



## GS2984 Adaptive Cable Equalizer

### Key Features

- SMPTE 424M, SMPTE 292M and SMPTE 259M compliant
- Automatic cable equalization
- Multi-standard operation from 143Mb/s to 2.97Gb/s
- Performance optimized for 270Mb/s, 1.485Gb/s and 2.97Gb/s. Typical equalized length of Belden 1694A cable:
  - ◆ 140m at 2.97Gb/s
  - ◆ 200m at 1.485Gb/s
  - ◆ 400m at 270Mb/s
- Supports DVB-ASI at 270Mb/s
- Manual bypass (useful for low data rates with slow rise/fall times)
- Programmable carrier detect with squelch threshold adjustment
- Differential outputs support DC coupling to 3.3V and 2.5V CML logic
- 0/6 dB gain boost selection pin
- Standard EIA/JEDEC logic control and status signal levels
- Single 3.3V power supply operation
- 195mW power consumption (typical)
- Wide temperature range of -40°C to +85°C
- Small footprint QFN package (4mm x 4mm)
  - ◆ Drop-in compatible with the GS2974
- Pb-free and RoHS compliant

### Applications

- SMPTE 424M, SMPTE 292M and SMPTE 259M coaxial cable serial digital interfaces

### Description

The GS2984 is a high-speed BiCMOS integrated circuit designed to equalize and restore signals received over 75Ω coaxial cable.

The device is designed to support SMPTE 424M, SMPTE292M and SMPTE 259M, and is optimized for performance at 270Mb/s, 1.485Gb/s and 2.97Gb/s.

The GS2984 features DC restoration to compensate for the DC content of SMPTE pathological test patterns.

The Carrier Detect output pin ( $\overline{CD}$ ) indicates whether a valid input signal has been detected. It can be connected directly to the MUTE pin to mute the output on loss of carrier. A voltage programmable threshold, which can be changed via the SQ\_ADJ pin, forces  $\overline{CD}$  high when the input signal amplitude falls below the threshold. This allows the GS2984 to distinguish between low-amplitude SDI signals and noise at the input of the device.

The equalizing and DC restore stages are disengaged when the BYPASS pin is HIGH. No equalization occurs in Bypass mode.

The GS2984 includes a gain selection pin (GAIN\_SEL) which, when tied HIGH, compensates for 6dB flat attenuation.

The differential outputs can be DC-coupled to Gennum 3.3V cable drivers and reclockers and to industry-standard 3.3V and 2.5V CML logic using the CMSET pin.

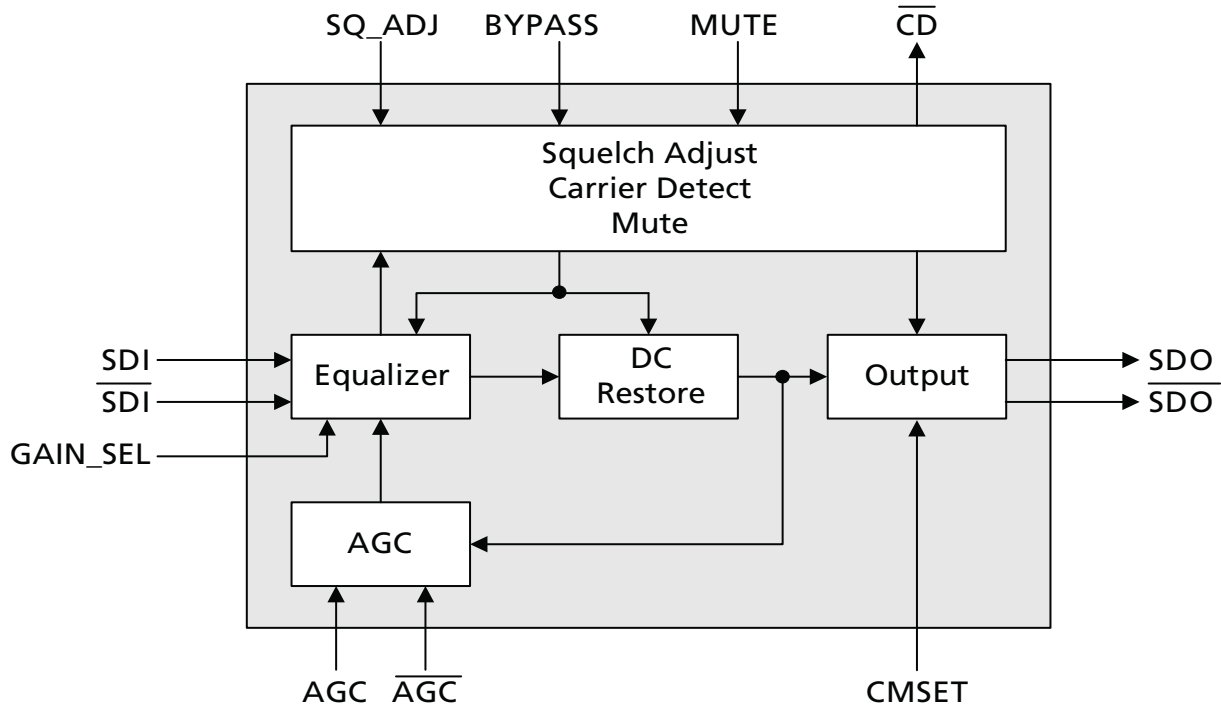
The GS2984 is footprint and drop-in compatible with existing GS2974 designs, with no additional application changes required.

The device is available in a 16-pin, 4mm x 4mm QFN package.

Power consumption of the GS2984 is typically 195mW.

The GS2984 is Pb-free, and the encapsulation compound does not contain halogenated flame retardant.

This component and all homogeneous subcomponents are RoHS compliant.



GS2984 Functional Block Diagram

## Revision History

| Version | ECR    | PCN   | Date           | Changes and/or Modifications   |
|---------|--------|-------|----------------|--|
| 3       | 153913 | 54547 | March 2010     | Changed ESD rating from 6kV to 5kV in <a href="#">Section 2.1 Absolute Maximum Ratings</a> .   |
| 2       | 152311 | -     | July 2009      | Converted to Data Sheet.   |
| 1       | 152027 | -     | June 2009      | Removed 'Proprietary & Confidential' from footer. Updated <a href="#">6.4 Marking Diagram</a> .  |
| 0       | 151621 | -     | April 2009     | Converted to Preliminary Data Sheet. Added sections <a href="#">2.4 Typical Performance Curves</a> and <a href="#">4.8 Output Rise/Fall Times</a> . Updates to section 2. <a href="#">Electrical Characteristics</a> . |
| B       | 151182 | -     | January 2009   | Updates.   |
| A       | 150385 | -     | September 2008 | New document.  |

# Contents

|  |    |
|--|----|
| Key Features .....                             | 1  |
| Applications.....                              | 1  |
| Description.....                               | 1  |
| Revision History .....                         | 2  |
| 1. Pin Out.....                                | 4  |
| 1.1 GS2984 Pin Assignment .....                | 4  |
| 1.2 GS2984 Pin Descriptions .....              | 4  |
| 2. Electrical Characteristics .....            | 6  |
| 2.1 Absolute Maximum Ratings .....             | 6  |
| 2.2 DC Electrical Characteristics .....        | 6  |
| 2.3 AC Electrical Characteristics .....        | 7  |
| 2.4 Typical Performance Curves .....           | 8  |
| 3. Input/Output Circuits .....                 | 9  |
| 4. Detailed Description.....                   | 10 |
| 4.1 Serial Digital Inputs .....                | 10 |
| 4.2 Cable Equalization .....                   | 11 |
| 4.3 Serial Digital Outputs .....               | 11 |
| 4.4 Programmable Squelch Adjust (SQ_ADJ) ..... | 12 |
| 4.5 Mute and Carrier Detect .....              | 12 |
| 4.6 GAIN_SEL .....                             | 13 |
| 4.7 CMSET Operation .....                      | 13 |
| 4.8 Output Rise/Fall Times .....               | 14 |
| 5. Application Information .....               | 15 |
| 5.1 High Gain Adaptive Cable Equalizers .....  | 15 |
| 5.2 PCB Layout .....                           | 15 |
| 5.3 Typical Application Circuit .....          | 16 |
| 6. Package & Ordering Information .....        | 17 |
| 6.1 Package Dimensions .....                   | 17 |
| 6.2 Packaging Data .....                       | 17 |
| 6.3 Recommended PCB Footprint .....            | 18 |
| 6.4 Marking Diagram .....                      | 18 |
| 6.5 Solder Reflow Profiles .....               | 19 |
| 6.6 Ordering Information .....                 | 19 |

# 1. Pin Out

## 1.1 GS2984 Pin Assignment

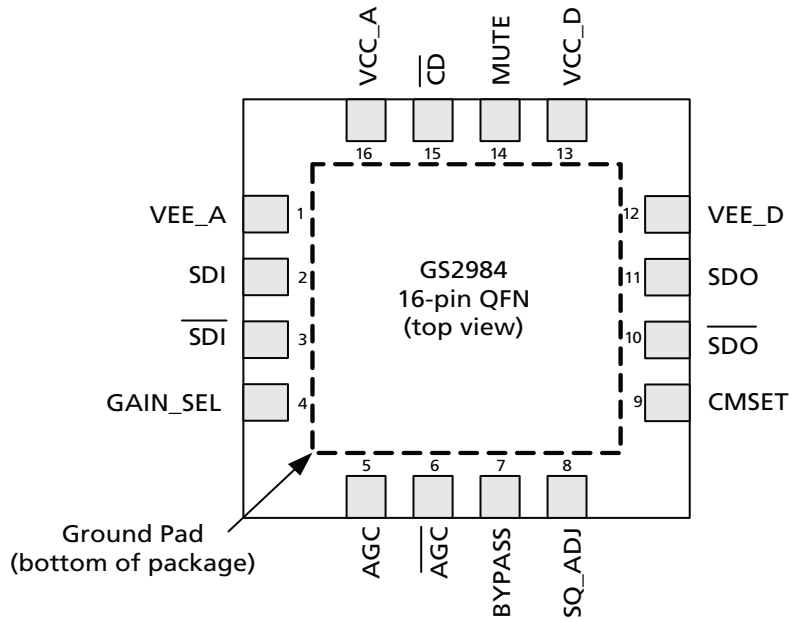


Figure 1-1: GS2984 Pin Out

## 1.2 GS2984 Pin Descriptions

Table 1-1: GS2984 Pin Descriptions

| Pin Number | Name                         | Timing          | Type  | Description   |
|------------|------------------------------|-----------------|-------|---|
| 1          | VEE_A                        | Analog          | Power | Most negative power supply for analog circuitry. Connect to GND.  |
| 2, 3       | SDI, $\overline{\text{SDI}}$ | Analog          | Input | Serial digital differential input.  |
| 4          | GAIN_SEL                     | Not Synchronous | Input | CONTROL SIGNAL INPUT levels are LVCMOS/LVTTL compatible. (3.3V tolerant) Controls flat band gain. See <a href="#">Section 4.6</a> . (Internal pull-down). |
| 5, 6       | AGC, $\overline{\text{AGC}}$ | Analog          | –     | External AGC capacitor. Connect pin 5 and pin 6 together as shown in the <a href="#">Typical Application Circuit on page 16</a> .                         |
| 7          | BYPASS                       | Not Synchronous | Input | Forces the Equalizing and DC RESTORE stages into bypass mode when HIGH. No equalization occurs in this mode. (Internal pull-down).                        |

**Table 1-1: GS2984 Pin Descriptions (Continued)**

| Pin Number | Name                   | Timing          | Type   | Description   |
|------------|------------------------|-----------------|--------|---|
| 8          | SQ_ADJ                 | Analog          | Input  | Squelch Adjust.<br>Adjusts the approximate amount of cable equalized before $\overline{CD}$ goes low. See <a href="#">Section 4.4</a> and <a href="#">Section 4.5</a> . (Internal pull-down).     |
| 9          | CMSET                  | Not Synchronous | Input  | CONTROL SIGNAL INPUT<br>levels are LVCMOS/LVTTL compatible. (3.3V Tolerant)<br>Controls output common mode level. (Internal pull-down).<br>See <a href="#">Section 4.7</a> .                      |
| 10, 11     | $\overline{SDO}$ , SDO | Analog          | Output | Equalized serial digital differential output.   |
| 12         | VEE_D                  | Analog          | Power  | Most negative power supply for the digital circuitry and output buffer.<br>Connect to GND.  |
| 13         | VCC_D                  | Analog          | Power  | Most positive power supply for the digital I/O pins of the device.<br>Connect to +3.3V DC.  |
| 14         | MUTE                   | Not Synchronous | Input  | CONTROL SIGNAL INPUT<br>levels are LVCMOS/LVTTL compatible. (3.3V Tolerant)<br>Controls output behaviour on SDO and $\overline{SDO}$ . (Internal pull-down).<br>See <a href="#">Section 4.5</a> . |
| 15         | $\overline{CD}$        | Not Synchronous | Output | STATUS SIGNAL OUTPUT<br>Signal levels are LVCMOS/LVTTL compatible.<br>Indicates the presence of an input signal.<br>See <a href="#">Section 4.5</a> .   |
| 16         | VCC_A                  | Analog          | Power  | Most positive power supply for the analog circuitry of the device.<br>Connect to +3.3V DC.  |
| –          | Center Pad             | –               | Power  | Internally bonded to VEE_A.   |

## 2. Electrical Characteristics

### 2.1 Absolute Maximum Ratings

| Parameter                       | Value                           |
|---------------------------------|---------------------------------|
| Supply Voltage                  | -0.5V to +3.6V DC               |
| Input ESD Voltage (HBM)         | 5kV                             |
| Storage Temperature Range       | -50°C < T <sub>s</sub> < 125°C  |
| Input Voltage Range (any input) | -0.3 to (V <sub>CC</sub> +0.3)V |
| Operating Temperature Range     | -20°C to +85°C                  |
| Functional Temperature Range    | -40°C to +85°C                  |
| Solder Reflow Temperature       | 260°C                           |

### 2.2 DC Electrical Characteristics

**Table 2-1: DC Electrical Characteristics**

V<sub>CC</sub> = 3.3V ±5%, T<sub>A</sub> = -20°C to +85°C, unless otherwise shown

| Parameter  | Symbol              | Conditions                | Min   | Typ                                       | Max   | Units | Notes |
|--|---------------------|---------------------------|-------|---|-------|-------|-------|
| Supply Voltage                                       | V <sub>CC</sub>     | –                         | 3.135 | 3.3                                       | 3.465 | V     | –     |
| Power Consumption                                    | P <sub>D</sub>      | T <sub>A</sub> = 25°C     | –     | 195                                       | 250   | mW    | –     |
| Supply Current                                       | I <sub>s</sub>      | T <sub>A</sub> = 25°C     | –     | 59  | –     | mA    | –     |
| Output Common Mode Voltage                           | V <sub>CMOUT</sub>  | T <sub>A</sub> = 25°C     | –     | V <sub>CMSET</sub> - ΔV <sub>SDO</sub> /2 | –     | V     | 1     |
| Input Common Mode Voltage                            | V <sub>CMIN</sub>   | T <sub>A</sub> = 25°C     | –     | 1.8                                       | –     | V     | –     |
| SQ_ADJ DC Voltage (to mute signal)                   | –                   | 0m, T <sub>A</sub> = 25°C | –     | 3.2                                       | –     | V     | –     |
| SQ_ADJ Range   | –                   | T <sub>A</sub> = 25°C     | –     | 0.9                                       | –     | V     | –     |
| CD Output Voltage                                    | V <sub>CD(OH)</sub> | Carrier not present       | 2.4   | –   | –     | V     | –     |
|  | V <sub>CD(OL)</sub> | Carrier present           | –     | –   | 0.4   | V     | –     |
| Mute Input Voltage Required to Force Outputs to Mute | V <sub>Mute</sub>   | Min to Mute               | 2.0   | –   | –     | V     | –     |
| Mute Input Voltage Required to Force Outputs Active  | V <sub>Mute</sub>   | Max to Activate           | –     | –   | 0.8   | V     | –     |

**NOTES:**

1. V<sub>CMSET</sub> is the voltage determined by the setting of the CM\_SET pin. It will be either 3.3V or 2.5V

## 2.3 AC Electrical Characteristics

**Table 2-2: AC Electrical Characteristics**

$V_{CC} = 3.3V \pm 5\%$ ,  $T_A = -20^\circ C$  to  $+85^\circ C$ , unless otherwise shown

| Parameter   | Symbol           | Conditions  | Min | Typ | Max  | Units             | Notes |
|---|------------------|---|-----|-----|------|-------------------|-------|
| Serial input data rate                                      | $DR_{SDO}$       | –   | 143 | –   | 2970 | Mb/s              | –     |
| Input Voltage Swing   | $\Delta V_{SDI}$ | $T_A = 25^\circ C$ , differential,<br>270Mb/s and 1.485Gb/s | 720 | 800 | 950  | mV <sub>p-p</sub> | 1     |
|   |                  | $T_A = 25^\circ C$ , differential,<br>2.97Gb/s              | 720 | 800 | 880  | mV <sub>p-p</sub> | 1     |
| Output Voltage Swing  | $\Delta V_{SDO}$ | 100 $\Omega$ load, $T_A = 25^\circ C$ ,<br>differential     | 680 | 800 | 900  | mV <sub>p-p</sub> | –     |
| Output Jitter of Various<br>Cable Lengths and Data<br>Rates | –                | 2.97Gb/s<br>Belden 1694A: 0-120m                            | –   | –   | 0.25 | UI                | 2, 5  |
|   | –                | 2.97Gb/s<br>Belden 1694A: 120-140m                          | –   | 0.3 | –    | UI                | 3, 5  |
|   | –                | 1.485Gb/s<br>Belden 1694A: 0-160m                           | –   | –   | 0.25 | UI                | 2, 5  |
|   | –                | 1.485Gb/s<br>Belden 1694A: 160-200m                         | –   | 0.2 | –    | UI                | 3, 5  |
|   | –                | 270Mb/s<br>Belden 1694A: 0-400m                             | –   | –   | 0.2  | UI                | 2, 5  |
| Output Rise/Fall time                                       | –                | 2.97Gb/s & 1.485Gb/s<br>20% - 80%                           | 35  | 65  | 90   | ps                | –     |
|   | –                | 270Mb/s (see <a href="#">Section 4.8</a> )                  | –   | –   | –    | –                 | –     |
| Mismatch in rise/fall time                                  | –                | –   | –   | –   | 30   | ps                | –     |
| Duty cycle distortion                                       | –                | –   | –   | –   | 30   | ps                | –     |
| Overshoot   | –                | –   | –   | –   | 10   | %                 | –     |
| Input Return Loss   | –                | –   | 15  | 21  | –    | dB                | 4     |
| Input Resistance  | –                | single ended  | –   | 1.9 | –    | k $\Omega$        | –     |
| Input Capacitance   | –                | single ended  | –   | 1.3 | –    | pF                | –     |
| Output Resistance   | –                | single ended  | –   | 50  | –    | $\Omega$          | –     |

**NOTES:**

- 0m cable length.
- All parts are production tested. In order to guarantee jitter over the full range of specification ( $V_{CC} = 3.3V \pm 5\%$ ,  $T_A = -20^\circ C$  to  $+85^\circ C$ , and 720-880mV launch swing from the SDI cable driver) the recommended applications circuit must be used.
- Based on characterization data using the recommended applications circuit, at  $V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$  and 800mV launch swing from the SDI cable driver.
- Tested on a 2984 board from 5MHz to 3GHz.
- CM\_SET = 0, GAIN\_SEL = 0

## 2.4 Typical Performance Curves

VCC=3.3V, room temperature, 800mV launch swing

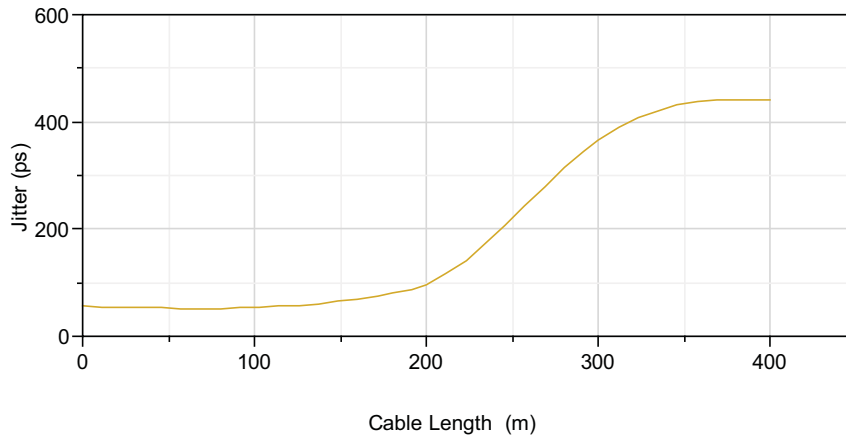


Figure 2-1: Jitter vs. Cable Length (270 Mb/s)

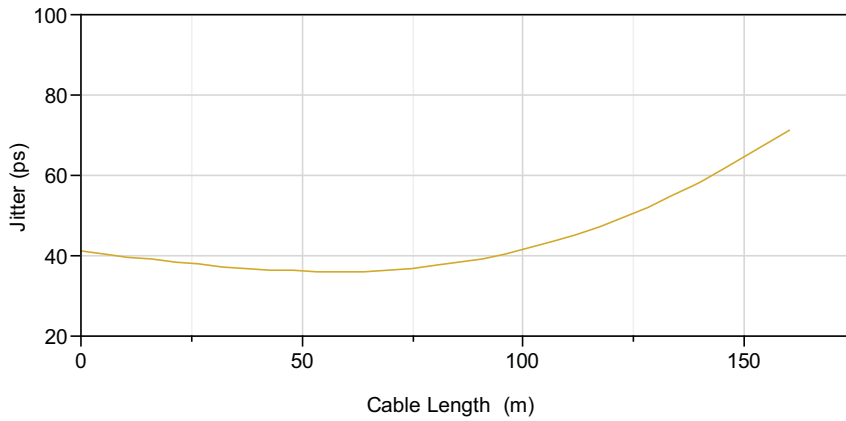


Figure 2-2: Jitter vs. Cable Length (1485 Mb/s)

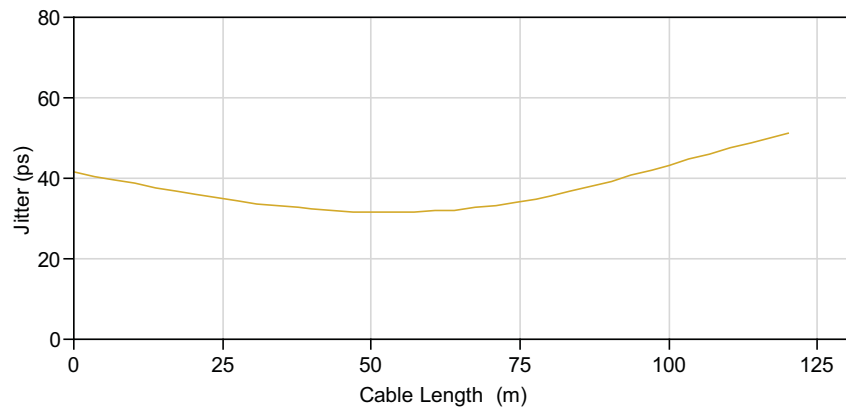


Figure 2-3: Jitter vs. Cable Length (2970 Mb/s)



# 3. Input/Output Circuits

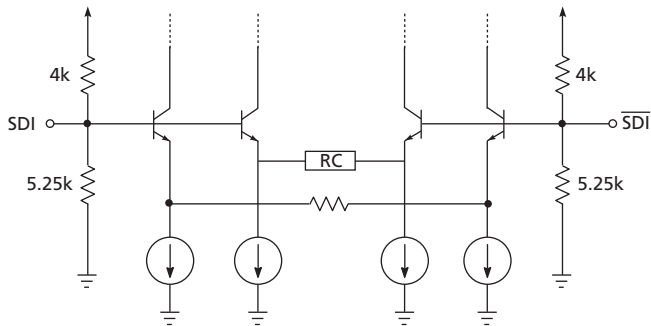


Figure 3-1: Input Equivalent Circuit

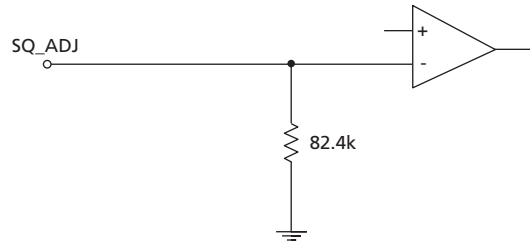


Figure 3-2: SQ\_ADJ Equivalent Circuit

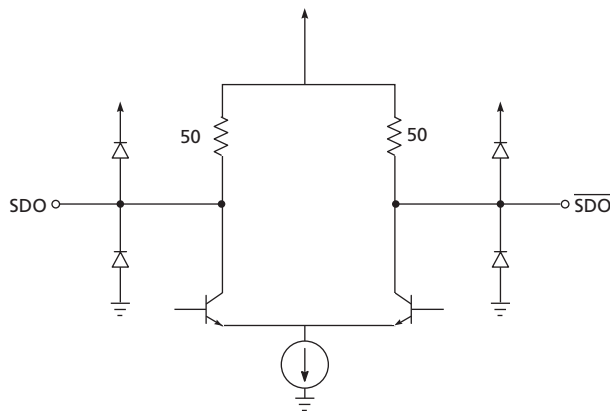


Figure 3-3: Output Circuit

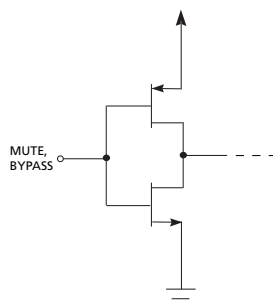


Figure 3-4: MUTE and BYPASS Circuits

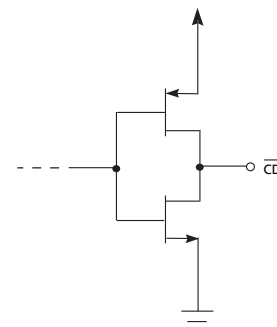


Figure 3-5:  $\overline{CD}$  Circuit

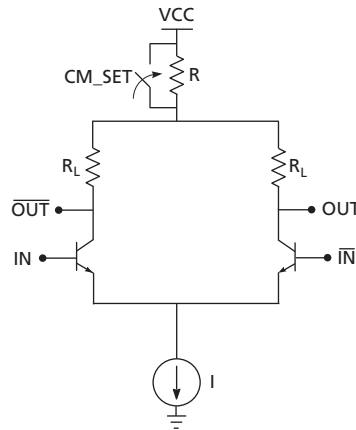


Figure 3-6: CM\_SET

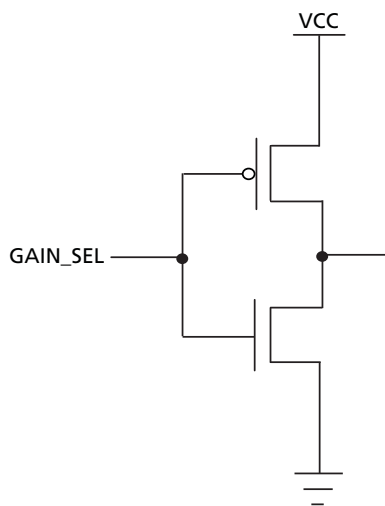


Figure 3-7: GAIN\_SEL

## 4. Detailed Description

The GS2984 is a high-speed BiCMOS IC designed to equalize serial digital signals.

The GS2984 can equalize 3Gb/s, HD and SD serial digital signals, and will typically equalize 140m of Belden 1694A cable at 2.97Gb/s, 200m at 1.485Gb/s and 400m at 270Mb/s. The GS2984 is powered from a single +3.3V power supply and consumes approximately 195mW of power.

### 4.1 Serial Digital Inputs

The Serial Data Signal may be connected to the input pins ( $\overline{\text{SDI}}/\overline{\text{SDI}}$ ) in either a differential or single ended configuration. AC coupling of the inputs is recommended, as the  $\overline{\text{SDI}}$  and  $\overline{\text{SDI}}$  inputs are internally biased at approximately 1.8V.

## 4.2 Cable Equalization

The input signal passes through a variable gain equalizing stage, whose frequency response closely matches the inverse of the cable loss characteristic. In addition, the variation of the frequency response with control voltage imitates the variation of the inverse cable loss characteristic with cable length.

The edge energy of the equalized signal is monitored by a detector circuit which produces an error signal corresponding to the difference between the desired edge energy and the actual edge energy. This error signal is integrated by both an internal and an external AGC filter capacitor providing a steady control voltage for the gain stage. As the frequency response of the gain stage is automatically varied by the application of negative feedback, the edge energy of the equalized signal is kept at a constant level which is representative of the original edge energy at the transmitter. The equalized signal is also DC restored, effectively restoring the logic threshold of the equalized signal to its correct level independent of shifts due to AC coupling.

## 4.3 Serial Digital Outputs

The digital output signals have a nominal voltage of  $800\text{mV}_{\text{pp}}$  differential, or  $400\text{mV}_{\text{pp}}$  single-ended when terminated with  $50\Omega$  as shown in Figure 4-1.

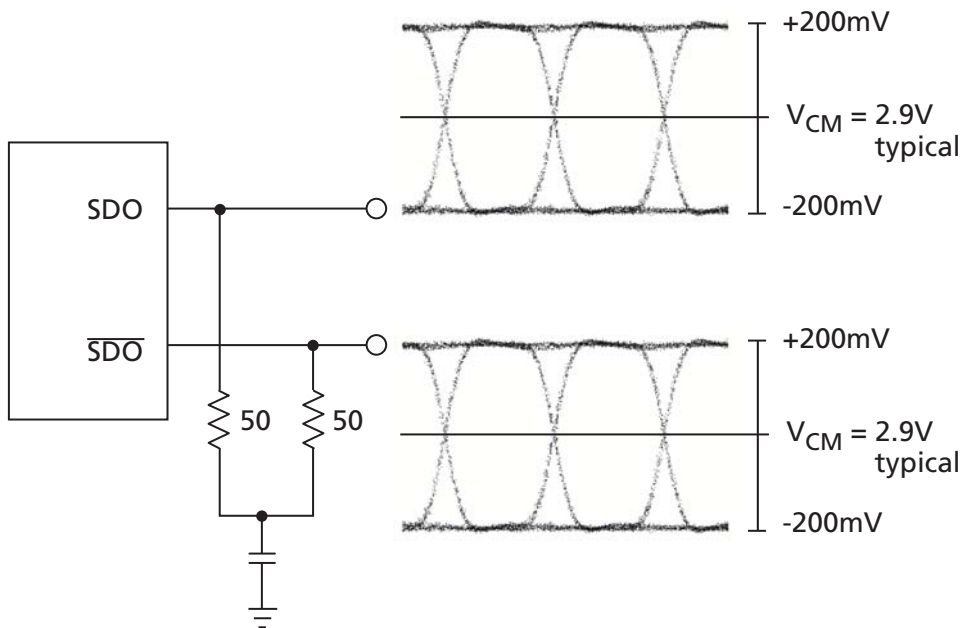


Figure 4-1: Typical Output Voltage Levels (for 3.3V Common Mode)

## 4.4 Programmable Squelch Adjust (SQ\_ADJ)

The GS2984 incorporates a programmable Squelch Adjust (SQ\_ADJ) threshold.

This feature can be useful in applications where there are multiple input channels using the GS2984 and the maximum gain can be limited to avoid crosstalk.

The SQ\_ADJ pin acts to change the threshold of the Carrier Detect ( $\overline{CD}$ ) pin, through voltage level variances. When the input signal drops below a certain threshold, the  $\overline{CD}$  pin will be driven high, indicating that there is not a valid input signal. In order to enable automatic muting of the output of the GS2984, the  $\overline{CD}$  pin should be connected directly to the MUTE pin. In applications where programmable squelch adjust is not required, the SQ\_ADJ pin may be left unconnected. Figure 4-2 shows the relationship between the SQ\_ADJ voltage and cable length at which  $\overline{CD}$  will assert or deassert.

This feature has been designed for use in applications such as routers, where signal crosstalk and circuit noise cause the Equalizer to output erroneous data when no input signal is present. The use of a Carrier Detect function with a fixed internal reference does not solve this problem, since the signal to noise ratio on the circuit board could be significantly less than the default signal detection level set by the on chip reference.

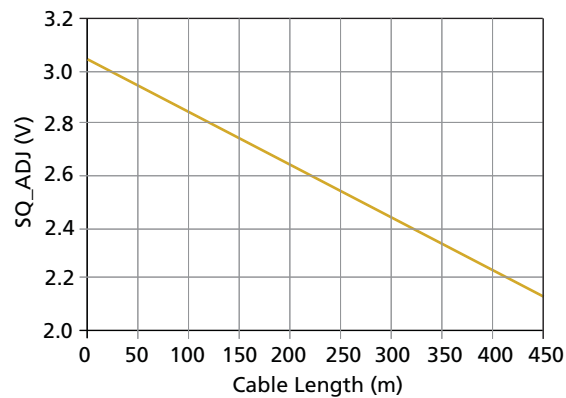


Figure 4-2: SQ\_ADJ vs. Cable Length (VCC=3.3V, room temperature, 800mV launch swing)

## 4.5 Mute and Carrier Detect

The GS2984 includes a MUTE input pin that allows the application interface to mute the Serial Digital Output at any time. Set the MUTE pin HIGH to mute SDO and  $\overline{SDO}$ . In this case, the outputs will mute regardless of the setting of the BYPASS pin.

A Carrier Detect output pin ( $\overline{CD}$ ) indicates the presence of a valid signal at the input of the GS2984. When  $\overline{CD}$  is LOW, the device has detected a valid input on SDI and  $\overline{SDI}$ . When  $\overline{CD}$  is HIGH, the device has not detected a valid input.

**NOTE 1:**  $\overline{CD}$  will only detect loss of carrier for data rates greater than 19Mb/s. The  $\overline{CD}$  output pin may be connected directly to the MUTE input pin to enable automatic muting of the GS2984 when no valid input signal has been detected.

**NOTE 2:** If the maximum cable length is exceeded (set by the SQ\_ADJ pin) and the device is not in Bypass mode, the  $\overline{CD}$  pin will not be driven low, even if a carrier is present.

**Table 4-1: Mute Input Table**

| Mute | Function   |
|------|--|
| 0    | SDO and $\overline{SDO}$ operate normally                                  |
| 1    | SDO and $\overline{SDO}$ are forced to a steady state (either high or low) |

**Table 4-2:  $\overline{CD}$  Output Table**

| $\overline{CD}$ | Input Status                              |
|-----------------|---|
| 0               | Valid Input on SDI, $\overline{SDI}$ pins |
| 1               | Input is not valid                        |

## 4.6 GAIN\_SEL

The GS2984 has an option of compensating for 6dB of flat attenuation in applications where there has been some type of attenuation prior to the equalizer.

**Table 4-3: GAIN\_SEL Input Table**

| GAIN_SEL | Function  |
|----------|---|
| 0        | No flat band gain is applied                                  |
| 1        | 6dB of flat attenuation will be compensated by the equalizer. |

## 4.7 CMSET Operation

The GS2984 has a selectable output common mode level. This is useful when interfacing to chips that can accept 2.5V input common mode levels. In these cases, AC coupling can be avoided by selecting the correct output common mode.

**Table 4-4: CMSET Output Table**

| CMSET | Output Common Mode Voltage Level                        |
|-------|---|
| 0     | The output common mode will be compatible with 3.3V CML |
| 1     | The output common mode will be compatible with 2.5V CML |

**NOTE:** See [Section 2.2](#) for Output Common Mode Voltage specification.

## 4.8 Output Rise/Fall Times

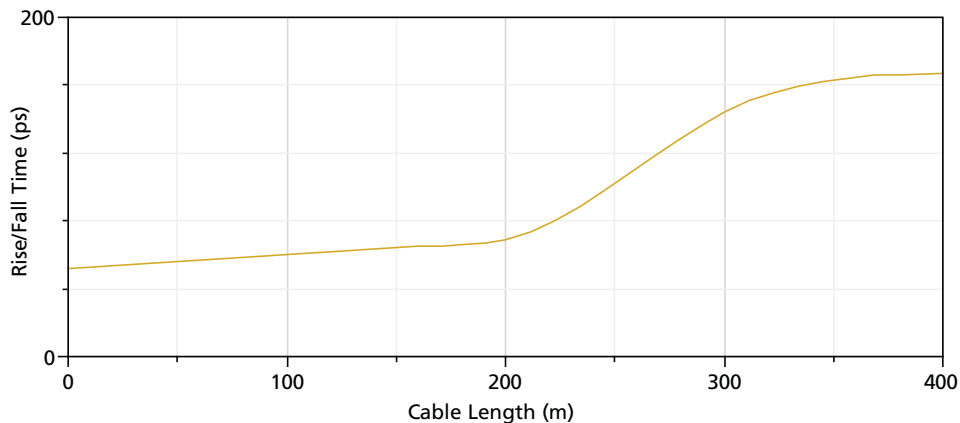


Figure 4-3: Typical Rise/Fall time for 270Mb/s data rate (VCC=3.3V, room temperature, 800mV launch swing)

The GS2984 was designed to limit bandwidth as cable length is increased. During normal 3G (2.97Gb/s), HD (1.485Gb/s), and SD (270Mb/s) operation, the impact of this is minimal on rise and fall time over the operating range from 0-200m. Above 200m, this bandwidth limitation becomes more significant, and reduction in rise and fall time is observed. This means that for SD (270Mb/s) operation at cable lengths greater than 200m, rise and fall times slow as shown in [Figure 4-3](#) above. This is beneficial because at 270Mb/s, one unit interval is equal to 3.7ns, therefore rise and fall times less than 100ps are not required, and slower rise and fall times actually help to reduce EMI.

# 5. Application Information

## 5.1 High Gain Adaptive Cable Equalizers

The GS2984 is Gennum's latest multi-rate adaptive cable equalizer. In order to continue to extend the cable length that an equalizer will remain operational over, it is necessary to have high gain in the equalizer.

A video cable equalizer must provide wide band gain over a range of frequencies in order to accommodate the range of data rates and signal patterns that are present in a SMPTE compliant serial video stream.

The GS2984 has an increase in gain over the GS2974A at critical HD and 3Gbps frequencies, and because of this, the GS2984 may be sensitive to signals at the input that the GS2974A will not be sensitive to.

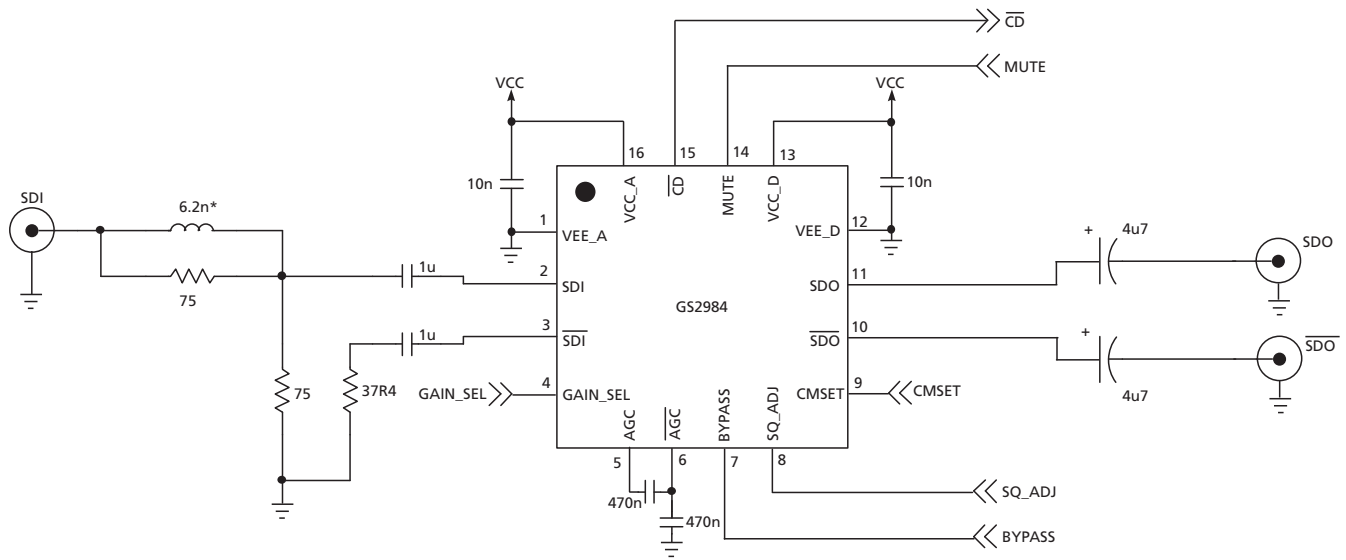
Small levels of signal or noise present at the input pins of the Equalizer may cause chatter at the output. In order to prevent this from happening, particular attention must be paid to board layout.

## 5.2 PCB Layout

Special attention must be paid to component layout when designing Serial Digital Interfaces for HDTV. An FR-4 dielectric can be used, however, controlled impedance transmission lines are required for PCB traces longer than approximately 1cm. Note the following PCB artwork features used to optimize performance:

- PCB trace width for 3Gb/s rate signals is closely matched to SMT component width to minimize reflections due to change in trace impedance.
- The PCB ground plane is removed under the GS2984 input components to minimize parasitic capacitance.
- The PCB ground plane is removed under the GS2984 output components to minimize parasitic capacitance.
- High speed traces are curved to minimize impedance changes.

## 5.3 Typical Application Circuit



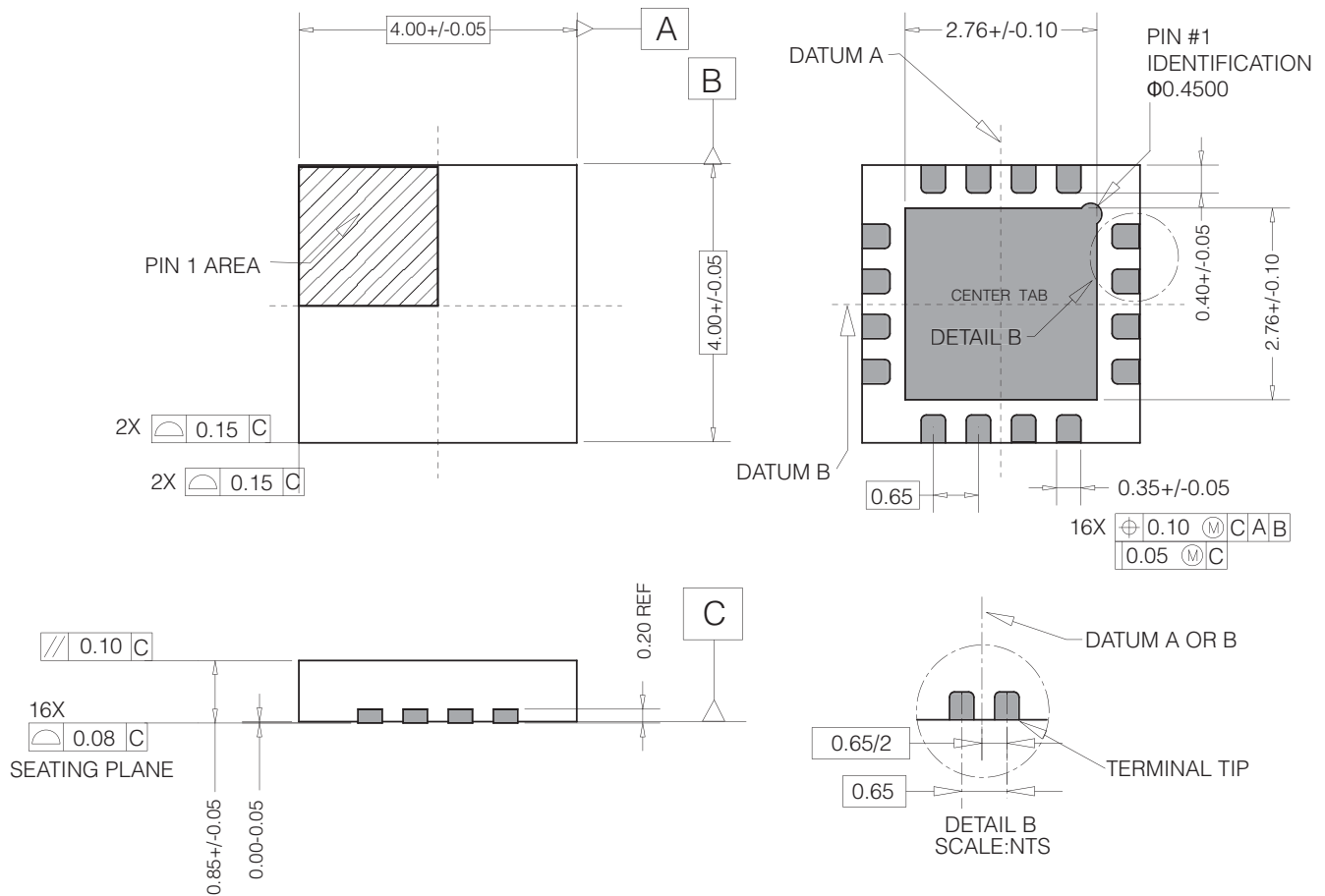
NOTE: All resistors in Ohms, capacitors in Farads, and inductors in Henrys, unless otherwise noted.  
\* Value dependent on layout

Figure 5-1: GS2984 Typical Application Circuit



# 6. Package & Ordering Information

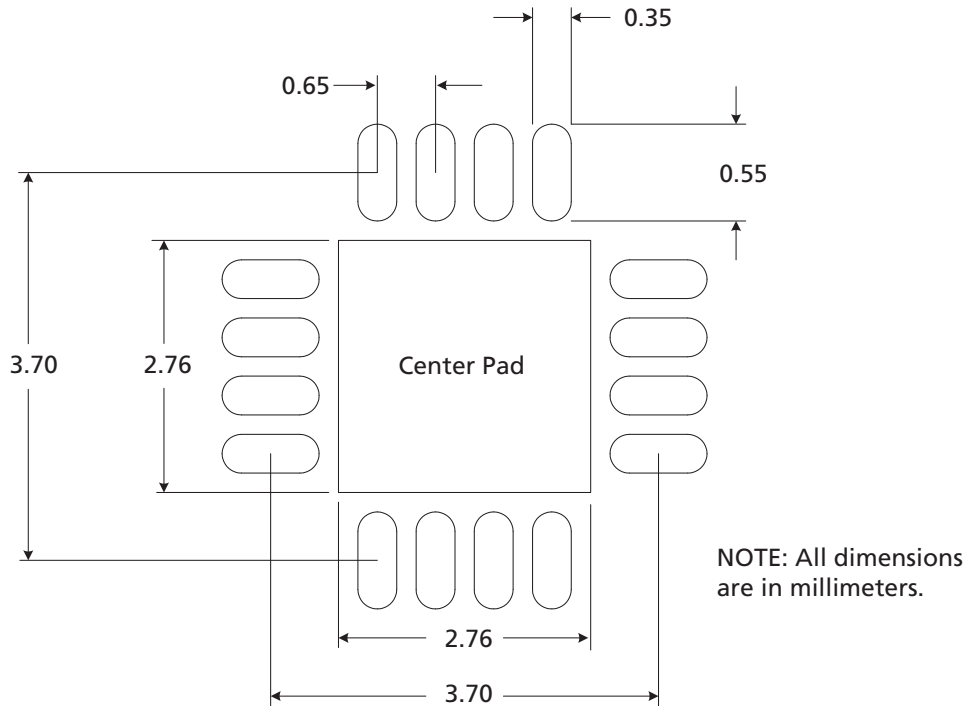
## 6.1 Package Dimensions



## 6.2 Packaging Data

| Parameter  | Value                    |
|--|--------------------------|
| Package Type   | 4mm x 4mm 16-pin QFN     |
| Package Drawing Reference  | JEDEC M0220              |
| Moisture Sensitivity Level   | 3                        |
| Junction to Case Thermal Resistance, $\theta_{j-c}$                  | $31.0^{\circ}\text{C/W}$ |
| Junction to Air Thermal Resistance, $\theta_{j-a}$ (at zero airflow) | $43.8^{\circ}\text{C/W}$ |
| Psi, $\psi$  | $11.0^{\circ}\text{C/W}$ |
| Pb-free and RoHS compliant   | Yes                      |

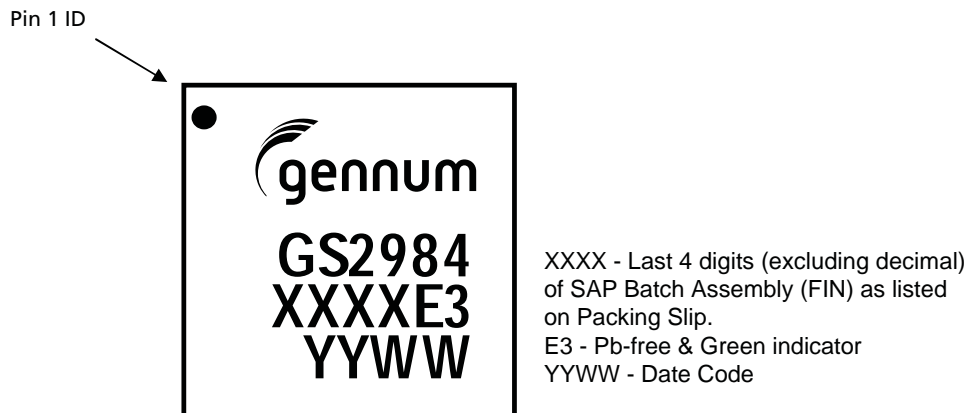
## 6.3 Recommended PCB Footprint



The Center Pad should be connected to the most negative power supply plane for analog circuitry in the device (VEE\_A) by a minimum of 5 vias.

NOTE: Suggested dimensions only. Final dimensions should conform to customer design rules and process optimizations.

## 6.4 Marking Diagram



## 6.5 Solder Reflow Profiles

The GS2984 is available in a Pb-free package. It is recommended that the Pb-free package be soldered with Pb-free paste using the reflow profile shown in Figure 6-1.

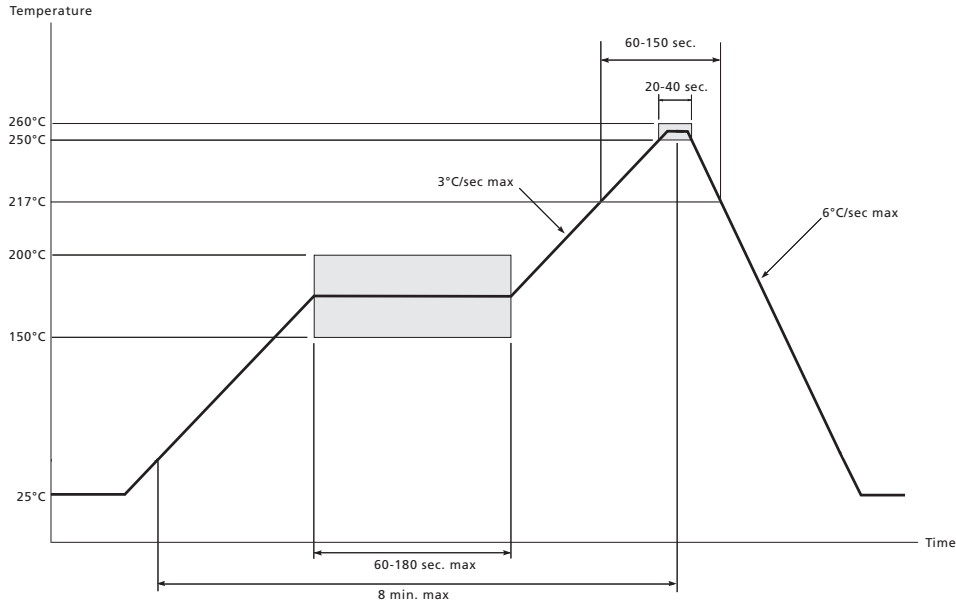


Figure 6-1: Maximum Pb-free Solder Reflow Profile

## 6.6 Ordering Information

|        | Part Number   | Package                          | Temperature Range |
|--------|---------------|----------------------------------|-------------------|
| GS2984 | GS2984-INE3   | 16-pin QFN                       | -40°C to 85°C     |
| GS2984 | GS2984-INTE3  | 16-pin QFN Tape & Reel (250pcs)  | -40°C to 85°C     |
| GS2984 | GS2984-INTE3Z | 16-pin QFN Tape & Reel (2500pcs) | -40°C to 85°C     |

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**DOCUMENT IDENTIFICATION  
DATA SHEET**

The product is in production. Gennum reserves the right to make changes to the product at any time without notice to improve reliability, function or design, in order to provide the best product possible.

**CAUTION**

ELECTROSTATIC SENSITIVE DEVICES

DO NOT OPEN PACKAGES OR HANDLE EXCEPT AT A  
STATIC-FREE WORKSTATION

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