 vertical lines, 25 frames per second interlaced; NTSC, which is 525 vertical lines, 30 frames per second interlaced; and either 625 or 525 line Pseudo-Progressive Scan (See [“Progressive Scan” on page 18](#)). These modes are selected in the CONTROL\_0 Register (0x00).

The CS4954/5 conforms to standard digital decompression dimensions and does not process digital input data for the active analog video half lines as they are typically in the over/underscan region of TV display. 240 active lines total per field are processed for NTSC, and 288 active lines total per field are processed for PAL. Frame vertical dimensions are 480 lines for NTSC and 576 lines for PAL. Table 2 specifies active line numbers for both NTSC and PAL. Refer to Figure 6 for  $\overline{\text{HSYNC}}$ ,  $\overline{\text{VSYNC}}$  and FIELD signal timing.

| Mode                  | Field                     | Active Lines       |
|-----------------------|---------------------------|--------------------|
| NTSC                  | 1, 3;<br>2, 4             | 22-261;<br>285-524 |
| PAL                   | 1, 3, 5, 7;<br>2, 4, 6, 8 | 23-310;<br>336-623 |
| NTSC Progressive-Scan | NA                        | 22-261             |
| PAL Progressive-Scan  | NA                        | 23-310             |

**Table 2.** Vertical Timing

### 5.2.4 Horizontal Timing

$\overline{\text{HSYNC}}$  is used to synchronize the horizontal-input-to-output timing in order to provide proper horizontal alignment.  $\overline{\text{HSYNC}}$  defaults to an input pin following RESET but switches to an output in Master Mode (CONTROL\_0 [4] = 1). Horizontal timing is referenced to  $\overline{\text{HSYNC}}$  transitioning low. For active video lines, digital video input is to be applied to the V [7:0] inputs for 244 (NTSC) or for 264 (PAL) CLK periods following the leading

(falling) edge of  $\overline{\text{HSYNC}}$  if the PROG\_HS Registers are set to default values.

### 5.2.5 NTSC Interlaced

The CS4954/5 supports NTSC-M, NTSC-J and PAL-M modes where there are 525 total lines per frame, two fixed 262.5-line fields per frame and 30 frames occurring per second. NTSC interlaced vertical timing is illustrated in Figure 7. Each field consists of one line for closed caption, 240 active lines of video, plus 21.5 lines of blanking.

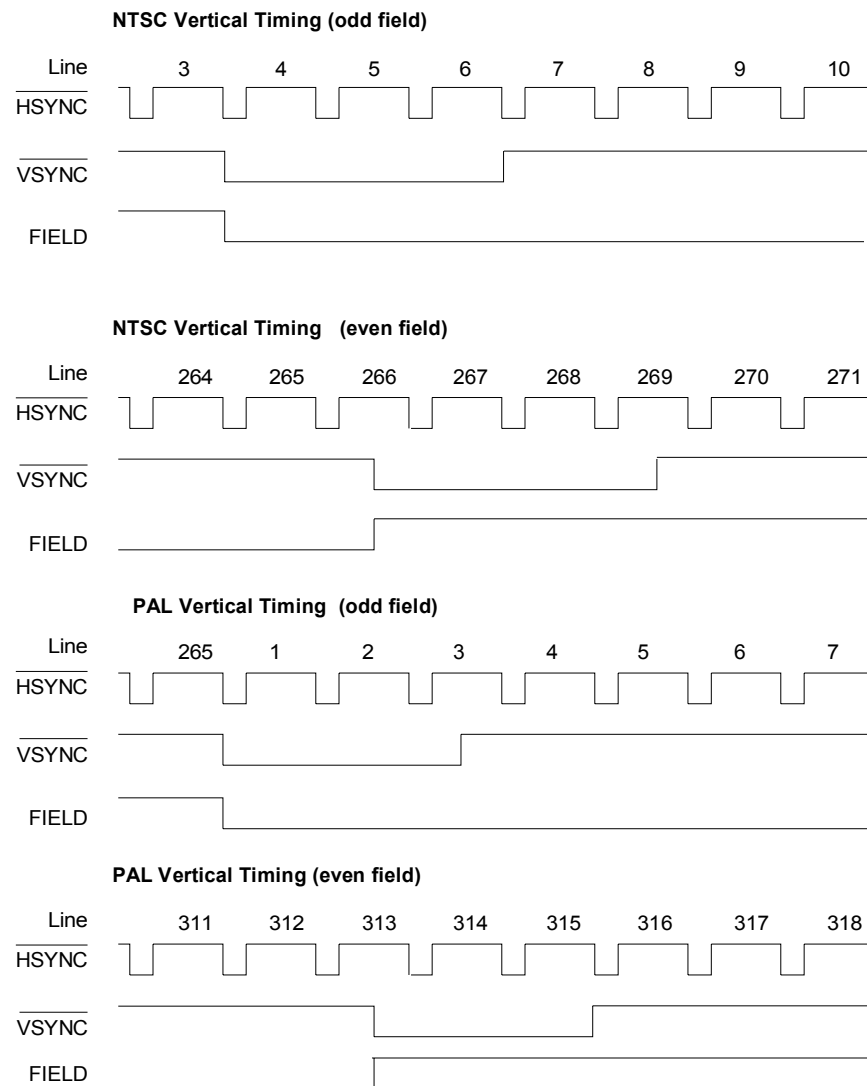
$\overline{\text{VSYNC}}$  field one transitions low at the beginning of line four and will remain low for three lines or 2574 pixel cycles ( $858 \times 3$ ). The CS4954/5 exclusively reserves line 21 of field one for closed caption insertion. Digital video input is expected to be delivered to the CS4954/5 V [7:0] pins for 240 lines beginning on active video lines 22 and continuing through line 261.  $\overline{\text{VSYNC}}$  field two transitions low in the middle of line 266 and stays low for three line-times and transitions high in the middle of line 269. The CS4954/5 exclusively reserves line 284 of field two for closed caption insertion. Video input on the V [7:0] pins is expected between lines 285 through line 525.

### 5.2.6 PAL Interlaced

The CS4954/5 supports PAL modes B, D, G, H, I, N, and Combination N, in which there are 625 total lines per frame, two fixed 312.5 line fields per frame, and 25 total frames per second. Figure 8 illustrates PAL interlaced vertical timing. Each field consists of 287 active lines of video plus 25.5 lines of blanking.

$\overline{\text{VSYNC}}$  will transition low to begin field one and will remain low for 2.5 lines or 2160 pixel cycles ( $864 \times 2.5$ ). Digital video input is expected to be delivered to the CS4954/5 V [7:0] pins for 287 lines beginning on active video line 24 and continuing through line 310.

Field two begins with  $\overline{\text{VSYNC}}$  transitioning low after 312.5 lines from the beginning of field one.



**Figure 6.** Vertical Timing

$\overline{\text{VSYNC}}$  stays low for 2.5 line-times and transitions high with the beginning of line 315. Video input on the V [7:0] pins is expected between line 336 through line 622.

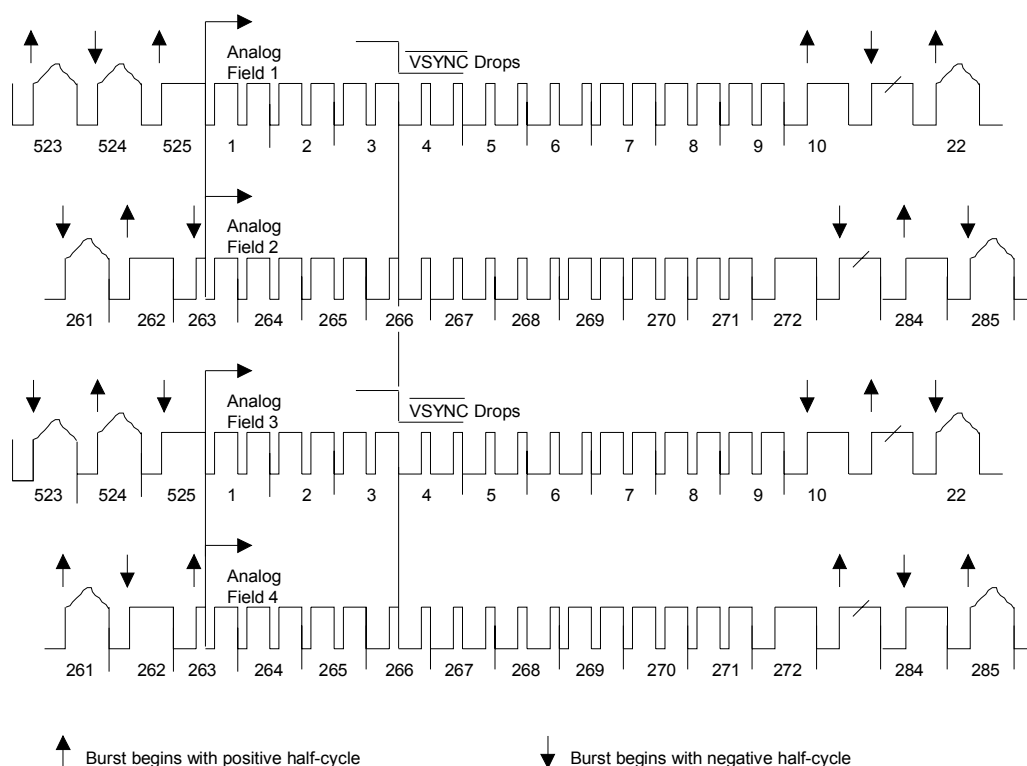
### 5.2.7 Progressive Scan

The CS4954/5 supports a pseudo-progressive scan mode for which “odd” and “even” numbered line information is presented in “odd” numbered line positions by varying the vertical blanking timing. This preserves precise MPEG-2 frame rates of 30 and 25 frames per second. This mode is in contrast to other digital video encoders, which commonly support progressive scan by repetitively displaying

a 262 line field (524/525 lines for NTSC). The common method is flawed: over time, the output display rate will overrun a system-clock-locked MPEG-2 decompressor and display a field twice every 8.75 seconds.

### 5.2.8 NTSC Progressive Scan

$\overline{\text{VSYNC}}$  will transition low at line four to begin field one and will remain low for three lines or 2574 pixel cycles ( $858 \times 3$ ). NTSC interlaced timing is illustrated in Figure 9. In this mode, the CS4954/5 expects digital video input at the V [7:0] pins for 240 lines beginning on active video line 22 and continuing through line 261.



**Figure 7.** NTSC Video Interlaced Timing

Field two begins with  $\overline{\text{VSYNC}}$  transitioning low at line 266.  $\overline{\text{VSYNC}}$  stays low for 3 line cycles and transitions high during the end of line 268. Video input on the V [7:0] pins is expected between line 284 and line 522. Field two is 263 lines; field one is 262 lines.

### 5.2.9 PAL Progressive Scan

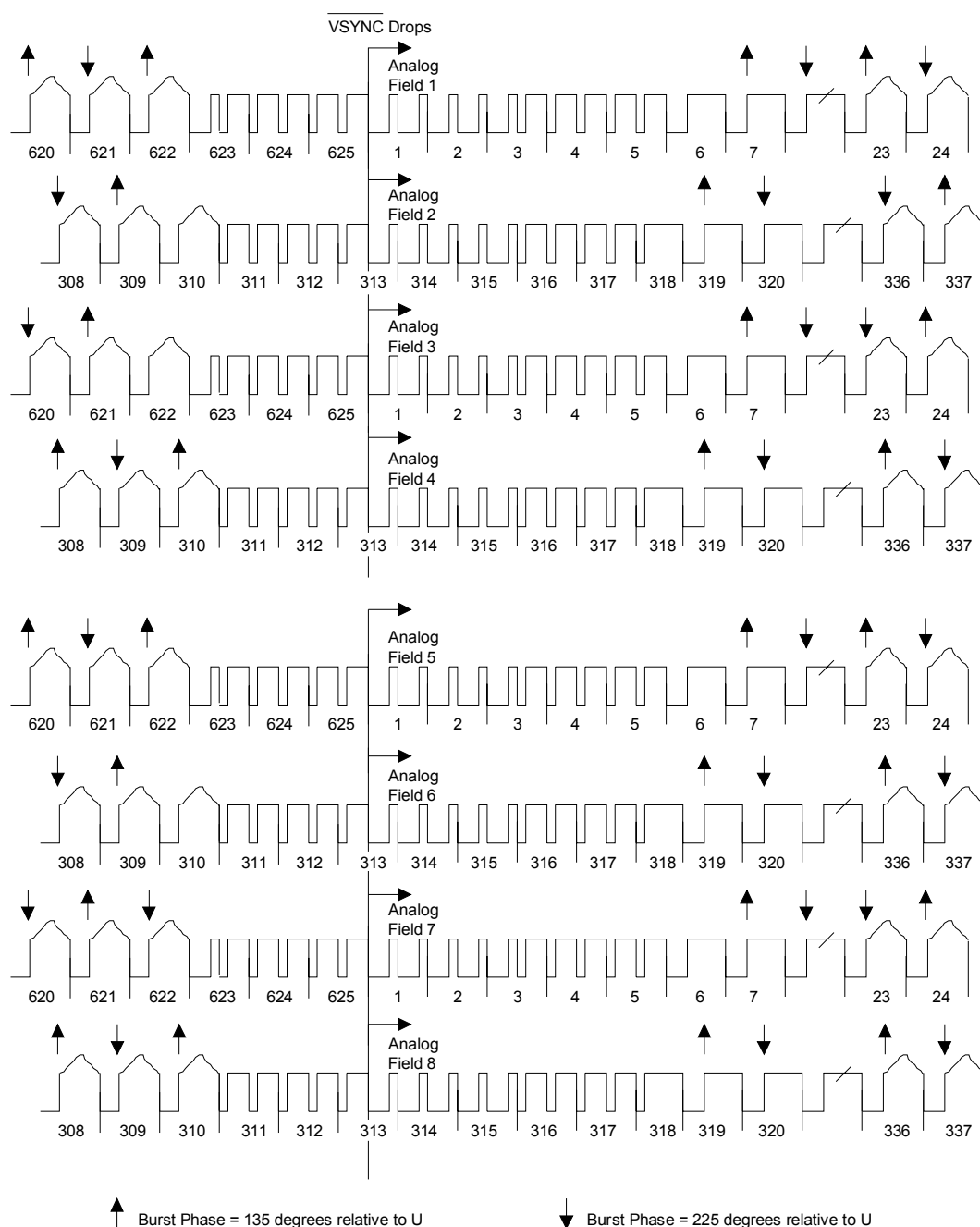
$\overline{\text{VSYNC}}$  will transition low at the beginning of the odd field and will remain low for 2.5 lines or 2160 pixel cycles ( $864 \times 2.5$ ). PAL non-interlaced timing is illustrated in Figure 10. In this mode, the CS4954/5 expects digital video input on the V [7:0] pins for 288 lines, beginning on active video line 23 and continuing through line 309.

The second field begins with  $\overline{\text{VSYNC}}$  transitioning low after 312 lines from the beginning of the first field.  $\overline{\text{VSYNC}}$  stays low for 2.5 line-times and transitions high during the middle of line 315. Video input on the V [7:0] pins is expected between line

335 through line 622. Field two is 313 lines; field one is 312 lines.

### 5.3 ITU-R.BT656

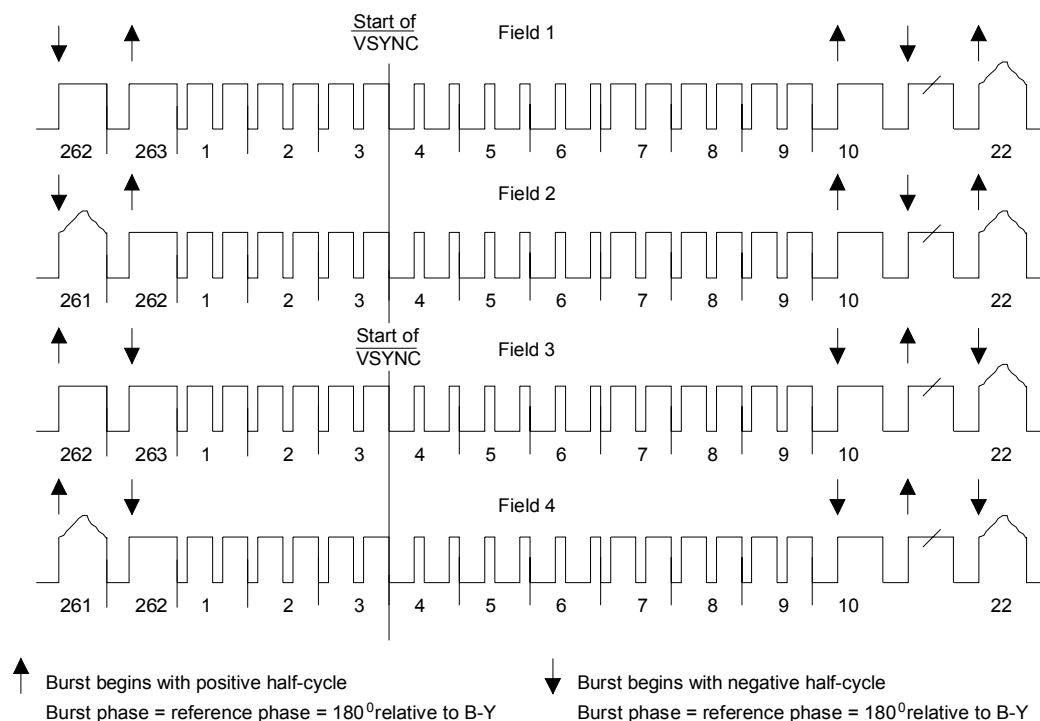
The CS4954/5 supports an ITU-R.BT656 slave mode feature that is selectable through the ITU-R.BT656 bit of the CONTROL\_0 Register. The ITU-R.BT656 slave feature is unique because the horizontal and vertical timing and digital video are combined into a single 8-bit 27 MHz input. With ITU-R.BT656 there are no horizontal and vertical input or output strobes, only 8-bit 27 MHz active CbYCrY data, with start- and end-of-video codes implemented using reserved 00 and FF code sequences within the video feed. As with all modes, V [7:0] are sampled with the rising edge of CLK. The CS4954/5 expects the digital ITU-R.BT656 stream to be error-free. The FIELD<sup>(1)</sup> output toggles as with non ITU-R.BT656 input. ITU-R.BT656 input timing is illustrated in Figure 11.



**Figure 8.** PAL Video Interlaced Timing

As mentioned above, there are no horizontal and vertical timing signals necessary in ITU-R.BT656 mode. However in some cases it is advantageous to output these timing signals for other purposes. By

setting the 656\_SYNC\_OUT register bit in CONTROL\_6 register, HSYNC and VSYNC are output, so that other devices in the system can synchronize to these timing signals.



**Figure 9.** NTSC Video Non-Interlaced Progressive Scan Timing

## 5.4 Digital Video Input Modes

The CS4954/5 provides two different digital video input modes that are selectable through the IN\_MODE bit in the CONTROL\_0 Register.

In Mode 0 and upon RESET, the CS4954/5 defaults to output a solid color (one of a possible of 256 colors). The background color is selected by writing the BKG\_COLOR Register (0x08). The colorspace of the register is RGB 3:3:2 and is unaffected by gamma correction. The default color following RESET is blue.

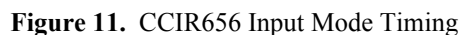
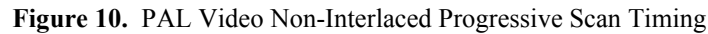
In Mode 1 the CS4954/5 supports a single 8-bit 27 MHz CbYCrY source as input on the V [7:0] pins. Input video timing can be ITU-R.BT601 master or slave or ITU-R.BT656.

## 5.5 Multi-standard Output Format Modes

The CS4954/5 supports a wide range of output formats compatible with worldwide broadcast standards. These formats include NTSC-M, NTSC-J, PAL-B/D/G/H/I, PAL-M, PAL-N, and PAL Combination N (PAL-Nc) which is the broadcast standard used in Argentina. After RESET, the CS4954/5 defaults to NTSC-M operation with ITU-R.BT601 analog timing. NTSC-J can also be supported in the Japanese format by turning off the 7.5 IRE pedestal through the PED bit in the CONTROL\_1 Register (0x01).

Output formats are configured by writing control registers with the values shown in Table 3.

NOTE 1: The FIELD pin (pin 9) remains an output pin in SLAVE mode. However, the FIELD pin state does not toggle in SLAVE mode and its output state should be considered random.



The CS4954/5 automatically synthesizes NTSC and PAL color subcarrier clocks using the CLK frequency and four control registers (SC\_SYNTH0/1/2/3). The NTSC subcarrier synthesizer is reset every four fields (every eight fields for PAL).

**DS278F6**

| System               | Fsubcarrier    | Value (hex) |
|----------------------|----------------|-------------|
| NTSC-M, NTSC-J       | 3.5795455 MHz  | 43E0F83E    |
| PAL-B, D, G, H, I, N | 4.43361875 MHz | 54131596    |
| PAL-N (Argentina)    | 3.582056 MHz   | 43ED288D    |
| PAL-M                | 3.579611 MHz   | 43CDDFC7    |

**Table 3.**

## 5.7 Subcarrier Compensation

Since the subcarrier is synthesized from CLK, the subcarrier frequency error will track the clock frequency error. If the input clock has a tolerance of 200 ppm then the resulting subcarrier will also have a tolerance of 200 ppm. Per the NTSC specification, the final subcarrier tolerance is  $\pm 10$  Hz which is approximately 3 ppm. Care must be taken in selecting a suitable clock source.

In MPEG-2 system environments the clock is actually recovered from the data stream. In these cases the recovered clock can be 27 MHz  $\pm 50$  ppm or  $\pm 1350$  Hz. It varies per television, but in many cases given an MPEG-2 system clock of 27 MHz,  $\pm 1350$  Hz, the resultant color subcarrier produced will be outside of the television's ability to compensate and the chrominance information will not be displayed (resulting in a black-and-white picture only).

The CS4954/5 is designed to provide automatic compensation for an excessively inaccurate MPEG-2 system clock. Sub-carrier compensation is enabled through the XTAL bit of the CONTROL\_2 Register. When enabled, the CS4954/5 will utilize a common quartz color burst crystal (3.579545 MHz  $\pm 50$  ppm for NTSC) attached to the XTAL\_IN and XTAL\_OUT pins to automatically compare and compensate the color subcarrier synthesis process.

## 5.8 Closed Caption Insertion

The CS4954/5 is capable of NTSC Closed Caption insertion on lines 21 and 284 independently. Closed captioning is enabled for either one or both lines via the CC\_EN [1:0] Register bits and the data to be inserted is also written into the four Closed Caption Data registers. The CS4954/5, when enabled, automatically generates the seven cycles of clock run-in (32 times the line rate), does start bit insertion (001), and finally does insertion of the two data bytes per line. Data low at the video outputs corresponds to 0 IRE and data high corresponds to 50 IRE.

There are two independent 8-bit registers per line (CC\_21\_1 & CC\_21\_2 for line 21 and CC\_284\_1 & CC\_284\_2 for line 284). Interrupts are also provided to simplify the handshake between the driver software and the device. Typically the host writes

| Address | Register  | NTSC-M<br>ITU<br>R.BT601 | NTSC-J<br>ITU<br>R.BT601 | NTSC-M<br>RS170A | PAL-<br>B,D,G,H,I | PAL-M | PAL-N | PAL-N<br>Comb.<br>(Argent) |
|---------|-----------|--------------------------|--------------------------|------------------|-------------------|-------|-------|----------------------------|
| 0x00    | CONTROL_0 | 01h                      | 01h                      | 21h              | 41h               | 61h   | A1h   | 81h                        |
| 0x01    | CONTROL_1 | 12h                      | 10h                      | 16h              | 30h               | 12h   | 30h   | 30h                        |
| 0x04    | CONTROL_4 | 07h                      | 07h                      | 07h              | 07h               | 07h   | 07h   | 07h                        |
| 0x05    | CONTROL_5 | 78h                      | 78h                      | 78h              | 78h               | 78h   | 78h   | 78h                        |
| 0x10    | SC_AMP    | 1Ch                      | 1Ch                      | 1Ch              | 15h               | 15h   | 15h   | 15h                        |
| 0x11    | SC_SYNTH0 | 3Eh                      | 3Eh                      | 3Eh              | 96h               | C7h   | 96h   | 8Ch                        |
| 0x12    | SC_SYNTH1 | F8h                      | F8h                      | F8h              | 15h               | DFh   | 15h   | 28h                        |
| 0x13    | SC_SYNTH2 | E0h                      | E0h                      | E0h              | 13h               | CDh   | 13h   | EDh                        |
| 0x14    | SC_SYNTH3 | 43h                      | 43h                      | 43h              | 54h               | 43h   | 54h   | 43h                        |

**Table 4.** Multi-standard Format Register Configurations

all 4 bytes to be inserted to the registers and then enables closed caption insertion and interrupts. As the closed caption interrupts occur, the host software responds by writing the next two bytes to be inserted to the correct control registers and then clears the interrupt and waits for the next field.

### 5.9 Programmable H-sync and V-sync

It is possible in master mode to change the H-sync and V-sync times based on register settings. Programmable H-sync and V-sync timing is helpful in systems where control signal latencies are present. The user can then program H-sync and V-sync timing according to their system requirements. The default values are 244, and 264 for NTSC and PAL respectively.

H-sync can be delayed by a full line, in 74 nsec intervals.

V-sync can be shifted in time in both directions. The default values are 18 and 23 for NTSC and PAL respectively. Since the V-sync register is 5 bits wide (Sync Register 0), the V-sync pulse can be shifted by 31 lines total.

V-sync timing can precede its default timing by a maximum of 18 lines (NTSC) or 23 lines (PAL) and can be delayed from its default timing by a maximum of 13 lines (NTSC) or 8 lines (PAL).

### 5.10 Wide Screen Signaling (WSS) and CGMS

Wide screen signaling support is provided for NTSC and for PAL standards. Wide screen signaling is currently used in most countries with 625 line systems as well as in Japan for EDTV-II applications. For a complete description of the WSS standard, please refer to **ITU-R BT.1119** (625 line system) and to **EIAJ CPX1204** for the Japanese 525 line system standard.

The wide screen signal is transferred in a blanking line of each video field (NTSC: lines 20 and 283, PAL: lines 23 and 336). Wide screen signaling is

enabled by setting WW\_23 to “1”. Some countries with PAL standard don’t use line 336 for wide screen signaling (they use only line 23), therefore we provide another enable bit (WSS\_22) for that particular line.

There are 3 registers dedicated to contain the transmitted WSS bits (WSS\_REG\_0, WSS\_REG\_1, WSS\_REG\_2). The data insertion into the appropriate lines is performed automatically by this device. The run-in and start code bits do not have to be loaded into this device. It automatically inserts the correct code at the beginning of transfer.

### 5.11 Teletext Support

This chip supports several teletext standards including European teletext, NABTS (North American teletext), and WST (World Standard Teletext) for NTSC and PAL.

All of these teletext standards are defined in the **ITU-R BT.653-2** document. The **European teletext** is defined as “**teletext system B**” for 625/50 Hz TV systems. **NABTS** teletext is defined as “**teletext system C**” for 525/60 Hz TV systems. **WST** for **PAL** is defined as “**teletext system D**” for 625/50 Hz TV systems and **WST** for **NTSC** is defined as “**teletext system D**” for 525/60 Hz TV systems.

This chip provides independent teletext encoding into composite 1, composite 2 and s-video signals. The teletext encoding into these various signals is software programmable.

In teletext pulsation mode, (TTX\_WINDOW=0), register 0×31 bit 3, the pin TTXDAT receives a teletext bitstream sampled at the 27 MHz clock. At each rising edge of the TTXRQ output signal a single teletext bit has to be provided after a programmable input delay at the TTXDAT input pin.

Phase variant interpolation of the data in the internal teletext encoder results in minimal phase jitter on the output text lines.

TTXRQ provides a fully programmable request signal to the teletext source, indicating the insertion period of the bitstream at independently selectable lines for both TV fields. The internal insertion window for text is set to either 360, 296 or 288 teletext bits, depending on the selected teletext standard. The clock run-in is included in this window.

Teletext is enabled by setting the TTX\_EN bit to “1”. The TTX\_WST bit in conjunction with the TV\_FORMAT register selects one of the 4 teletext encoding possibilities.

The teletext timing is shown in the Figure 12. TTXHS and TTXHD are user programmable and therefore allow the user to have full control over when teletext data is sent to this device.

The time  $t_{FD}$  is the time needed to interpolate teletext input data and insert it into the CVBS and Y output signals, such that it appears between  $t_{TTX} = 9.8 \mu s$  and  $t_{TTX} = 12 \mu s$  after the leading edge of the horizontal synchronization pulse.  $t_{FD}$  changes with the TV standard and the selected teletext standard. Please refer to ITU-R BT.653-2 for more detailed information.

The time  $t_{PD}$  is the pipeline delay time introduced by the source that is gated by TTXRQ in order to deliver teletext data. This delay is programmable through the register TTXHD. For every active HIGH transition at output pin TTXRQ, a new teletext bit must be provided by the source. The time between the beginning of the first TTXRQ pulse

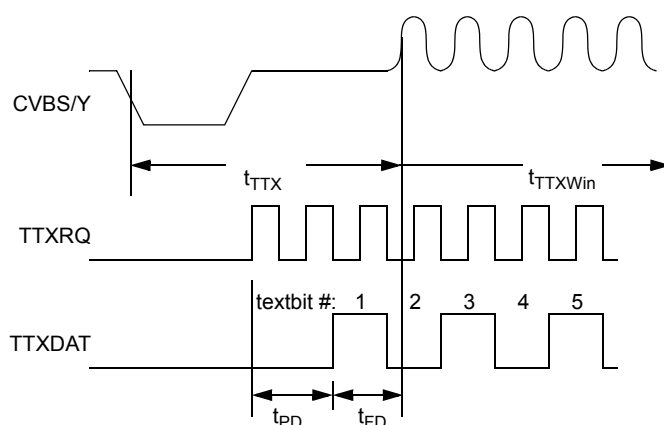
and the leading edge of H-sync is programmable through the TTXHS register.

Since the beginning of the pulses representing the TTXRQ signal and the delay between the rising edge of TTXRQ and valid teletext input data are fully programmable, the TTXDAT data is always inserted at the correct position after the leading edge of the outgoing horizontal synchronization pulse.

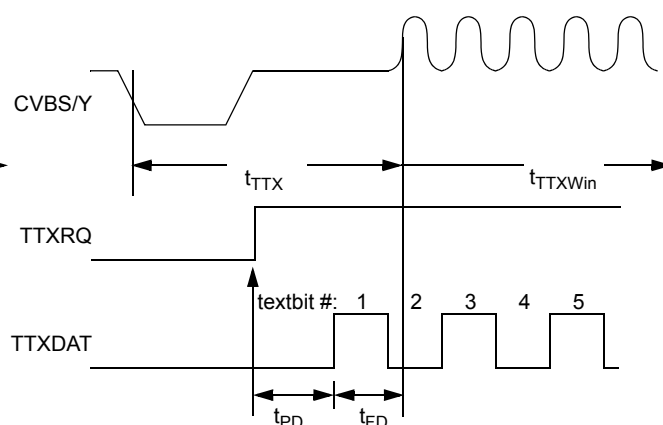
The time  $t_{TTXWin}$  is the internally used insertion window for TTX data; it has a constant length depending on the selected teletext standard which allows insertion of 360 TTX bits (6.9375 Mbit/sec) (European teletext) or 296 TTX bits (5.6427875 Mbit/sec) (WST PAL) or 288 TTX bits (5.727272 Mbit/sec) (NABTS) or 296 TTX bits (5.727272 Mbit/sec) (WST NTSC) respectively.

Using the appropriate programming, all suitable lines of the odd field (TTXOVS through TTXOVE) plus all suitable lines of the even field (TTXEVS through TTXEVE) can be used for teletext insertion. In addition it is possible to selectively disable the teletext insertion on single lines. This can be programmed by setting the TTX\_LINE\_DIS1, TTX\_LINE\_DIS2 and TTX\_LINE\_DIS3 registers appropriately.

Note that the TTXDAT signal must be synchronized with the 27 MHz clock. The pulse width of the TTXRQ signal varies between three and four 27 MHz clock cycles. The variation is necessary in



**Figure 12.** Teletext Timing (Pulsation Mode)



**Figure 13.** Teletext Timing (Window Mode)

order to maintain the strict timing requirements of the teletext standard.

Table 5 shows how to program the TTXHS register for teletext instantiation into the analog signals for the various supported TV formats. TTXHS is the time between the leading edge of the HSYNC signal and the rising edge of the first TTXRQ signal and consists of multiples of 27 MHz clock cycles

Note that with increasing values of TTXHS the time  $t_{TTX}$  increases as well. The time  $t_{FD}$  accounts for the internal pipeline delay due to processing, synchronization and instantiation of the teletext data. The time  $t_{PD}$  is dependant on the TTXHD register.

Note that the teletext databits are shaped according to the ITU R.BT653-2 specifications.

If register 0×31 bit 3 is set, (TTX\_WINDOW=1) the teletext is in windows mode. In this mode, the request pulses become a window where the bit provided on the TTXDAT pin is valid (see Figure 13).

In pulse mode (where the number of request pulses are determined by the teletext standard chosen), the length of the window must be programmed by the user independent of the teletext standard used. The length of the window is programmed through register 0×29 TTXHS (start of window), register 0×2A (TTXHD) and register 0×31 (end of window). The end-of-window register is a 11 bit value.

In teletext window mode, the TTXHS value can be selected using the values in Table 5. Although these values may need to be adjusted to match your system delay, use the following equation to compute the TTXHD value:

$$TTXHS + 1402 = TTXHD \text{ (for Europe)}$$

$$TTXHS + 1151 = TTXHD \text{ (for WST)}$$

$$TTXHS + 1122 = TTXHD \text{ (for NABTS)}$$

| TV standard      | Teletext standard | TTXHS (register value) | $t_{TTX}$    |
|------------------|-------------------|------------------------|--------------|
| NTSC-M           | NABTS             | 161                    | 10.5 $\mu$ s |
| NTSC-M           | WST-NTSC          | 142                    | 9.8 $\mu$ s  |
| PAL-B            | Europe TTX        | 204                    | 12.0 $\mu$ s |
| PAL-B            | WST-PAL           | 163                    | 10.5 $\mu$ s |
| PAL-M            | NABTS             | 161                    | 10.5 $\mu$ s |
| PAL-M            | WST-NTSC          | 142                    | 9.8 $\mu$ s  |
| PAL-N (non Arg.) | Europe TTX        | 204                    | 12.0 $\mu$ s |
| PAL-N (non Arg.) | WST-PAL           | 163                    | 10.5 $\mu$ s |
| PAL-N (Arg.)     | Europe TTX        | 204                    | 12.0 $\mu$ s |
| PAL-N (Arg.)     | WST-PAL           | 163                    | 10.5 $\mu$ s |

**Table 5.** Teletext timing parameters

## 5.12 Color Bar Generator

The CS4954/5 is equipped with a color bar generator that is enabled through the CBAR bit of the CONTROL\_1 Register. The color bar generator works in Master or Slave Mode and has no effect on the video input/output timing. If the CS4954/5 is configured for Slave Mode color bars, proper video timing must be present on the HSYNC and VSYNC pins for the color bars to be displayed. Given proper Slave Mode input timing or Master Mode timing, the color bar generator will override the video input pixel data.

The output of the color bar generator is instantiated after the chroma interpolation filter and before the luma delay line. The generated color bar numbers are for 100% amplitude, 100% saturation NTSC EIA color bars or 100% amplitude, 100% saturation PAL EBU color bars. For PAL color bars, the CS4954/5 generates NTSC color bar values, which are very close to standard PAL values. The exact luma and chroma values are listed in Table 6.

| Color   | Cb   | Cr   | Y     |
|---------|------|------|-------|
| White   | 0    | 0    | + 167 |
| Yellow  | - 84 | + 14 | + 156 |
| Cyan    | + 28 | - 84 | + 138 |
| Green   | - 56 | - 70 | + 127 |
| Magenta | + 56 | + 70 | + 110 |
| Red     | - 28 | + 84 | + 99  |
| Blue    | + 84 | - 14 | + 81  |
| Black   | 0    | 0    | + 70  |

**Table 6.** Internal Color Bar Values (8-bit values, Cb/Cr are in twos complement format)

### 5.13 VBI encoding

VBI (Vertical Blanking Interval) encoding is performed according to SMPTE RP 188 recommendations. In NTSC mode, lines 10 - 20 and lines 272 - 283 are used for the transmission of ancillary data. In PAL mode lines 6 - 22 and lines 318 - 335 are used. The VBI encoding mode can be set through the CONTROL\_3 register.

All digital input data is passed through the chip when this mode is enabled. It is therefore the responsibility of the user to ensure appropriate amplitude levels. Table 7 shows the relationship of the digital input signal and the analog output voltage.

| Digital Input | Analog Output Voltage |
|---------------|-----------------------|
| 0×38          | 286 mV                |
| 0×3B          | 300 mV                |
| 0×C4          | 1000 mV               |

**Table 7.** VBI Encoding Signal Amplitudes

Each LSB corresponds to a step of 5 mV in the output voltage.

### 5.14 Super White/Super Black support

The ITU-R BT.601 recommendation limits the allowed range for the digital video data between 0×10 - 0×EB for luma and between 0×10 - 0×F0 for the chrominance values. This chip will clip any

digital input value which is out of this range to conform to the ITU-R BT.601 specifications.

However for some applications it is useful to allow a wider input range. By setting the CLIP\_OFF bit (CONTROL\_6 register), the allowed input range is extended to 0×01 - 0×FE for both luma and chrominance values.

Note that 0×00 and 0×FF values are never allowed, since they are reserved for synchronization information.

### 5.15 Interrupts

In order to better support precise video mode switches and to establish a software/hardware handshake with the closed caption insertion block, the CS4954/5 is equipped with an interrupt pin named INT. The INT pin is active high. There are three interrupt sources: VSYNC, Line 21, and Line 284. Each interrupt can be individually disabled with the INT\_EN Register. Each interrupt is also cleared via writing a one to the corresponding INT\_CLR Register bits. The three individual interrupts are OR-ed together to generate an interrupt signal which is presented on the INT output pin. If an interrupt has occurred, it cannot be eliminated with a disable, it must be cleared.

### 5.16 General Purpose I/O Port

The CS4954/5 has a GPIO port and register that is available when the device is configured for I<sup>2</sup>C host interface operation. In I<sup>2</sup>C host interface mode, the PDAT [7:0] pins are unused by the host interface and they can operate as input or output pins for the GPIO\_DATA\_REG Register (0×0A). The CS4954/5 also contains the GPIO\_CTRL\_REG Register (0×09) which is used to configure the GPIO pins for input or output operation.

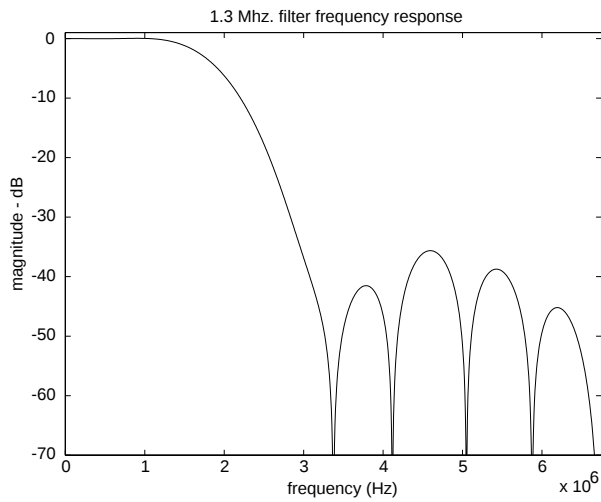
The GPIO port PDAT [7:0] pins are configured for input operation when the corresponding GPIO\_CTRL\_REG [7:0] bits are set to 0. In GPIO input mode, the CS4954/5 will latch the data on the PDAT [7:0] pins into the corresponding bit loca-

tions of GPIO\_DATA\_REG when it detects register address 0×0A through the I<sup>2</sup>C interface. A detection of address 0×0A can happen in two ways. The first and most common way this will happen is when address 0×0A is written to the CS4954/5 via its I<sup>2</sup>C interface. The second method for detecting address 0×0A is implemented by accessing register address 0×09 through I<sup>2</sup>C. In I<sup>2</sup>C host interface operation, the CS4954/5 register address pointer will

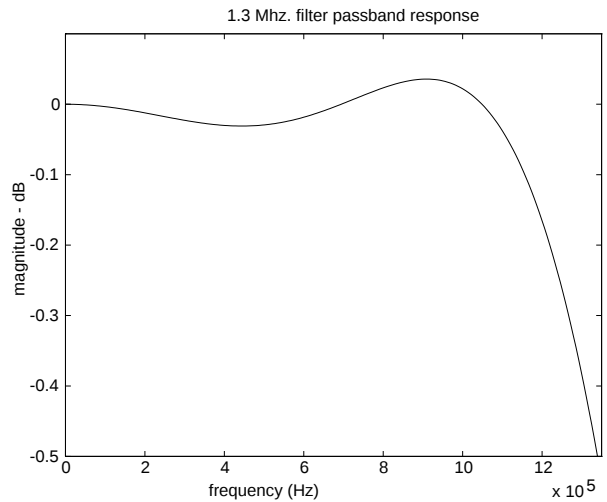
auto-increment to address 0×0A after an address 0×09 access.

The GPIO port PDAT [7:0] pins are configured for output operation when the corresponding GPIO\_CTRL\_REG [7:0] bits are set. In GPIO output mode, the CS4954/5 will output the data in GPIO\_DATA\_REG [7:0] bit locations onto the corresponding PDAT [7:0] pins when it detects a register address 0×0A through the I<sup>2</sup>C interface.

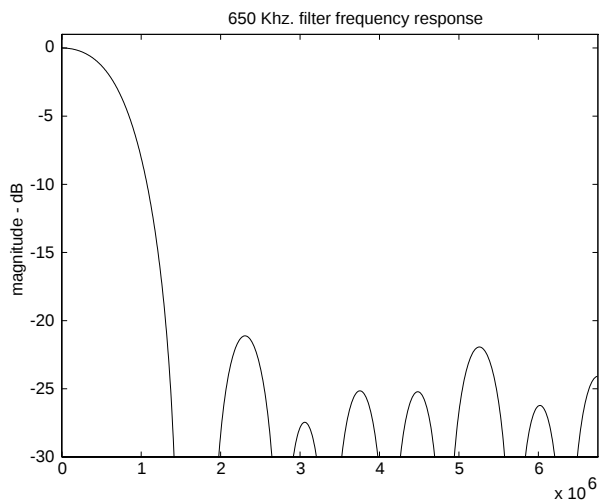
## 6. FILTER RESPONSES



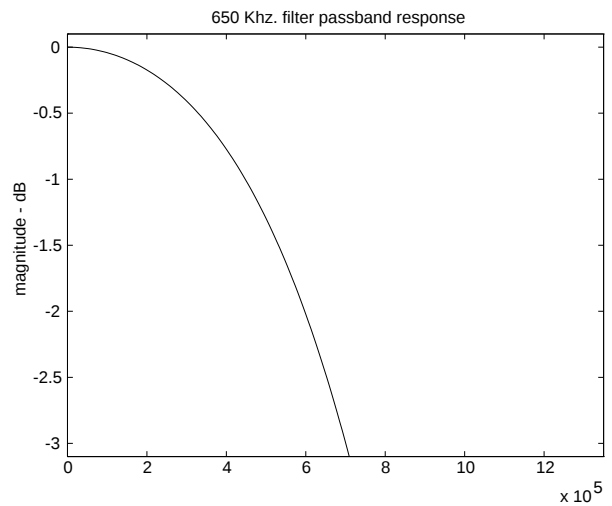
**Figure 14.** 1.3 MHz Chrominance low-pass filter transfer characteristic



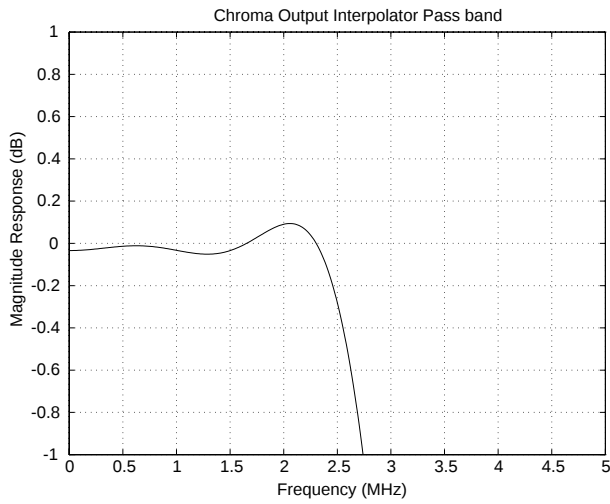
**Figure 15.** 1.3 MHz Chrominance low-pass filter transfer characteristic (passband)



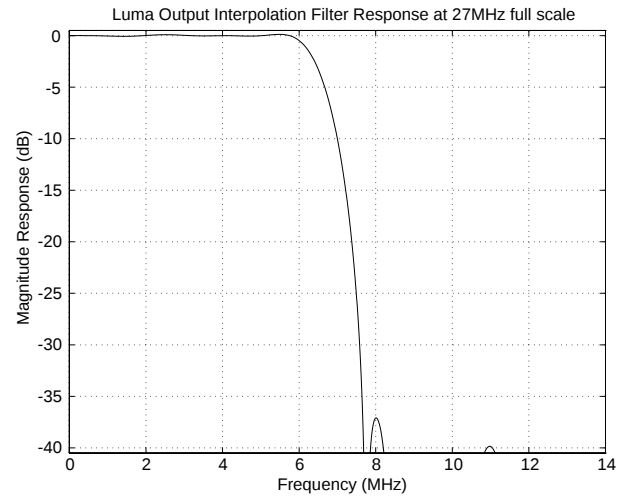
**Figure 16.** 650 kHz Chrominance low-pass filter transfer characteristic



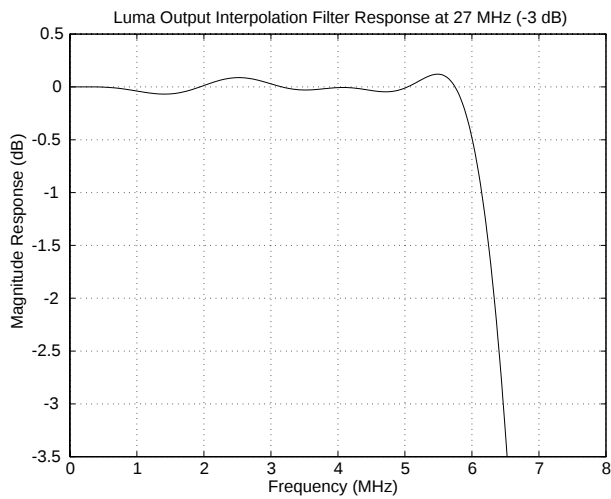
**Figure 17.** 650 kHz Chrominance low-pass filter transfer characteristic (passband)



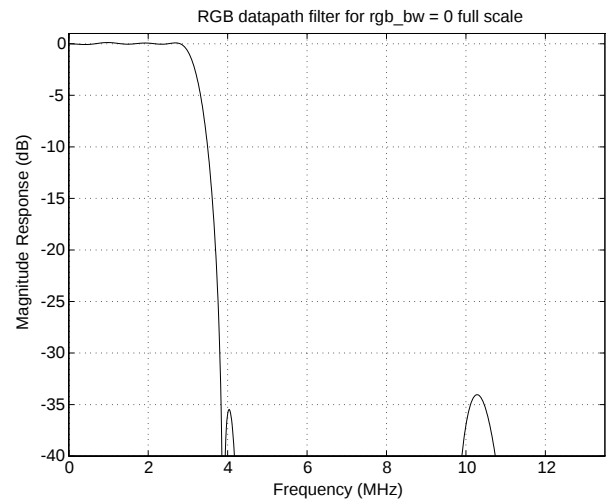
**Figure 18.** Chrominance output interpolation filter transfer characteristic (passband)



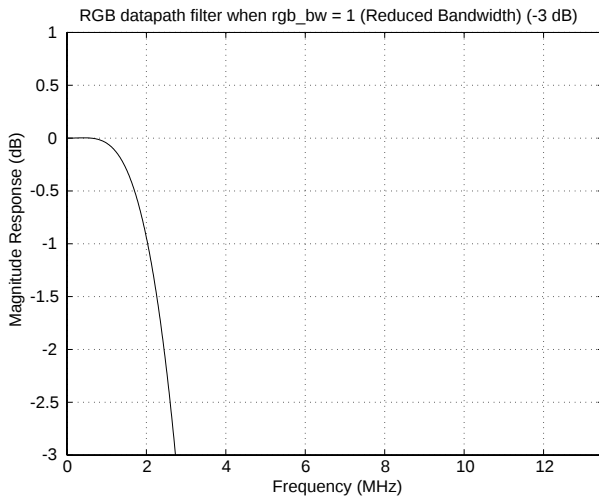
**Figure 19.** Luminance interpolation filter transfer characteristic



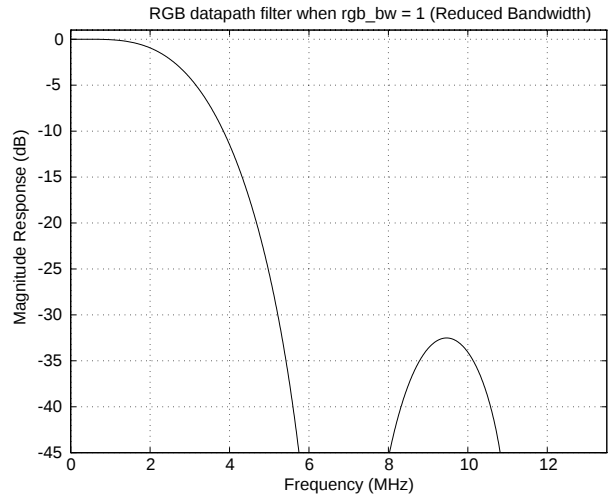
**Figure 20.** Luminance interpolation filter transfer characteristic (passband)



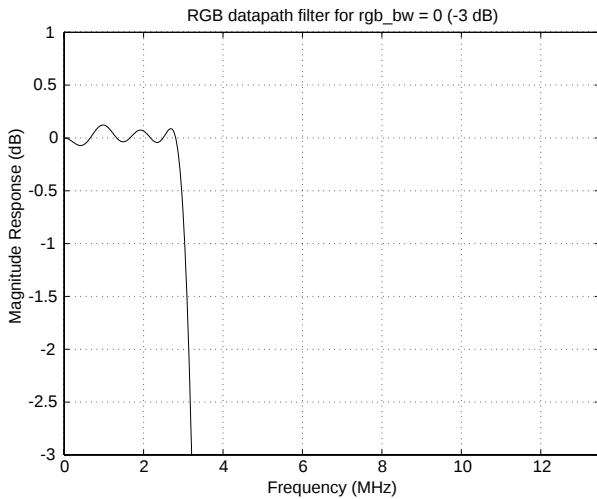
**Figure 21.** Chrominance interpolation filter transfer characteristic for RGB datapath



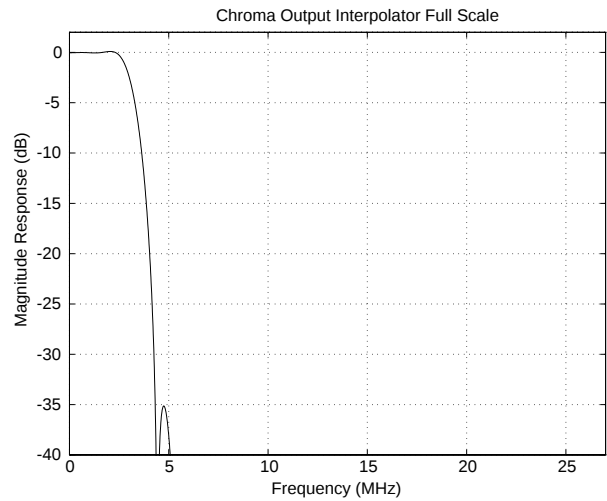
**Figure 22.** Chroma Interpolator for RGB Datapath when  $\text{rgb\_bw}=1$  (Reduced Bandwidth)



**Figure 23.** Chroma Interpolator for RGB Datapath when  $\text{rgb\_bw}=1$  (Reduced Bandwidth)



**Figure 24.** Chroma Interpolator for RGB Datapath when  $\text{rgb\_bw}=0$  -3 dB



**Figure 25.** Chroma Interpolator for RGB Datapath when  $\text{rgb\_bw}=0$  (Full Scale)

## 7. ANALOG

### 7.1 Analog Timing

All CS4954/5 analog timing and sequencing is derived from the 27 MHz clock input. The analog outputs are controlled internally by the video timing generator in conjunction with master and slave timing.

Since the CS4954/5 is almost entirely a digital circuit, great care has been taken to guarantee analog timing and slew rate performance as specified in the NTSC and PAL analog specifications. Reference the Analog Parameters section of this data sheet for the performance specifications.

### 7.2 VREF

The CS4954/5 can operate with or without the aid of an external voltage reference. The CS4954/5 is designed with an internal voltage reference generator that provides a VREFOUT signal at the VREF pin. The internal voltage reference is utilized by not making a connection to the VREF pin. The VREF pin can also be connected to an external precision 1.232 volt reference, which then overrides the internal reference.

### 7.3 ISET

All six of the CS4954/5 digital to analog converter DACs are output current normalized with a common ISET device pin. The DAC output current per bit is determined by the size of the resistor connected between ISET and electrical ground. Typically a 4 K $\Omega$ , 1% metal film resistor should be used. The ISET resistance can be changed by the user to accommodate varying video output attenuation via post filters and also to suit individual preferred performance needs.

In conjunction with the ISET value, the user can also independently vary the chroma, luma and colorburst amplitude levels via host addressable con-

trol register bits that are used to control internal digital amplifiers. The DAC output levels are defined by the following equations:

$$\begin{aligned} V_{REF}/I_{SET} &= I_{REF} \\ (\text{e.g., } 1.232 \text{ V}/4\text{K } \Omega &= 308 \mu\text{A}) \end{aligned}$$

CVBS/Y/C/R/G/B outputs in low impedance mode:

$$V_{OUT}(\text{max}) = I_{REF} * (16/145) * 1023 * 37.5 \Omega = 1.304\text{V}$$

CVBS/Y/C/R/G/B outputs in high impedance mode:

$$V_{OUT}(\text{max}) = I_{REF} * (4/145) * 1023 * 150\Omega = 1.304 \text{ V}$$

### 7.4 DACs

The CS4954/5 has six independent, video-grade, current-output, digital-to-analog converters (DACs). They are 10-bit DACs operating at a 27 MHz two-times-oversampling rate. All six DACs are disabled and default to low power mode upon RESET. Each DAC can be individually powered down and disabled. The output-current-per-bit of all six DACs is determined by the size of the resistor connected between the ISET pin and ground.

#### 7.4.1 Luminance DAC

The Y output pin is driven from a 10-bit 27 MHz current output DAC that internally receives the Y, or luminance (black and white only) or CVBS data based on its configuration. See [Table 1](#) and “CVBS DAC” on [page 33](#). The Y DAC is designed to drive proper video levels into a 37.5  $\Omega$  load. Reference the detailed electrical section of this data sheet for the exact Y digital to analog AC and DC performance data. A EN\_L enable control bit in the Control Register 5 (0x05) is provided to enable or disable the luminance DAC. To completely disable or for low power device operation, the luminance DAC can be totally shut down via the SVIDLUM\_PD control bit in Control Register 4 (0x04). In this mode, turn-on using the control register will not be instantaneous.

### 7.4.2 Chrominance DAC

The C output pin is driven from a 10-bit 27 MHz current output DAC that internally receives the C or chrominance portion of the video signal (color only). The C DAC is designed to drive proper video levels into a 37.5  $\Omega$  load. Reference the detailed electrical section of this data sheet for the exact C digital to analog AC and DC performance data. The EN\_C enable control register bit in Control Register 1 (0×05) is provided to enable or disable the chrominance DAC. To completely disable or for low power device operation, the chrominance DAC can be totally shut down via the SVIDCHR\_PD register bit in Control Register 4 (0×04). In this mode turn-on using the control register will not be instantaneous.

### 7.4.3 CVBS DAC

The CVBS output pin is driven from a 10-bit 27 MHz current output DAC that internally receives a combined luma and chroma signal to provide composite video output. The CVBS DAC is designed to drive proper composite video levels into a 37.5  $\Omega$  load. Reference the detailed electrical section of this data sheet for the exact CVBS digital to analog AC and DC performance data. The EN\_COM enable control register bit, in Control Register 1 (0×05), is provided to enable or disable the output pin. When disabled, there is no current flow from the output. To completely disable or for low power device operation, the CVBS37 DAC can be totally shut down via the COMDAC\_PD control register bit in Control Register 4 (0×04). In this mode turn-on using the control register will not be instantaneous.

### 7.4.4 Red DAC

The Red output pin is driven from a 10-bit 27 MHz current output DAC that internally receives either red component video data or V (Cr) data. The Red DAC is designed to drive proper component video levels into a 37.5  $\Omega$  load. Reference the detailed

electrical section of this data sheet for the exact red digital to analog AC and DC performance data. The EN\_R enable control register bit in Control Register 1 (0×05) is provided to enable or disable the output pin. When disabled, there is no current flow from the output. To completely disable or for low power device operation, the red DAC can be totally shut down via the R\_PD control register bit in Control Register 4 (0×04). In this mode turn-on using the control register will not be instantaneous.

### 7.4.5 Green DAC

The Green output pin is driven from a 10-bit 27 MHz current output DAC that internally receives either Green component video data, Y luminance data or CVBS data depending upon its configuration. See [Table 1, “CVBS DAC” on page 33](#) and [“Luminance DAC” on page 32](#). The Green DAC is designed to drive proper composite video levels into a 37.5  $\Omega$  load. Reference the detailed electrical section of this data sheet for the exact green digital to analog AC and DC performance data. The EN\_G enable control register bit, in Control Register 1 (0×05), is provided to enable or disable the output pin. When disabled, there is no current flow from the output. To completely disable or for low power device operation, the green DAC can be totally shut down via the G\_PD control register bit in Control Register 4 (0×04). In this mode turn-on using the control register will not be instantaneous.

### 7.4.6 Blue DAC

The Blue output pin is driven from a 10-bit 27 MHz current output DAC that internally receives either blue component video data or U (Cb) data. The Blue DAC is designed to drive proper component video levels into a 37.5  $\Omega$  load. Reference the detailed electrical section of this data sheet for the exact blue digital to analog AC and DC performance data. The EN\_B enable control register bit, in Control Register 5 (0×05), is provided to enable or disable the output pin. When disabled, there is no

current flow from the output. To completely disable or for low power device operation, the blue DAC can be totally shut down via the B\_PD control register bit in Control Register 4 (0×04). In this mode turn-on using the control register will not be instantaneous.

#### 7.4.7 DAC Usage Rules

If some of the 6 DACs are not used, it is strongly recommended to power them down (see CONTROL\_4 register) in order to reduce the power dissipation.

Depending on the external resistor connected to the ISET pin the output drive of the DACs can be changed. An external resistor of 4 kΩ must be connected to the ISET pin for normal operation.

There are two output impedance modes that the DACs can be operated in. The first mode is the high impedance mode (LOW\_IMP bit set to 0). In this mode, the DAC output drives a double terminated 300 Ω load and will output a video signal which conforms to the proper analog video specifications. External buffers will be needed if the DAC output load differs from a double terminated 300 Ω load.

The second mode is the low impedance mode (LOW\_IMP but set to 1). In this mode, the DAC output drives a double terminated 75 Ω load and will output a video signal which conforms to the proper analog video specifications. No external buffers are necessary. The outputs can directly drive a television input.

**Note** that for power dissipation purposes it is not always possible to have all the 6 DACs active at the same time. Table 8 shows the maximum number of active DACs allowed depending on the power supply and low/high impedance modes. If less than 6 DACs are allowed to be active, the other DACs **must** be powered down (see CONTROL\_4 register).

| Nominal Power supply | Low/High Impedance mode | maximum # of active DACs |
|----------------------|-------------------------|--------------------------|
| 3.3V                 | Low Impedance           | 3                        |
| 3.3V                 | High Impedance          | 6                        |
| 5.0V                 | Low Impedance           | 3                        |
| 5.0V                 | High Impedance          | 6                        |

**Table 8.** Maximum DAC Numbers

## 8. PROGRAMMING

### 8.1 Host Control Interface

The CS4954/5 host control interface can be configured for I<sup>2</sup>C or 8-bit parallel operation. The CS4954/5 will default to I<sup>2</sup>C operation when the  $\overline{RD}$  and  $\overline{WR}$  pins are both tied low at power up. The  $\overline{RD}$  and  $\overline{WR}$  pins are active for 8-bit parallel operation only.

#### 8.1.1 I<sup>2</sup>C® Interface

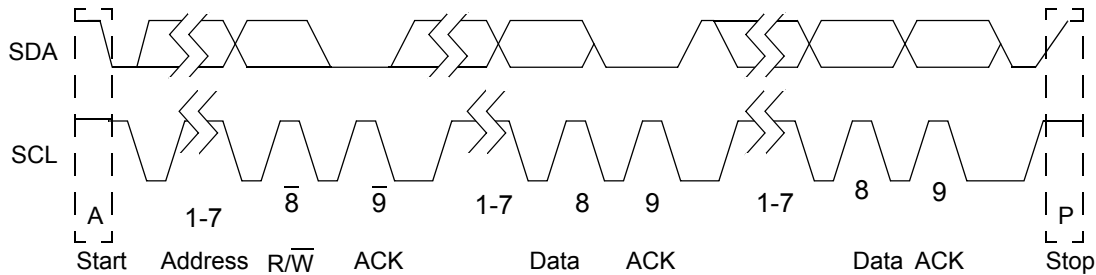
The CS4954/5 provides an I<sup>2</sup>C interface for accessing the internal control and status registers. External pins are a bidirectional data pin (SDA) and a serial input clock (SCL). The protocol follows the I<sup>2</sup>C specifications. A complete data transfer is shown in Figure 26. Note that this I<sup>2</sup>C interface will work in Slave Mode only - it is not a bus master.

SDA and SCL are connected via an external pull-up resistor to a positive supply voltage. When the bus is free, both lines are high. The output stages of devices connected to the bus must have an open-drain or open-collector in order to perform the wired-AND function. Data on the I<sup>2</sup>C bus can be transferred at a rate of up to 400 Kbits/sec in fast mode. The number of interfaces to the bus is solely dependent on the limiting bus capacitance of 400 pF. When 8-bit parallel interface operation is being used, SDA and SCL can be tied directly to ground.

The I<sup>2</sup>C bus address for the CS4954/5 is programmable via the I2C\_ADR Register (0×0F). When I<sup>2</sup>C interface operation is being used,  $\overline{RD}$  and  $\overline{WR}$

must be tied to ground. PDAT [7:0] are available to be used for GPIO operation in I<sup>2</sup>C host interface

mode. For 3.3 V operation it is necessary to have the appropriate level shifting for I<sup>2</sup>C signals.



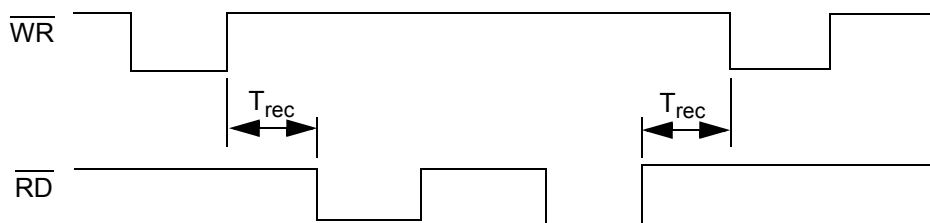
Note: I<sup>2</sup>C transfers data always with MSB first, LSB last

**Figure 26.** I<sup>2</sup>C Protocol

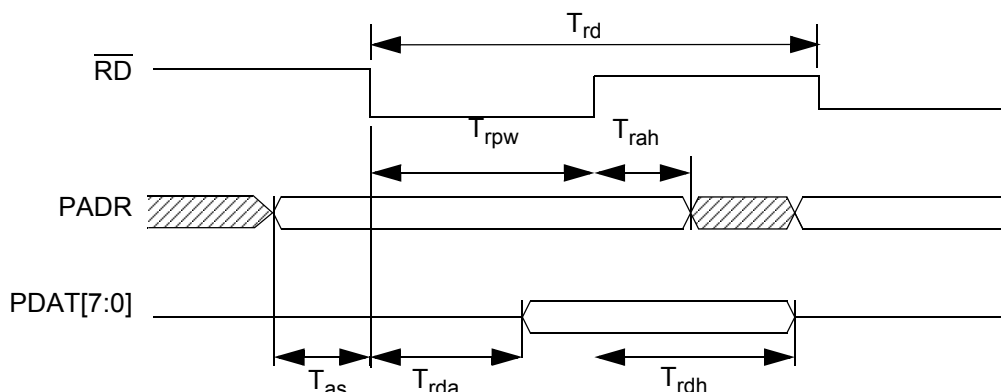
### 8.1.2 8-bit Parallel Interface

The CS4954/5 is equipped with a full 8-bit parallel microprocessor write and read control port. Along with the PDAT [7:0] pins, the control port interface is comprised of host read ( $\overline{RD}$ ) and host write ( $\overline{WR}$ ) active low strobes and host address enable (ADDR), which, when low, enables unique address register accesses. The control port is used to access internal registers which configure the CS4954/5 for various modes of operation. The internal registers are uniquely addressed via an address register. The

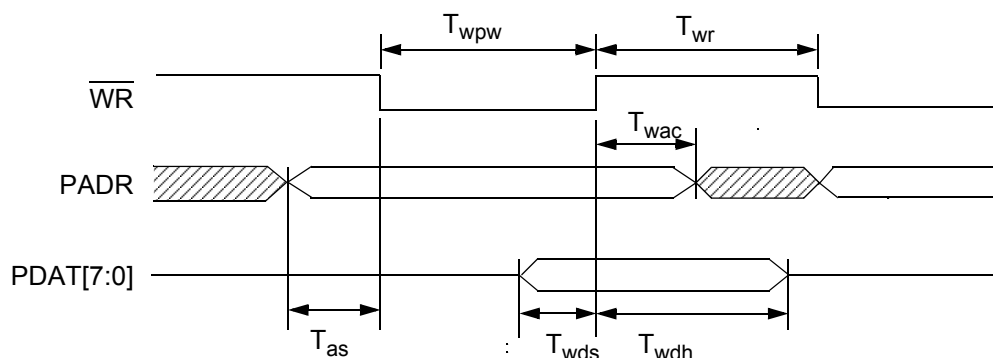
address register is accessed during a host write cycle when the  $\overline{WR}$  and ADDR pins set low. Host write cycles with ADDR set high will write 8-bit data to the PDAT [7:0] pins into the register currently selected by the address register. Likewise read cycles occurring with  $\overline{RD}$  set low and ADDR set high will return the register contents selected by the address register. Reference the detailed electrical timing parameter section of this data sheet for exact host parallel interface timing characteristics and specifications.



**Figure 27.** 8-bit Parallel Host Port Timing: Read-Write/Write-Read Cycle



**Figure 28.** 8-bit Parallel Host Port Timing: Address Read Cycle



**Figure 29.** 8-bit Parallel Host Port Timing: Address Write Cycle

## 8.2 Register Description

A set of internal registers are available for controlling the operation of the CS4954/5. The registers extend from internal address 0×00 through 0×5A. Table 9 shows a complete list of these registers and their internal addresses. Note that this table and the

subsequent register description section describe the full register map for the CS4954 only. A complete CS4955 register set description is available only to Macrovision™ ACP-PPV Licensed Buyers.

### 8.2.1 Control Registers

| Address | Register Name | Type | Default value |
|---------|---------------|------|---------------|
| 0×00    | control_0     | r/w  | 01h           |
| 0×01    | control_1     | r/w  | 02h           |
| 0×02    | control_2     | r/w  | 00h           |
| 0×03    | control_3     | r/w  | 00h           |
| 0×04    | control_4     | r/w  | 3Fh           |
| 0×05    | control_5     | r/w  | 00h           |
| 0×06    | control_6     | r/w  | 00h           |
| 0×07    | RESERVED      |      |               |
| 0×08    | bkg_color     | r/w  | 03h           |

**Table 9.** Control Registers

| Address | Register Name        | Type | Default value |
|---------|----------------------|------|---------------|
| 0×09    | gpio_ctrl_reg        | r/w  | 00h           |
| 0×0A    | gpio_data_reg        | r/w  | 00h           |
| 0×0B    | RESERVED             |      |               |
| 0×0C    | RESERVED             |      |               |
| 0×0D    | SYNC_0               | r/w  | 90h           |
| 0×0E    | SYNC_1               | r/w  | F4h           |
| 0×0F    | I <sup>2</sup> C_ADR | r/w  | 00h           |
| 0×10    | SC_AMP               | r/w  | 1Ch           |
| 0×11    | SC_SYNTH0            | r/w  | 3Eh           |
| 0×12    | SC_SYNTH1            | r/w  | F8h           |
| 0×13    | SC_SYNTH2            | r/w  | E0h           |
| 0×14    | SC_SYNTH3            | r/w  | 43h           |
| 0×15    | HUE_LSB              | r/w  | 00h           |
| 0×16    | HUE_MSB              | r/w  | 00h           |
| 0×17    | SCH PHASE ADJUST     | r/w  | 00h           |
| 0×18    | CC_EN                | r/w  | 00h           |
| 0×19    | CC_21_1              | r/w  | 00h           |
| 0×1A    | CC_21_2              | r/w  | 00h           |
| 0×1B    | CC_284_1             | r/w  | 00h           |
| 0×1C    | CC_284_2             | r/w  | 00h           |
| 0×1D    | RESERVED             |      |               |
| 0×1E    | WSS_REG_0            | r/w  | 00h           |
| 0×1F    | WSS_REG_1            | r/w  | 00h           |
| 0×20    | WSS_REG_2            | r/w  | 00h           |
| 0×21    | RESERVED             |      |               |
| 0×22    | CB_AMP               | r/w  | 80h           |
| 0×23    | CR_AMP               | r/w  | 80h           |
| 0×24    | Y_AMP                | r/w  | 80h           |
| 0×25    | R_AMP                | r/w  | 80h           |
| 0×26    | G_AMP                | r/w  | 80h           |
| 0×27    | B_AMP                | r/w  | 80h           |
| 0×28    | BRIGHT_OFFSET        | r/w  | 00h           |
| 0×29    | TTXHS                | r/w  | A1h           |
| 0×2A    | TTXHD                | r/w  | 02h           |
| 0×2B    | TTXOVS               | r/w  | 00h           |
| 0×2C    | TTXOVE               | r/w  | 00h           |
| 0×2D    | TTXEVS               | r/w  | 00h           |
| 0×2E    | TTXEVE               | r/w  | 00h           |
| 0×2F    | TTX_DIS1             | r/w  | 00h           |
| 0×30    | TTX_DIS2             | r/w  | 00h           |
| 0×31    | TTX_DIS_3            | r/w  | 00h           |
| 0×32    | INT_EN               | r/w  | 00h           |
| 0×33    | INT_CLR              | r/w  | 00h           |

**Table 9.** Control Registers (Continued)

| Address     | Register Name | Type      | Default value |
|-------------|---------------|-----------|---------------|
| 0×34        | STATUS_0      | read only |               |
| 0×35 - 0×59 | RESERVED      |           |               |
| 0×5A        | STATUS_1      | read only | 04h           |
| 0×61 - 0×7F | RESERVED      |           |               |

**Table 9.** Control Registers (Continued)

### Control Register 0

Address            0×00            CONTROL\_0    Read/Write            Default Value = 01h

|            |          |          |          |          |          |          |          |          |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Bit Number | <b>7</b> | <b>6</b> | <b>5</b> | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> | <b>0</b> |
| Bit Name   | TV_FMT   |          |          | MSTR     | CCIR656  | PROG     | IN_MODE  | CBCR_UV  |
| Default    | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 1        |

| Bit | Mnemonic | Function                                                                                                                                                                                                                                                                                        |
|-----|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:5 | TV_FMT   | selects the TV display format<br>000:            NTSC-M CCIR601 timing (default)<br>001:            NTSC-M RS170A timing<br>010:            PAL-B, D, G, H, I<br>011:            PAL-M<br>100:            PAL-N (Argentina)<br>101:            PAL-N (non Argentina)<br>110-111:       reserved |
| 4   | MSTR     | 1 = Master Mode, 0 = Slave Mode                                                                                                                                                                                                                                                                 |
| 3   | CCIR656  | video input is in ITU R.BT656 format with embedded EAV and SAV (0 = off, 1 = on)                                                                                                                                                                                                                |
| 2   | PROG     | Progressive scanning enable (enable = 1)                                                                                                                                                                                                                                                        |
| 1   | IN_MODE  | Input select (0 = solid background, 1 = use V [7:0] data)                                                                                                                                                                                                                                       |
| 0   | CBCR_UV  | enable YCbCr to YUV conversion (1 = enable, 0 = disable)                                                                                                                                                                                                                                        |

### Control Register 1

Address            0×01            CONTROL\_1    Read/Write            Default Value = 02h

|            |          |          |          |          |          |          |          |          |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Bit Number | <b>7</b> | <b>6</b> | <b>5</b> | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> | <b>0</b> |
| Bit Name   | LUM_DEL  |          | CH_BW    | LPF_ON   | RGB_BW   | FLD      | PED      | CBCRSEL  |
| Default    | 0        | 0        | 0        | 0        | 0        | 0        | 1        | 0        |

| Bit | Mnemonic | Function                                                                                                                                                                                   |
|-----|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:6 | LUM_DEL  | luma delay on the composite1 output<br>00:            no delay (default)<br>01:            1 pixel clock delay<br>10:            2 pixel clock delay<br>11:            3 pixel clock delay |

| Bit | Mnemonic | Function                                                                      |
|-----|----------|-------------------------------------------------------------------------------|
| 5   | CH_BW    | chroma lpf bandwidth (0 = 650 kHz, 1 = 1.3 MHz)                               |
| 4   | LPF_ON   | chroma lpf on/off (0 = off, 1 = on)                                           |
| 3   | RGB_BW   | 0 = Full bandwidth on RGB, 1 = BW reduced to 2.5 MHz (3 dB point) (default 0) |
| 2   | FLD_POL  | Polarity of Field (0: odd field = 0, 1: odd field = 1)                        |
| 1   | PED      | Pedestal offset (0: 0 IRE, 1: 7.5 IRE)                                        |
| 0   | CBCRSEL  | CbCr select (0 = chroma undelayed, 1 = chroma delayed by one clock)           |

**Control Register 2**

Address                    0×02            CONTROL\_2    Read/Write            Default Value = 00h

|            |               |   |   |         |        |          |      |       |
|------------|---------------|---|---|---------|--------|----------|------|-------|
| Bit Number | 7             | 6 | 5 | 4       | 3      | 2        | 1    | 0     |
| Bit Name   | OUTPUT_FORMAT |   |   | TTX_WST | TTX_EN | SYNC_DLY | XTAL | SC_EN |
| Default    | 0             | 0 | 0 | 0       | 0      | 0        | 0    | 0     |

| Bit | Mnemonic      | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:5 | OUTPUT_FORMAT | <p>selects the output through the DACs</p> <p>000 :                    rgb, s-video, composite1 (6 DACs) (default)</p> <p>001 :                    yuv, s-video, composite1 (6 DACs)</p> <p>010 :                    s-video, composite1, composite2, (4 DACs)</p> <p>011 :                    rgb, composite1, composite2 (5 DACs)</p> <p>100 :                    yuv, composite1, composite2 (5 DACs)</p> <p>101-111:                don't care</p>                                                                                                               |
| 4   | TTX_WST       | <p>To select between world standard (NTSC), world standard (PAL), or north american teletext standard during NTSC or PAL modes (1 = WST TTX) (default is 0)</p> <p>In NTSC-M or PAL-M mode. This bit works in conjunction with the TV_FORMAT register.</p> <p>0:                        NABTS, if TV_FORMAT is NTSC or PAL-M</p> <p>1:                        WST (NTSC), if TV_FORMAT is NTSC or PAL-M</p> <p>0:                        Europe TTX, if TV_FORMAT is PAL-B, G..., N</p> <p>1:                        WST (PAL), if TV_FORMAT is PAL-B, G, ..., N</p> |
| 3   | TTX_EN        | Enable teletext process (1 = enable)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2   | SYNC_DLY      | Slave mode 1 pixel sync delay (1 = enable)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 1   | XTAL          | Crystal oscillator for subcarrier adjustment enable (1 = enable)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 0   | BU_DIS        | Chroma burst disable (1 = disable)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

### Control Register 3

Address            0×03            CONTROL\_3    Read/Write            Default Value = 00h

|            |          |   |   |           |           |           |           |      |
|------------|----------|---|---|-----------|-----------|-----------|-----------|------|
| Bit Number | 7        | 6 | 5 | 4         | 3         | 2         | 1         | 0    |
| Bit Name   | RESERVED |   |   | FD_THR_C1 | FD_THR_C2 | FD_THR_SV | FD_THR_EN | CBAR |
| Default    | 0        | 0 | 0 | 0         | 0         | 0         | 0         | 0    |

| Bit | Mnemonic  | Function                                                           |
|-----|-----------|--------------------------------------------------------------------|
| 7:5 | -         | reserved                                                           |
| 4   | FD_THR_C1 | feedthrough enabled for composite_1 output (0 = off, 1 = on)       |
| 3   | FD_THR_C2 | feedthrough enabled for composite_2 output (0 = off, 1 = on)       |
| 2   | FD_THR_SV | feedthrough enabled for s-video (on luma signal) (0 = off, 1 = on) |
| 1   | FD_THR_EN | Enable (1 = enable) input to feed through during inactive lines    |
| 0   | CBAR      | internal color bar generator (0 = off, 1 = on)                     |

### Control Register 4

Address            0×04            CONTROL\_4    Read/Write            Default Value = 3Fh

|            |          |                           |           |            |            |      |      |      |
|------------|----------|---------------------------|-----------|------------|------------|------|------|------|
| Bit Number | 7        | 6                         | 5         | 4          | 3          | 2    | 1    | 0    |
| Bit Name   | CB_H_SEL | CB_FLD_SEL <sup>(1)</sup> | COMDAC_PD | SVIDLUM_PD | SVIDCHR_PD | R_PD | G_PD | B_PD |
| Default    | 0        | 0                         | 1         | 1          | 1          | 1    | 1    | 1    |

| Bit | Mnemonic   | Function                                                                               |
|-----|------------|----------------------------------------------------------------------------------------|
| 7   | CB_H_SEL   | Composite Blank / HSYNC output select (1 = CB select, 0 = HSYNC select)                |
| 6   | CB_FLD_SEL | Composite Blank / FIELD output select (1 = CB select, 0 = FIELD select) <sup>(1)</sup> |
| 5   | COMDAC_PD  | power down composite DAC<br>0: power up, 1: power down                                 |
| 4   | SVIDLUM_PD | power down luma s-video DAC<br>0: power up, 1: power down                              |
| 3   | SVIDCHR_PD | power down chroma s-video DAC<br>0: power up, 1: power down                            |
| 2   | R_PD       | power down red rgb video DAC<br>0: power up, 1: power down                             |
| 1   | G_PD       | power down green rgb video DAC<br>0: power up, 1: power down                           |
| 0   | B_PD       | power down blue rgb video DAC<br>0: power up, 1: power down                            |

NOTE: 1. The FIELD pin (pin 9) remains an output pin in SLAVE mode. However, the FIELD pin state does not toggle in SLAVE mode and its output state should be considered random.

### Control Register 5

Address            0×05            CONTROL\_5    Read/Write            Default Value = 00h

|            |          |          |          |          |          |          |          |          |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Bit Number | <b>7</b> | <b>6</b> | <b>5</b> | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> | <b>0</b> |
| Bit Name   | RSVD     | LOW_IMP  | EN_COM   | EN_L     | EN_C     | EN_R     | EN_G     | EN_B     |
| Default    | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |

| Bit | Mnemonic | Function                                                                |
|-----|----------|-------------------------------------------------------------------------|
| 7   | -        | reserved                                                                |
| 6   | LOW_IMP  | selects between tri-state output (0) or output enabled (1) mode of DACs |
| 5   | EN_COM   | enable composite (CVBS) DAC 0: high-impedance, 1: enable                |
| 4   | EN_L     | enable S-VIDEO Y DAC for luma output 0: high-impedance, 1: enable       |
| 3   | EN_C     | enable S-VIDEO C DAC for chroma output 0: high-impedance, 1: enable     |
| 2   | EN_R     | enable RGB video R DAC for red output 0: high-impedance, 1: enable      |
| 1   | EN_G     | enable RGB video G DAC for green output 0: high-impedance, 1: enable    |
| 0   | EN_B     | enable RGB video B DAC for blue output 0: high-impedance, 1: enable     |

### Control Register 6

Address            0×06            CONTROL\_6    Read/Write            Default Value = 00h

|            |              |          |            |            |            |           |           |           |
|------------|--------------|----------|------------|------------|------------|-----------|-----------|-----------|
| Bit Number | <b>7</b>     | <b>6</b> | <b>5</b>   | <b>4</b>   | <b>3</b>   | <b>2</b>  | <b>1</b>  | <b>0</b>  |
| Bit Name   | 656_SYNC_OUT | CLIP_OFF | TTXEN_COM2 | TTXEN_COM1 | TTXEN_SVID | BSYNC_DIS | GSYNC_DIS | RSYNC_DIS |
| Default    | 0            | 0        | 0          | 0          | 0          | 0         | 0         | 0         |

| Bit | Mnemonic     | Function                                                                              |
|-----|--------------|---------------------------------------------------------------------------------------|
| 7   | 656_SYNC_OUT | Enable (=1) output of hsync and vsync when in ITU R.BT656 mode                        |
| 6   | CLIP_OFF     | Clipping input signals disable (0: clipping active 1: no clipping)                    |
| 5   | TTXEN_COM2   | Enable teletext at the composite 2 output (0: disable teletext, 1 : enable teletext)  |
| 4   | TTXEN_COM1   | Enable teletext at the composite 1 output ( 0: disable teletext, 1 : enable teletext) |
| 3   | TTXEN_SVID   | Enable teletext at the s-video output ( 0: disable teletext, 1: enable teletext)      |
| 2   | BSYNC_DIS    | Disable syncs in the blue or v output (0: enable syncs, 1: disable syncs)             |
| 1   | GSYNC_DIS    | Disable syncs in the green or u output ( 0: enable syncs, 1: disable syncs)           |
| 0   | RSYNC_DIS    | Disable syncs in the red or y output (0: enable syncs, 1: disable syncs)              |

### Background Color Register

Address            0×08            BKG\_COLOR    Read/Write            Default Value = 03h

|            |    |   |   |   |   |   |   |   |
|------------|----|---|---|---|---|---|---|---|
| Bit Number | 7  | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | BG |   |   |   |   |   |   |   |
| Default    | 0  | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

| Bit | Mnemonic | Function                                                                   |
|-----|----------|----------------------------------------------------------------------------|
| 7:0 | BG       | Background color (7:5 = R, 4:2 = G, 1:0 = B) (default is 0000 0011 - blue) |

### GPIO Control Register

Address            0×09            GPIO\_REG    Read/Write            Default Value = 00h

|            |           |   |   |   |   |   |   |   |
|------------|-----------|---|---|---|---|---|---|---|
| Bit Number | 7         | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | GPR_CNTRL |   |   |   |   |   |   |   |
| Default    | 0         | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic  | Function                                                                      |
|-----|-----------|-------------------------------------------------------------------------------|
| 7:0 | GPR_CNTRL | Input(0)/output(1) control of GPIO registers (bit 0: PDAT(0), bit 7: PDAT(7)) |

### GPIO Data Register

Address            0×0A            GPIO\_REG    Read/Write            Default Value = 00h

|            |          |   |   |   |   |   |   |   |
|------------|----------|---|---|---|---|---|---|---|
| Bit Number | 7        | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | GPIO_REG |   |   |   |   |   |   |   |
| Default    | 0        | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                                                                                                                                                                                                             |
|-----|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:0 | GPIO_REG | GPIO data register ( data is output on PDAT bus if appropriate bit in address 09 is set to "1", otherwise data is input/output through I <sup>2</sup> C)- This register is only accessible in I <sup>2</sup> C mode. |

### Sync Register 0

Address            0×0D            Sync\_0            Read/Write            Default Value = 90h

|            |              |   |   |   |               |   |   |   |
|------------|--------------|---|---|---|---------------|---|---|---|
| Bit Number | 7            | 6 | 5 | 4 | 3             | 2 | 1 | 0 |
| Bit Name   | PROG_VS[4:0] |   |   |   | PROG_HS[10:8] |   |   |   |
| Default    | 1            | 0 | 0 | 1 | 0             | 0 | 0 | 0 |

| Bit | Mnemonic      | Function                                            |
|-----|---------------|-----------------------------------------------------|
| 7:3 | PROG_VS[4:0]  | programmable vsync lines                            |
| 2:0 | PROG_HS[10:8] | programmable hsync pixels (3 most significant bits) |



### *Hue LSB Adjust Register*

Address            0×15        HUE\_LSB        Read/Write        Default Value = 00h

|            |         |   |   |   |   |   |   |   |
|------------|---------|---|---|---|---|---|---|---|
| Bit Number | 7       | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | HUE_LSB |   |   |   |   |   |   |   |
| Default    | 0       | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                   |
|-----|----------|----------------------------|
| 7:0 | HUE_LSB  | 8 LSBs for hue phase shift |

### *Hue MSB Adjust Register*

Address            0×16        HUE\_MSB        Read/Write        Default Value = 00h

|            |          |   |   |   |   |   |     |   |
|------------|----------|---|---|---|---|---|-----|---|
| Bit Number | 7        | 6 | 5 | 4 | 3 | 2 | 1   | 0 |
| Bit Name   | RESERVED |   |   |   |   |   | MSB |   |
| Default    | 0        | 0 | 0 | 0 | 0 | 0 | 0   | 0 |

| Bit | Mnemonic | Function                   |
|-----|----------|----------------------------|
| 7:2 | -        | reserved                   |
| 1:0 | HUE_MSB  | 2 MSBs for hue phase shift |

### *SCH Sync Phase Adjust*

Address            0×17        SCH            Read/Write        Default Value = 00h

| Bit | Mnemonic | Function                                               |
|-----|----------|--------------------------------------------------------|
| 7:0 | SCH      | Adjust in increments of ≈1.4 degree per bit up to 360° |

### *Closed Caption Enable Register*

Address            0×18        CC\_EN        Read/Write        Default Value = 00h

|            |          |   |   |   |   |   |        |       |
|------------|----------|---|---|---|---|---|--------|-------|
| Bit Number | 7        | 6 | 5 | 4 | 3 | 2 | 1      | 0     |
| Bit Name   | RESERVED |   |   |   |   |   | EN_284 | EN_21 |
| Default    | 0        | 0 | 0 | 0 | 0 | 0 | 0      | 0     |

| Bit | Mnemonic | Function                           |
|-----|----------|------------------------------------|
| 7:2 | -        | reserved                           |
| 1   | CC_EN[1] | enable closed caption for line 284 |
| 0   | CC_EN[0] | enable closed caption for line 21  |

### *Closed Caption Data Register*

|         |      |          |            |                     |
|---------|------|----------|------------|---------------------|
| Address | 0×19 | CC_21_1  | Read/Write | Default Value = 00h |
|         | 0×1A | CC_21_2  |            | 00h                 |
|         | 0×1B | CC_284_1 |            | 00h                 |
|         | 0×1C | CC_284_2 |            | 00h                 |

| Bit | Mnemonic | Function                                   |
|-----|----------|--------------------------------------------|
| 7:0 | CC_21_1  | first closed caption databyte of line 21   |
| 7:0 | CC_21_2  | second closed caption databyte of line 21  |
| 7:0 | CC_284_1 | first closed caption databyte of line 284  |
| 7:0 | CC_284_2 | second closed caption databyte of line 284 |

### *Wide Screen Signaling Register 0*

|         |      |           |            |                     |
|---------|------|-----------|------------|---------------------|
| Address | 0×1E | WSS_REG_0 | Read/Write | Default Value = 00h |
|---------|------|-----------|------------|---------------------|

|            |        |        |        |        |        |        |        |        |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Bit Number | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      |
| Bit Name   | WSS_23 | WSS_22 | WSS_21 | WSS_20 | WSS_19 | WSS_18 | WSS_17 | WSS_16 |
| Default    | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      |

| Bit | Mnemonic | Function                                                                |
|-----|----------|-------------------------------------------------------------------------|
| 7   | WSS_23   | Enable wide screen signalling (enable =1)                               |
| 6   | WSS_22   | PAL: enable WSS (enable = 1) on line 23 of field 2,<br>NTSC: don't care |
| 5   | WSS_21   | PAL: group 4, bit 13, NTSC: don't care                                  |
| 4   | WSS_20   | PAL: group 4, bit 12, NTSC: don't care                                  |
| 3   | WSS_19   | PAL: group 4, bit 11, NTSC: bit 20                                      |
| 2   | WSS_18   | PAL: group 3, bit 10, NTSC: bit 19                                      |
| 1   | WSS_17   | PAL: group 3, bit 9, NTSC: bit 18                                       |
| 0   | WSS_16   | PAL: group 3, bit 8, NTSC: bit 17                                       |

### Wide Screen Signalling Register 1

Address            0×1F            WSS\_REG\_1    Read/Write            Default Value = 00h

|            |          |          |          |          |          |          |          |          |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Bit Number | <b>7</b> | <b>6</b> | <b>5</b> | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> | <b>0</b> |
| Bit Name   | WSS_15   | WSS_14   | WSS_13   | WSS_12   | WSS_11   | WSS_10   | WSS_9    | WSS_8    |
| Default    | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |

| Bit | Mnemonic | Function                          |
|-----|----------|-----------------------------------|
| 7   | WSS_15   | PAL: group 2, bit 7, NTSC: bit 16 |
| 6   | WSS_14   | PAL: group 2, bit 6, NTSC: bit 15 |
| 5   | WSS_13   | PAL: group 2, bit 5, NTSC: bit 14 |
| 4   | WSS_12   | PAL: group 2, bit 4, NTSC: bit 13 |
| 3   | WSS_11   | PAL: group 1, bit 3, NTSC: bit 12 |
| 2   | WSS_10   | PAL: group 1, bit 2, NTSC: bit 11 |
| 1   | WSS_9    | PAL: group 1, bit 1, NTSC: bit 10 |
| 0   | WSS_8    | PAL: group 1, bit 0, NTSC: bit 9  |

### Wide Screen Signalling Register 2

Address            0×20            WSS\_REG\_2    Read/Write            Default Value = 00h

|            |          |          |          |          |          |          |          |          |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Bit Number | <b>7</b> | <b>6</b> | <b>5</b> | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> | <b>0</b> |
| Bit Name   | WSS_7    | WSS_6    | WSS_5    | WSS_4    | WSS_3    | WSS_2    | WSS_1    | WSS_0    |
| Default    | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |

| Bit | Mnemonic | Function                     |
|-----|----------|------------------------------|
| 7   | WSS_7    | PAL: don't care, NTSC: bit 8 |
| 6   | WSS_6    | PAL: don't care, NTSC: bit 7 |
| 5   | WSS_5    | PAL: don't care, NTSC: bit 6 |
| 4   | WSS_4    | PAL: don't care, NTSC: bit 5 |
| 3   | WSS_3    | PAL: don't care, NTSC: bit 4 |
| 2   | WSS_2    | PAL: don't care, NTSC: bit 3 |
| 1   | WSS_1    | PAL: don't care, NTSC: bit 2 |
| 0   | WSS_0    | PAL: don't care, NTSC: bit 1 |

### Filter Register 0

Address            0×22            CB\_AMP            Read/Write            Default Value = 80h

|            |          |          |          |          |          |          |          |          |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Bit Number | <b>7</b> | <b>6</b> | <b>5</b> | <b>4</b> | <b>3</b> | <b>2</b> | <b>1</b> | <b>0</b> |
| Bit Name   | U_AMP    |          |          |          |          |          |          |          |
| Default    | 1        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |

| Bit | Mnemonic | Function                    |
|-----|----------|-----------------------------|
| 7:0 | U_AMP    | U(Cb) amplitude coefficient |

### Filter Register 1

Address            0×23            CR\_AMP            Read/Write            Default Value = 80h

|            |       |   |   |   |   |   |   |   |
|------------|-------|---|---|---|---|---|---|---|
| Bit Number | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | V_AMP |   |   |   |   |   |   |   |
| Default    | 1     | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                    |
|-----|----------|-----------------------------|
| 7:0 | V_AMP    | V(Cr) amplitude coefficient |

### Filter Register 2

Address            0×24            Y\_AMP            Read/Write            Default Value = 80h

|            |       |   |   |   |   |   |   |   |
|------------|-------|---|---|---|---|---|---|---|
| Bit Number | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | Y_AMP |   |   |   |   |   |   |   |
| Default    | 1     | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                   |
|-----|----------|----------------------------|
| 7:0 | Y_AMP    | Luma amplitude coefficient |

### Filter Register 3

Address            0×25            R\_AMP            Read/Write            Default Value = 80h

|            |       |   |   |   |   |   |   |   |
|------------|-------|---|---|---|---|---|---|---|
| Bit Number | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | R_AMP |   |   |   |   |   |   |   |
| Default    | 1     | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                  |
|-----|----------|---------------------------|
| 7:0 | R_AMP    | Red amplitude coefficient |

### Filter Register 4

Address            0×26            G\_AMP            Read/Write            Default Value = 80h

|            |       |   |   |   |   |   |   |   |
|------------|-------|---|---|---|---|---|---|---|
| Bit Number | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | G_AMP |   |   |   |   |   |   |   |
| Default    | 1     | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                    |
|-----|----------|-----------------------------|
| 7:0 | G_AMP    | Green amplitude coefficient |

### Filter Register 5

Address            0×27            B\_AMP            Read/Write            Default Value = 80h

|            |       |   |   |   |   |   |   |   |
|------------|-------|---|---|---|---|---|---|---|
| Bit Number | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | B_AMP |   |   |   |   |   |   |   |
| Default    | 1     | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                   |
|-----|----------|----------------------------|
| 7:0 | B_AMP    | Blue amplitude coefficient |

### Filter Register 6

Address            0×28            Bright\_Offsett            Read/Write            Default Value = 00h

|            |                   |   |   |   |   |   |   |   |
|------------|-------------------|---|---|---|---|---|---|---|
| Bit Number | 7                 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | BRIGHTNESS_OFFSET |   |   |   |   |   |   |   |
| Default    | 0                 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic     | Function                                     |
|-----|--------------|----------------------------------------------|
| 7:0 | BRGHT_OFFSET | Brightness adjustment ( range: -128 to +127) |

### Teletext Register 0

Address            0×29            TTXHS            Read/Write            Default Value = A1h

|            |       |   |   |   |   |   |   |   |
|------------|-------|---|---|---|---|---|---|---|
| Bit Number | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTXHS |   |   |   |   |   |   |   |
| Default    | 1     | 0 | 1 | 0 | 0 | 0 | 0 | 1 |

| Bit | Mnemonic | Function                                            |
|-----|----------|-----------------------------------------------------|
| 7:0 | TTXHS    | Start of teletext request pulses or start of window |

### Teletext Register 1

Address            0×2A            TTXHD            Read/Write            Default Value = 02h

|            |       |   |   |   |   |   |   |   |
|------------|-------|---|---|---|---|---|---|---|
| Bit Number | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTXHD |   |   |   |   |   |   |   |
| Default    | 0     | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

| Bit | Mnemonic | Function                                                                                                                                                                                                                                                                                                                                              |
|-----|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:0 | TTXHD    | <p>If TTX_WINDOW = 0 then this register is used as the Pipeline delay between TTXRQ and TTXDAT signals in the teletext source. User programmable delay step of 37 ns per LSB.</p> <p>If TTX_WINDOW = 1 then this register is used as the 8 LSBs of the teletext insertion windows; the 3 MSBs are located in register 0×31. (register 0×31 bit 3)</p> |

### Teletext Register 2

Address            0×2B            TTXOVS            Read/Write            Default Value = 00h

|            |        |   |   |   |   |   |   |   |
|------------|--------|---|---|---|---|---|---|---|
| Bit Number | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTXOVS |   |   |   |   |   |   |   |
| Default    | 0      | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                                   |
|-----|----------|--------------------------------------------|
| 7:0 | TTXOVS   | Start of teletext line window in odd field |

### Teletext Register 3

Address            0×2C            TTXOVE            Read/Write            Default Value = 00h

|            |        |   |   |   |   |   |   |   |
|------------|--------|---|---|---|---|---|---|---|
| Bit Number | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTXOVE |   |   |   |   |   |   |   |
| Default    | 0      | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                                 |
|-----|----------|------------------------------------------|
| 7:0 | TTXOVE   | End of teletext line window in odd field |

### Teletext Register 4

Address            0×2D            TTxEVS            Read/Write            Default Value = 00h

|            |        |   |   |   |   |   |   |   |
|------------|--------|---|---|---|---|---|---|---|
| Bit Number | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTxEVS |   |   |   |   |   |   |   |
| Default    | 0      | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                                    |
|-----|----------|---------------------------------------------|
| 7:0 | TTxEVS   | Start of teletext line window in even field |

### Teletext Register 5

Address            0×2E            TTxEVE            Read/Write            Default Value = 00h

|            |        |   |   |   |   |   |   |   |
|------------|--------|---|---|---|---|---|---|---|
| Bit Number | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTxEVE |   |   |   |   |   |   |   |
| Default    | 0      | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic | Function                                  |
|-----|----------|-------------------------------------------|
| 7:0 | TTxEVE   | End of teletext line window in even field |

### Teletext Register 6

Address            0×2F            TTX\_DIS1            Read/Write            Default Value = 00h

|            |               |   |   |   |   |   |   |   |
|------------|---------------|---|---|---|---|---|---|---|
| Bit Number | 7             | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTX_LINE_DIS1 |   |   |   |   |   |   |   |
| Default    | 0             | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic      | Function                                                                                                                                                |
|-----|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:0 | TTX_LINE_DIS1 | Teletext disable bits corresponding to the lines 5-12 respectively, (11111111=all eight lines are disabled),<br>(MSB is for line 5, LSB is for line 12) |

### Teletext Register 7

Address            0×30            TTX\_DIS2            Read/Write            Default Value = 00h

|            |               |   |   |   |   |   |   |   |
|------------|---------------|---|---|---|---|---|---|---|
| Bit Number | 7             | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | TTX_LINE_DIS2 |   |   |   |   |   |   |   |
| Default    | 0             | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | Mnemonic      | Function                                                                                                                                                  |
|-----|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:0 | TTX_LINE_DIS2 | Teletext disable bits corresponding to the lines 13-20 respectively, (11111111=all eight lines are disabled),<br>(MSB is for line 13, LSB is for line 20) |

### Teletext Register 8

Address            0×31            TTX\_DIS3            Read/Write            Default Value = 00h

|            |       |   |   |          |            |               |   |   |
|------------|-------|---|---|----------|------------|---------------|---|---|
| Bit Number | 7     | 6 | 5 | 4        | 3          | 2             | 1 | 0 |
| Bit Name   | TTXHD |   |   | RESERVED | TTX_WINDOW | TTX_LINE_DIS3 |   |   |
| Default    | 0     | 0 | 0 | 0        | 0          | 0             | 0 | 0 |

| Bit | Mnemonic      | Function                                                                                                                                                                             |
|-----|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:5 | TTXHD         | If TTX_WINDOW = 0 these 3 bits are unused.<br>If TTX_WINDOW = 1 these 3 bits are the MSBs of the register 0×2A; they are used to specify the length of the teletext insertion window |
| 4   | Reserved      |                                                                                                                                                                                      |
| 3   | TTX_WINDOW    | Selects between TTXRQ (= 0) pulsation or TTXRQ (= 1) Window mode                                                                                                                     |
| 2:0 | TTX_LINE_DIS3 | Teletext disable bits corresponding to the lines 13-20 respectively, (111=all three lines are disabled),<br>(MSB is for line 21, LSB is for line 23)                                 |

### Interrupt Register 0

Address            0×32            INT\_EN            Read/Write            Default Value = 00h

|            |          |   |   |   |   |           |            |          |
|------------|----------|---|---|---|---|-----------|------------|----------|
| Bit Number | 7        | 6 | 5 | 4 | 3 | 2         | 1          | 0        |
| Bit Name   | RESERVED |   |   |   |   | INT_21_EN | INT_284_EN | INT_V_EN |
| Default    | 0        | 0 | 0 | 0 | 0 | 0         | 0          | 0        |

| Bit | Mnemonic   | Function                                     |
|-----|------------|----------------------------------------------|
| 7:3 | -          | reserved                                     |
| 2   | INT_21_EN  | interrupt enable for closed caption line 21  |
| 1   | INT_284_EN | interrupt enable for closed caption line 284 |
| 0   | INT_V_EN   | interrupt enable for new video field         |

### Interrupt Register 1

Address            0×33            INT\_CLR            Read/Write            Default Value = 00h

|            |          |   |   |   |   |            |             |           |
|------------|----------|---|---|---|---|------------|-------------|-----------|
| Bit Number | 7        | 6 | 5 | 4 | 3 | 2          | 1           | 0         |
| Bit Name   | RESERVED |   |   |   |   | CLR_INT_21 | CLR_INT_284 | CLR_INT_V |
| Default    | 0        | 0 | 0 | 0 | 0 | 0          | 0           | 0         |

| Bit | Mnemonic    | Function                                              |
|-----|-------------|-------------------------------------------------------|
| 7:3 | -           | reserved                                              |
| 2   | CLR_INT_21  | clear interrupt for closed caption line 21 (INT 21)   |
| 1   | CLR_INT_284 | clear interrupt for closed caption line 284 (INT_284) |
| 0   | CLR_INT_V   | clear interrupt for new video field (INT_V)           |

### Status Register 0

Address            0×34            STATUS\_0            Read Only            Default Value = 00h

|            |        |         |       |     |
|------------|--------|---------|-------|-----|
| Bit Number | 5      | 4       | 3     | 2:0 |
| Bit Name   | INT_21 | INT_284 | INT_V | FLD |
| Default    | 0      | 0       | 0     | 0   |

| Bit | Mnemonic | Function                                              |
|-----|----------|-------------------------------------------------------|
| 5   | INT_21   | Interrupt flag for line 21 (closed caption) complete  |
| 4   | INT_284  | Interrupt flag for line 284 (closed caption) complete |
| 3   | INT_V    | Interrupt flag for video field change                 |
| 2:0 | FLD_ST   | Field Status bits(001 = field 1,000 = field 8)        |

### Status Register 1

Address            0×5A            STATUS\_1            Read only            Default Value = 04h

|            |           |   |   |   |   |   |   |   |
|------------|-----------|---|---|---|---|---|---|---|
| Bit Number | 7         | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Bit Name   | DEVICE_ID |   |   |   |   |   |   |   |
| Default    | 0         | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

| Bit | Mnemonic  | Function                                                    |
|-----|-----------|-------------------------------------------------------------|
| 7:0 | DEVICE_ID | Device identification: CS4954: 0000 0100, CS4955: 0000 0101 |

## 9. BOARD DESIGN AND LAYOUT CONSIDERATIONS

The printed circuit layout should be optimized for lowest noise on the CS4954/5 placed as close to the output connectors as possible. All analog supply traces should be as short as possible to minimize inductive ringing.

A well designed power distribution network is essential in eliminating digital switching noise. The ground planes must provide a low-impedance return path for the digital circuits. A PC board with a minimum of four layers is recommended. The ground layer should be used as a shield to isolate noise from the analog traces. The top layer (1) should be reserved for analog traces but digital traces can share this layer if the digital signals have sufficiently slow edges and edge rates and switch little current or if they are separated from the analog traces by a significant distance (dependent on their frequency content and current). The PCB layer “stack up” (from top to bottom) should be: analog/digital signal then ground plane followed by the analog power plane and the digital signal layer.

### 9.1 Power and Ground Planes

The power and ground planes need isolation gaps of at least 0.05" to minimize digital switching noise effects on the analog signals and components. A split analog/digital ground plane should be connected at one location as close as possible to the CS4954/5.

### 9.2 Power Supply Decoupling

Start by reducing power supply ripple and wiring harness inductance by placing a large (33-100 uF) capacitor as close to the power entry point as possible. Use separate power planes or traces for the digital and analog sections even if they use the same supply. If necessary, further isolate the digital and analog power supplies by using ferrite beads on each supply branch followed by a low ESR capacitor.

Place all decoupling caps as close as possible to the device. Surface mount capacitors generally have lower inductance than radial lead or axial lead components. Surface mount caps should be placed on the component side of the PCB to minimize inductance caused by board vias. Any vias, especially to ground, should be as large as possible to reduce their inductive effects.

### 9.3 Digital Interconnect

The digital inputs and outputs of the CS4954/5 should be isolated from the analog outputs as much as possible. Use separate signal layers whenever possible and do not route digital signals over the analog power and ground planes.

Noise from the digital section is related to the digital edge rates and rise/fall times. Ringing, overshoot, undershoot, and ground bounce are all related to edge rise/fall times. Use lower speed logic such as HCMOS for the host port interface to reduce switching noise. For the video input ports, higher speed logic is required, but use logic that produces the slowest practical edge rise/fall times to reduce noise. It is also important to match the source impedance, line impedance, and load impedance as much as possible. Generally, if the line length is greater than one fourth of the signal wavelength or period (from  $\lambda = v/f$ ), a line termination is necessary. Ringing can also be reduced by damping the line with a series resistor (22-150  $\Omega$ ). Under extreme cases, it may be advisable to use microstrip techniques to further reduce radiated switching noise if there are very fast (<2 ns) rise/fall times in the system. If microstrip techniques are used, split the analog and digital ground planes and use proper RF decoupling techniques.

### 9.4 Analog Interconnect

The CS4954/5 should be located as close as possible to the output connectors to minimize noise pickup and reflections due to impedance mismatch. All unused analog outputs should be placed in shutdown.

This reduces the total power that the CS4954/5 requires, and eliminates the impedance mismatch presented by an unused connector. The analog outputs should not overlay the analog power plane in order to maximize high frequency power supply rejection.

### 9.5 Analog Output Protection

To minimize the possibility of damage to the analog output sections, make sure that all video connectors are well grounded. The connector should have a good DC ground path to the analog and digital power supply grounds. If no DC (and low frequency) path is present, improperly grounded equipment can impose damaging reverse currents

on the video out lines. Therefore, it is also a good idea to use output filters that are AC coupled to avoid any problems.

### 9.6 ESD Protection

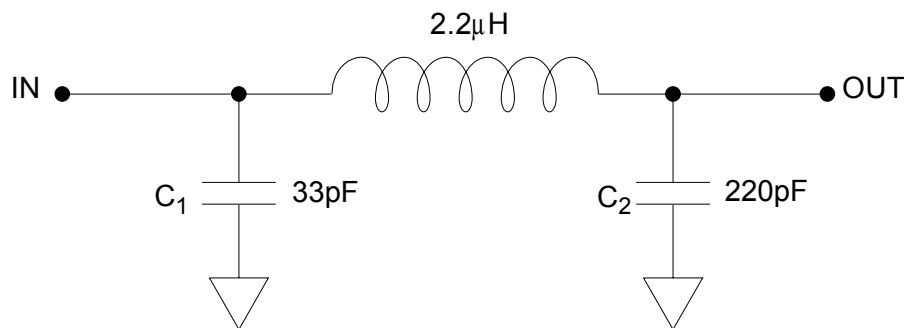
All MOS devices are sensitive to Electro Static Discharge (ESD). When manipulating these devices, proper ESD precautions are recommended to avoid performance degradation or permanent damage.

### 9.7 External DAC Output Filter

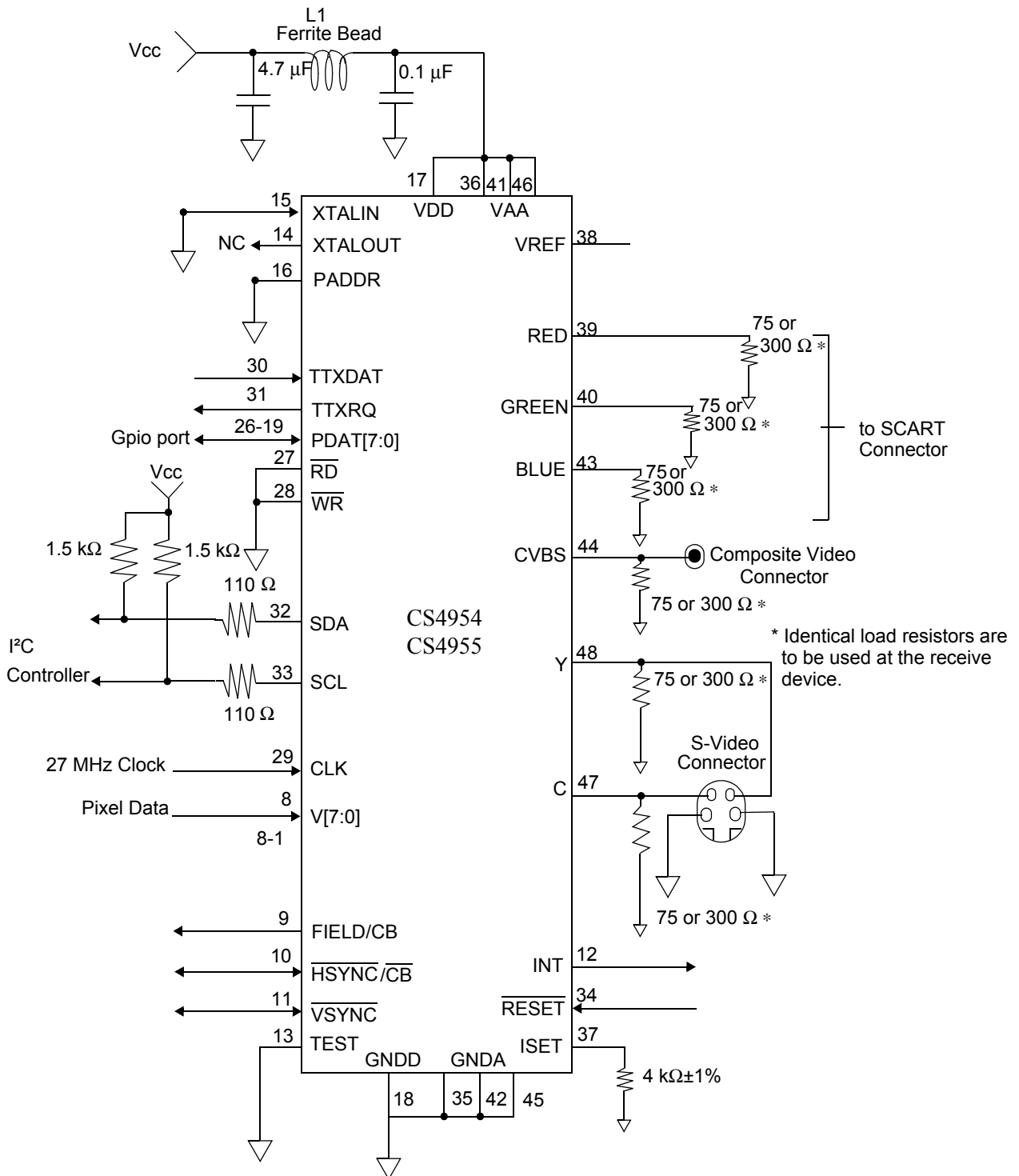
If an output filter is required, the low pass filter shown in Figure 30 can be used.

**NOTE:**

$C_2$  should be chosen so that  $C_1 = C_2 + C_{\text{cable}}$

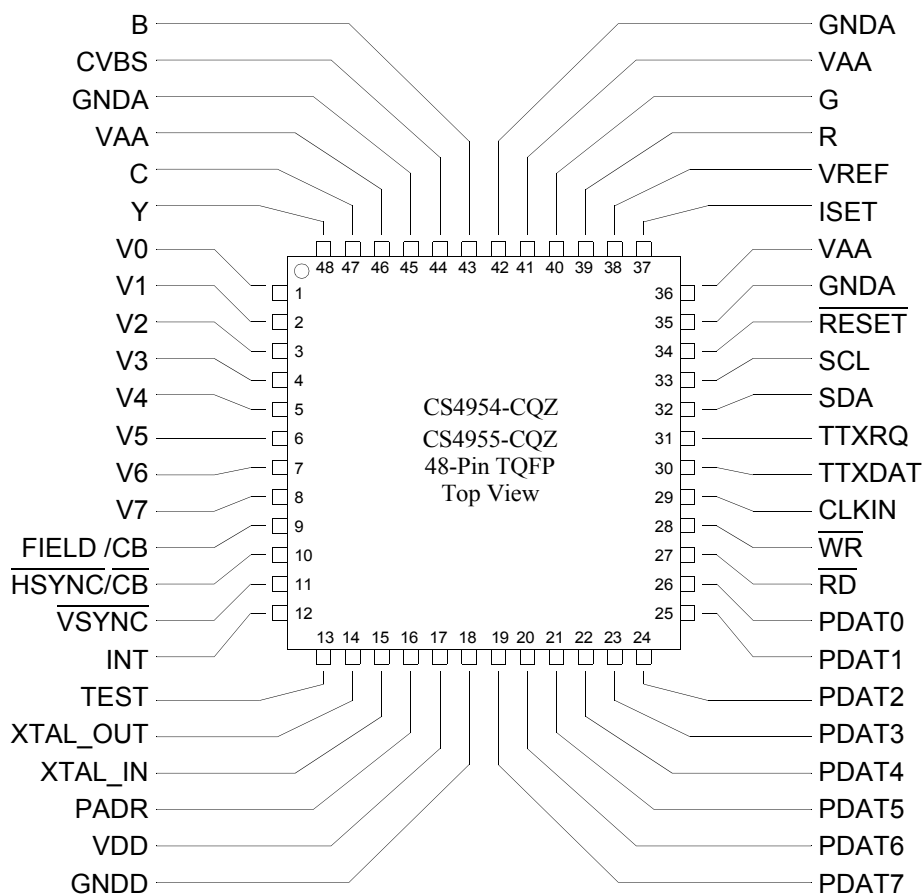


**Figure 30.** External Low Pass Filter



**Figure 31.** Typical Connection Diagram

## 10. PIN DESCRIPTION



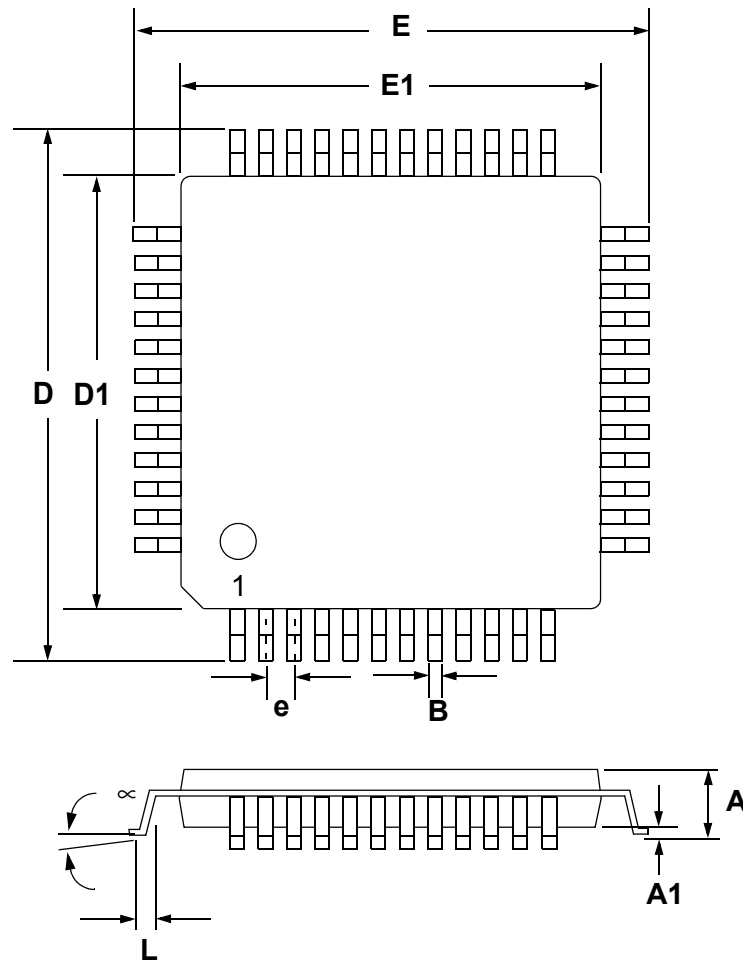
| Pin Name                | Pin Number                     | Type               | Description                                                   |
|-------------------------|--------------------------------|--------------------|---------------------------------------------------------------|
| V [7:0]                 | 8, 7, 6, 5, 4, 3, 2, 1         | IN                 | Digital video data inputs                                     |
| CLK                     | 29                             | IN                 | 27 MHz input clock                                            |
| PADDR                   | 16                             | IN                 | Address enable line                                           |
| XTAL_IN                 | 15                             | IN                 | subcarrier crystal input                                      |
| XTAL_OUT                | 14                             | OUT                | subcarrier crystal output                                     |
| HSYNC/CB                | 10                             | I/O                | Active low horizontal sync, or composite blank signal         |
| VSYNC                   | 11                             | I/O                | Active low vertical sync.                                     |
| FIELD/CB <sup>(1)</sup> | 9                              | OUT <sup>(1)</sup> | Video field ID. Selectable polarity or composite blank        |
| RD                      | 27                             | IN                 | Host parallel port read strobe, active low                    |
| WR                      | 28                             | IN                 | Host parallel port write strobe, active low                   |
| PDAT [7:0]              | 19, 20, 21, 22, 23, 24, 25, 26 | I/O                | Host parallel port/ general purpose I/O                       |
| SDA                     | 32                             | I/O                | I <sup>2</sup> C data                                         |
| SCL                     | 33                             | IN                 | I <sup>2</sup> C clock input                                  |
| CVBS                    | 44                             | CURRENT            | Composite video output                                        |
| Y                       | 48                             | CURRENT            | Luminance analog output                                       |
| C                       | 47                             | CURRENT            | Chrominance analog output                                     |
| R                       | 39                             | CURRENT            | Red analog output                                             |
| G                       | 40                             | CURRENT            | Green analog output                                           |
| B                       | 43                             | CURRENT            | Blue analog output                                            |
| VREF                    | 38                             | I/O                | Internal voltage reference output or external reference input |
| ISET                    | 37                             | CURRENT            | DAC current set                                               |
| TTXDAT                  | 30                             | IN                 | Teletext data input                                           |
| TTXRQ                   | 31                             | OUT                | Teletext request output                                       |
| INT                     | 12                             | OUT                | Interrupt output, active high                                 |
| RESET                   | 34                             | IN                 | Active low master RESET                                       |
| TEST                    | 13                             | IN                 | TEST pin. Ground for normal operation                         |
| VAA                     | 36, 41, 46                     | PS                 | + 5 V or + 3.3 V supply (must be same as VDD)                 |
| GNDD                    | 18                             | PS                 | Ground                                                        |
| VDD                     | 17                             | PS                 | +5 V or 3.3 V supply (must be same as VAA)                    |
| GNDA                    | 35, 42, 45                     | PS                 | Ground                                                        |

**Table 10.** Device Pin Descriptions

NOTE: 1. The FIELD pin (pin 9) remains an output pin in SLAVE mode. However, the FIELD pin state does not toggle in SLAVE mode and its output state should be considered random.

## 11. PACKAGE DRAWING

### 48L TQFP PACKAGE DRAWING



| DIM      | INCHES |        | MILLIMETERS |       |
|----------|--------|--------|-------------|-------|
|          | MIN    | MAX    | MIN         | MAX   |
| A        | ---    | 0.063  | ---         | 1.60  |
| A1       | 0.002  | 0.006  | 0.05        | 0.15  |
| B        | 0.007  | 0.011  | 0.17        | 0.27  |
| D        | 0.343  | 0.366  | 8.70        | 9.30  |
| D1       | 0.272  | 0.280  | 6.90        | 7.10  |
| E        | 0.343  | 0.366  | 8.70        | 9.30  |
| E1       | 0.272  | 0.280  | 6.90        | 7.10  |
| e*       | 0.016  | 0.024  | 0.40        | 0.60  |
| L        | 0.018  | 0.030  | 0.45        | 0.75  |
| $\infty$ | 0.000° | 7.000° | 0.00°       | 7.00° |

\* Nominal pin pitch is 0.50 mm

Controlling dimension is mm.

JEDEC Designation: MS026

## 12. REVISION HISTORY

| Revision | Date           | Change                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| F1       | July 1999      | Initial release                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| F2       | April 2004     | Corrected List of Figures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| F3       | September 2004 | Added lead free package option (CS4955).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| F4       | August 2005    | Updated ordering information. Added lead-free package for CS4954; deleted CQ packages; updated Revision History and Legal notice.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| F5       | July 2006      | <ul style="list-style-type: none"> <li>- Changed operating temperature range in “<a href="#">Description</a>” on <a href="#">page 1</a> to -40 to 85° C</li> <li>- Changed operating temperature range in “<a href="#">RECOMMENDED Operating Conditions</a>” on <a href="#">page 6</a></li> <li>- Changed operating temperature range in “<a href="#">Ordering Information</a>” on <a href="#">page 2</a>.</li> <li>- Changed Allowable Junction Temperature specification and added note to “<a href="#">Thermal Characteristics</a>” on <a href="#">page 6</a></li> <li>- Revised description in “<a href="#">Progressive Scan</a>” on <a href="#">page 18</a>.</li> <li>- Revised descriptions in “<a href="#">Luminance DAC</a>” on <a href="#">page 32</a>, “<a href="#">Chrominance DAC</a>” on <a href="#">page 33</a>, “<a href="#">CVBS DAC</a>” on <a href="#">page 33</a>, “<a href="#">Red DAC</a>” on <a href="#">page 33</a>, “<a href="#">Green DAC</a>” on <a href="#">page 33</a> and “<a href="#">Blue DAC</a>” on <a href="#">page 33</a>.</li> <li>- Added “<a href="#">DAC Usage Rules</a>” on <a href="#">page 34</a> and revised text in that section.</li> <li>- Revised bit 3 “Function” description for “<a href="#">Control Register 0</a>” on <a href="#">page 38</a>.</li> <li>- Revised “Function” descriptions for “<a href="#">Control Register 5</a>” on <a href="#">page 42</a>.</li> <li>- Added note to clarify DAC loading to <a href="#">Figure 31</a> on <a href="#">page 55</a>.</li> <li>- Revised text throughout the document to correct content and grammar.</li> </ul> |
| F6       | September 2006 | <p>Added “This port can operate in standard (up to 100 kb/sec) or fast (up to 400 kb/sec) modes” in Section 4.10 on page 14.</p> <p>Updated SCL Frequency values in Timing Characteristics table on page 9.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

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## Contacting Cirrus Logic Support

For all product questions and inquiries contact a Cirrus Logic Sales Representative.

To find the one nearest to you go to [www.cirrus.com](http://www.cirrus.com)

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