



# **Sil9589 Port Processor**

## **Data Sheet**

Sil-DS-1097-E

May 2017

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# 1. General Description

The Lattice Semiconductor SiI9589 HDMI® port processor delivers five HDMI inputs with fast InstaPort™ S port switching to DTVs and other consumer electronic devices. One HDMI input can automatically detect and switch between HDMI and Mobile High-definition Link (MHL®) mode.

MHL technology is available on any one input port. MHL allows consumers to attach their mobile devices to the television and view high definition content while the television charges the mobile device battery.

In Port Power-only mode, the SiI9589 port processor does not require initialization and does not consume any system power. The 5 V provided by the HDMI source device powers the EDID circuitry. The EDID information is read from SRAM, which loads from an NVRAM that can be reprogrammed multiple times by system firmware.

The SiI9589-3 version is rated at 300 MHz, which enables 4K x 2K, 1080p 60 Hz 3D and 1080p 120 Hz resolution.

This part supports the single-mode Audio Return Channel (ARC) described in the HDMI 1.4 Specification. ARC transmits an S/PDIF audio signal from an HDMI sink to an HDMI source in the opposite direction of the TMDS data flow. ARC simplifies audio connectivity and switching for the consumer.

The SiI9589 port processor enables 3D television design with three essential features: Vendor Specific InfoFrame (VSIF) extraction that recognizes 3D video; VSYNC insertion to convert frame-packed 3D video into 1080p, 120 Hz, 1080p, 48 Hz, or 720p, 100/120 Hz video which can be used by an SoC; and Left/Right markers sent in-band over TMDS to identify left and right video frames. The left marker can also optionally be sent on the GPIO0 pin.

## 1.1. Features

- Adaptive equalizer provides long cable support
- Built-in pattern generator to speed design, test, and manufacturing

## 1.2. HDMI Inputs and Output

- Five HDMI input ports and one output port
- HDMI, HDCP, and DVI compatible
- TMDS™ cores run at 300 MHz (SiI9589-3 device only)
- Supports video resolutions up to 4K x 2K, 1080p 120 Hz, and 1080P 3D, 60 Hz (SiI9589-3 device only)
- MHL support up to 1080p @ 30 Hz
- Pre-programmed with HDCP keys
- Repeater function supports up to 127 devices

## 1.3. Performance Improvement Features

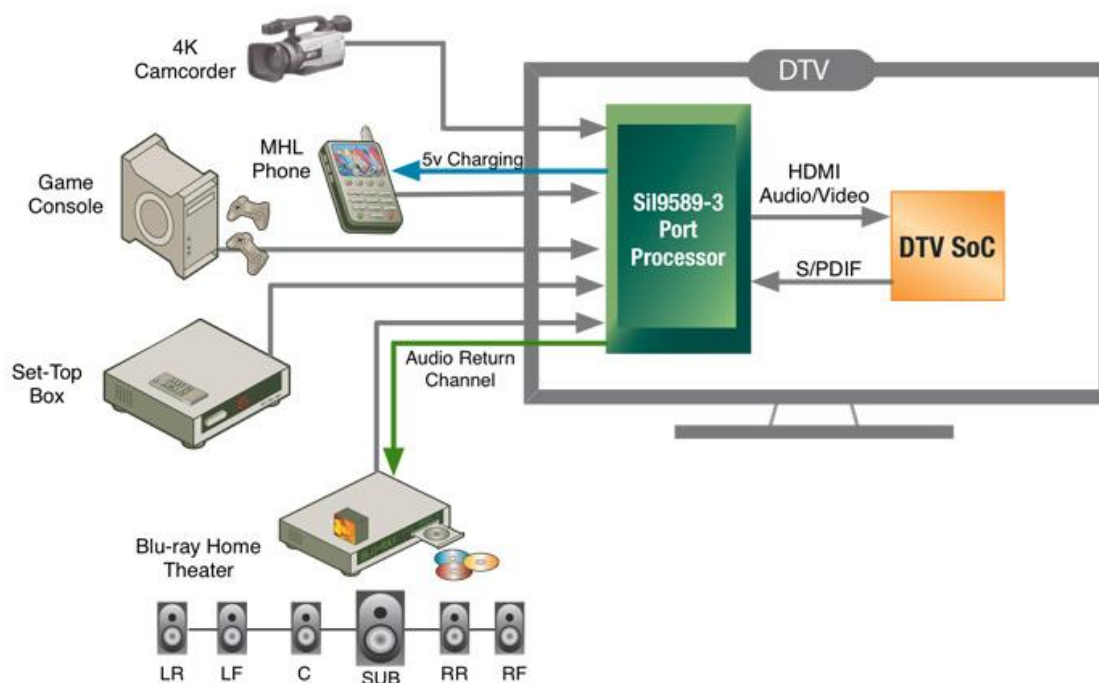
- InstaPort™ S viewing technology allows manufacturers to build TVs which switch HDMI input ports in one second
- AVI, Audio InfoFrame, and video input resolution detection for all input ports, accessible port-by-port
- Hardware-based HDCP error detection and recovery minimizes firmware intervention
- Automatic output mute and unmute based on link stability, such as cable connect/detach

## 1.4. Control Capability

- Integrated EDID and DDC support for the HDMI/VGA ports using a 512-byte NVRAM shared between ports.
- Individual control of Hot Plug Detect (HPD) for each port
- Controllable by the local I²C bus

## 1.5. Packaging

- 100-pin, 14 mm x 14 mm, 0.5 mm pitch TQFP package with exposed pad (ePad)



**Figure 1.1. Port Processor Application**

## 2. Functional Description

Figure 2.1 shows the block diagram of the SiI9589 port processor.

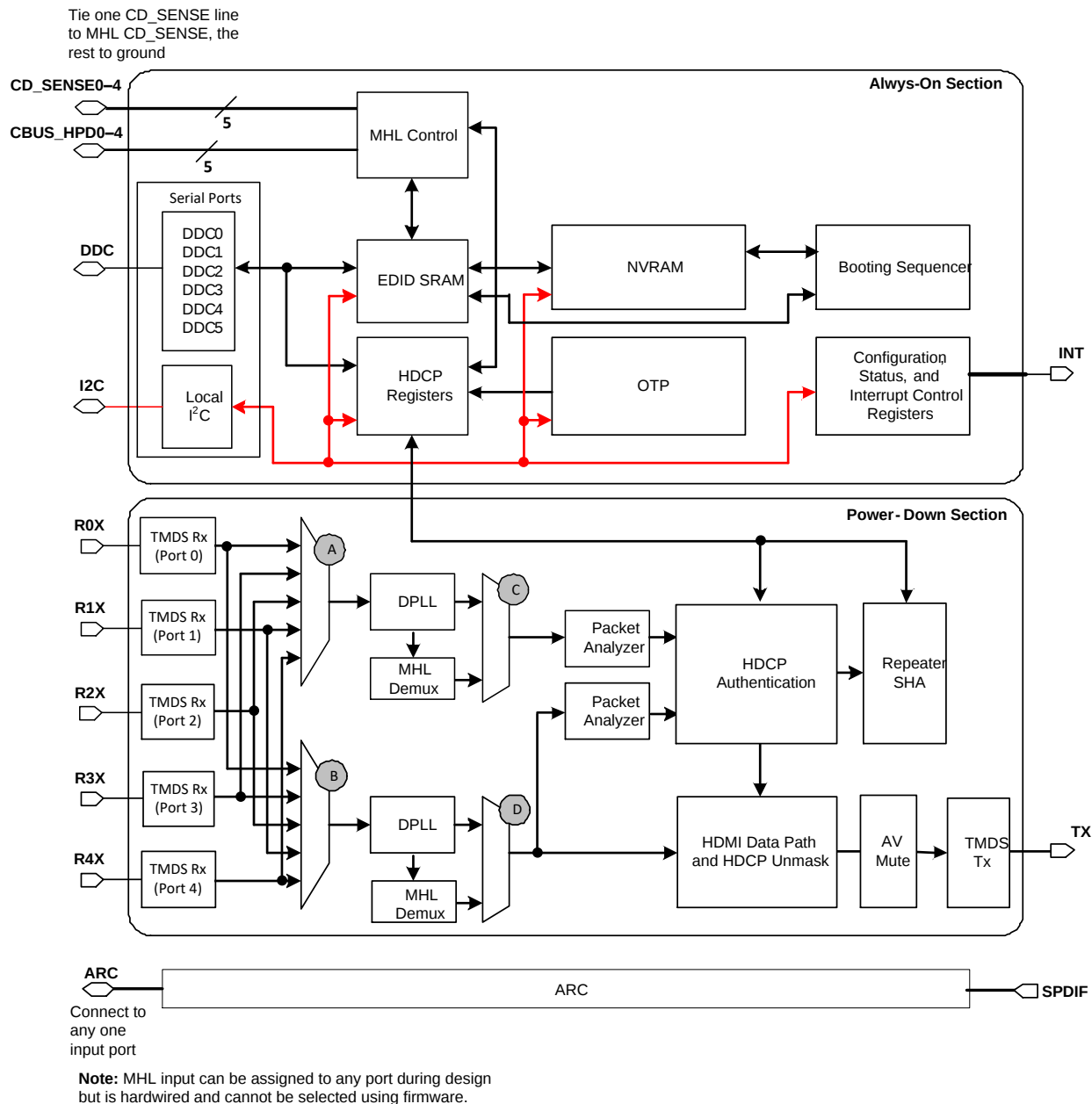


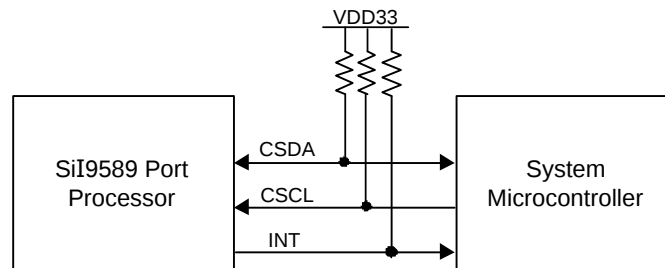
Figure 2.1. Functional Block Diagram

### 2.1. Always-on Section

The Always-on section contains the low speed control parts of the HDMI connection, and includes the I<sup>2</sup>C interfaces, internal memory blocks, and the registers that control the blocks of the Power-down section.

### 2.1.1. Serial Ports Block

The Serial Ports Block provides seven I<sup>2</sup>C serial interfaces: 5 DDC ports to communicate with the HDMI or DVI hosts, one VGA DDC port, and one local I<sup>2</sup>C port for initialization and control by a local microcontroller in the display. Each interface is 5 V tolerant. Figure 2.2 shows the connection of the local I<sup>2</sup>C port to the system microcontroller.



**Figure 2.2. I<sup>2</sup>C Control Mode Configuration**

The six DDC interfaces (DDC 0–5) on the SiI9589 port processor are slave interfaces that can run up to 400 kHz. Each interface connects to one E-DDC bus and is used to read the integrated EDID and HDCP authentication information. The port is accessible on the E-DDC bus at device addresses 0xA0 for the EDID and 0x74 for HDCP control. This feature complies with the HDCP 1.4 Specification.

Refer to the [Local I<sup>2</sup>C](#) section on page 29 for information about the I<sup>2</sup>C addresses and the use of the CI2CA pin.

### 2.1.2. Static RAM Block

The EDID Static RAM (SRAM) Block contains 2176 bytes of RAM. Each port is allocated a 256-byte block for DDC; this allows all ports to be read simultaneously from five different sources connected to the SiI9589 device. A 128-byte block is available for VGA DDC, 640 bytes are available for KSVs, 64 bytes are used for the Auto-boot feature, and 64 bytes are reserved. Every EDID and SHA KSV has an offset location. The SRAM can be written to and read from using the local I<sup>2</sup>C interface and it can be read through the DDC interface. The memory can be read without main TV power (VCC33), using 5 V power from the HDMI connector. See the [EDID Memory](#) section on page 28 for information about how the SRAM and NVRAM work together.

### 2.1.3. NVRAM Block

The port processor contains 512 bytes of NVRAM, 256 of which is used to store common EDID data used by each of the ports, 128 of which is used for VGA DDC, and 64 of which is used by the Auto-boot feature. (64 bytes are unused.) Both the NVRAM EDID data and NVRAM Auto-boot data should be initialized by software using the local I<sup>2</sup>C bus at least once during the time of manufacture.

### 2.1.4. HDCP Register Block

The HDCP Register Block controls the necessary logic to decrypt the incoming audio and video data. The decryption process is controlled entirely by the host side microcontroller using a set sequence of register reads and writes through the DDC channel. The decryption process uses pre-programmed HDCP keys and Key Selection Vector (KSV) stored in the on-chip non-volatile memory.

### 2.1.5. OTP ROM Block

The OTP ROM Block is programmed at the factory and contains the pre-programmed HDCP keys. System manufacturers do not need to purchase key sets from the Digital Content Protection LLC. All purchasing, programming, and security for the HDCP keys is handled by Lattice Semiconductor. The preprogrammed HDCP keys provide the highest level of security, as keys cannot be read out of the device after they are programmed.

### 2.1.6. Booting Sequencer

The Booting Sequencer boots up the required data, such as EDID, initial HPD status, and MHL port selection from NVRAM during power-on.

### 2.1.7. Configuration, Status, and Interrupt Control Registers Blocks

The Configuration, Status, and Interrupt Control Registers blocks incorporate the registers required for configuring and managing the features of the SiI9589 port processor. These registers are used to perform audio/video/auxiliary format processing, CEA-861E InfoFrame Packet format, and power-down control. The registers are accessible from the local I<sup>2</sup>C port. This block also handles interrupt operation.

### 2.1.8. MHL Control Block

The MHL Control Block handles CBUS conversion of RCP and DDC signals for the HDCP interface and EDID blocks.

## 2.2. Power-down Section

The Power-down section contains HDMI high-speed data paths, including the analog TMDS input and output blocks and the digital logic for HDMI data and HDCP processing.

### 2.2.1. TMDS Receiver Blocks

The receiver ports, defined as Port 0, Port 1, Port 2, Port 3, and Port 4 are terminated separately, equalized under the control of the receiver digital block, and controlled by the local I<sup>2</sup>C bus.

### 2.2.2. 5:1 Input Multiplexer Blocks

5:1 Input Multiplexer Blocks A and B select one of the five inputs. Multiplexer Block A sequentially selects one of the four inactive inputs and sends its data over the roving pipe to the DPLL block and the MHL demux block. Multiplexer Block B selects the active input and sends its data over the main pipe to be processed.

### 2.2.3. MHL Demultiplexer Blocks

If the signal received from the DPLL block only appears in one of the three lanes, the input is an MHL signal. The Demultiplexer block distributes the single-lane RGB serial data blocks over the three parallel RGB lanes of video data.

### 2.2.4. 2:1 HDMI/MHL Multiplexer Blocks

2:1 HDMI/MHL Multiplexer Blocks C and D select either the HDMI from the DPLL block or the MHL converted to HDMI by the MHL Demultiplexer. Block C transfers data from the roving pipe, and block D transfers data from the main pipe.

### 2.2.5. Packet Analyzer Blocks

The Packet Analyzer blocks extract the control signals from the HDMI control packets that are needed to control the HDCP decryption process in the main and the roving pipe. HDCP decryption is controlled by register information.

### 2.2.6. HDCP Authentication Block

The active receiver port switched to the main pipe is permanently connected to its HDCP decryption block. The remaining four ports share the roving pipe. Each of the decryption blocks are sequentially switched to its input port for a period long enough to get the control information from the HDMI packets needed for the preauthentication process. There is a small probability of missing important information in the roving process because of the unpredictable occurrence of control packets. The missed information is detected and leads to a full reauthentication of the corresponding HDCP path.

### 2.2.7. MP and RP HDMI Receive Data Path and HDCP Unmask Blocks

HDMI data from the Main Pipe (MP) and Roving Pipe (RP) are sent to and processed by the respective HDMI Receive Data Path and HDCP Unmask blocks. The appropriate decryption key for the main port and the input port currently

connected to the roving pipe is applied to the XOR mask in these blocks to descramble the video, audio, and auxiliary packets.

#### **2.2.8. Repeater SHA Block**

The Repeater Secured Hash Algorithm (SHA) Block is used only when the port processor is configured as a repeater, in which HDMI receiver and transmitter connections are cascaded. In this case each transmitter has to ensure that all downstream receivers are HDCP-compliant. To make sure that all receivers in the downstream path are protected by HDCP, the downstream transmitters propagate a ready signal to the final upstream source transmitter.

#### **2.2.9. AV Mute Block**

The AV Mute Block controls audio and video mute, using two methods. Software mute is controlled by register settings. When hardware mute is enabled, audio and video are automatically muted and un-muted if an ECC error occurs.

#### **2.2.10. TMDS Transmitter Block**

The Transmitter Block delivers an HDMI content stream, based on the content of the original stream from the selected source. Internal source termination eliminates the need to use external R-C components for signal shaping. The internal source termination can be disabled.

### **2.3. ARC Block**

The Audio Return Channel (ARC) Block allows digital S/PDIF data received from the sink device to be transmitted in the direction opposite to the TMDS input port signal. The block embeds the audio data, in single mode format, in the same lines connected to the Utility pin of the HDMI connector.

## 3. Electrical Specifications

### 3.1. Absolute Maximum Conditions

Table 3.1. Absolute Maximum Conditions

| Symbol           | Parameter                                  | Min  | Typ | Max         | Unit | Notes   |
|------------------|--------------------------------------------|------|-----|-------------|------|---------|
| VDD33            | Supply voltage                             | -0.3 | —   | 4.0         | V    | 1, 2    |
| SBVCC5           | Supply voltage                             | -0.3 | —   | 5.7         | V    | 1, 2    |
| RnPWR5V          | 5 V input from power pin of HDMI connector | -0.3 | —   | 5.7         | V    | 1, 2    |
| R5PWR5V          | 5 V input from power pin of VGA connector  | -0.3 | —   | 5.7         | V    | 1, 2    |
| LPSBV            | Low-power Standby voltage                  | -0.3 | —   | 4.0         | V    | 1, 2    |
| AVDD12           | TMDS receiver core supply voltage          | -0.3 | —   | 1.5         | V    | 1, 2    |
| VDD12            | Digital core supply voltage                | -0.3 | —   | 1.5         | V    | 1, 2    |
| TCVDD12          | TMDS transmitter core supply voltage       | -0.3 | —   | 1.5         | V    | 1, 2    |
| TPVDD12          | TMDS transmitter PLL supply voltage        | -0.3 | —   | 1.5         | V    | 1, 2    |
| V <sub>I</sub>   | Input voltage                              | -0.3 | —   | VDD33 + 0.3 | V    | 1, 2, 3 |
| V <sub>O</sub>   | Output voltage                             | -0.3 | —   | VDD33 + 0.3 | V    | 1, 2, 4 |
| T <sub>J</sub>   | Junction temperature                       | 0    | —   | 125         | °C   | —       |
| T <sub>STG</sub> | Storage temperature                        | -65  | —   | 150         | °C   | —       |
| V <sub>ESD</sub> | ESD voltage per IEC 61000-4-2 (Contact)    | 8    | —   | —           | kV   | 5       |
|                  | ESD voltage per IEC 61000-4-2 (Air)        | 8    | —   | —           | kV   | 5       |

**Notes:**

1. Permanent device damage can occur if absolute maximum conditions are exceeded.
2. Functional operation should be restricted to the conditions described in the Normal Operating Conditions section below.
3. 5 V tolerant input signals.
4. 5 V output signals.
5. System-level tests at HDMI connectors.

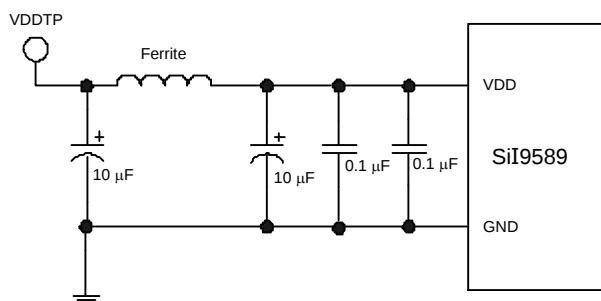
## 3.2. Normal Operating Conditions

**Table 3.2. Normal Operating Conditions**

| Symbol             | Parameter                                  | Min  | Typ | Max  | Unit              | Notes |
|--------------------|--------------------------------------------|------|-----|------|-------------------|-------|
| VDD33              | Supply voltage                             | 3.14 | 3.3 | 3.46 | V                 | —     |
| SBVCC5             | Supply voltage                             | 4.3  | 5.0 | 5.5  | V                 | 2     |
| RnPWR5V            | 5 V input from power pin of HDMI connector | 4.3  | 5.0 | 5.5  | V                 | 2     |
| R5PWR5V            | 5 V input from power pin of VGA connector  | 4.3  | 5.0 | 5.5  | V                 | 2     |
| LPSBV              | Low-power Standby voltage                  | 3.14 | 3.3 | 3.46 | V                 | 7     |
| AVDD12             | TMDS receiver core supply voltage          | 1.08 | 1.2 | 1.32 | V                 | 5     |
|                    |                                            | 1.14 | 1.2 | 1.26 | V                 | 6     |
| VDD12              | Digital core supply voltage                | 1.08 | 1.2 | 1.32 | V                 | 5     |
|                    |                                            | 1.14 | 1.2 | 1.26 | V                 | 6     |
| TCVDD12            | TMDS transmitter core supply voltage       | 1.08 | 1.2 | 1.32 | V                 | 5     |
|                    |                                            | 1.14 | 1.2 | 1.26 | V                 | 6     |
| TPVDD12            | TMDS transmitter PLL supply voltage        | 1.08 | 1.2 | 1.32 | V                 | 5     |
|                    |                                            | 1.14 | 1.2 | 1.26 | V                 | 6     |
| V <sub>DD12N</sub> | Supply voltage noise for 1.2V power        | —    | —   | 75   | mV <sub>p-p</sub> | 1     |
| V <sub>DD33N</sub> | Supply voltage noise for 3.3V power        | —    | —   | 100  | mV <sub>p-p</sub> | 1     |
| T <sub>A</sub>     | Ambient temperature (with power applied)   | 0    | +25 | +70  | °C                | —     |
| Θ <sub>ja</sub>    | Ambient thermal resistance (Theta JA)      | —    | —   | 29.3 | °C/W              | 3,4   |
| Θ <sub>jc</sub>    | Junction to case resistance (Theta JC)     | —    | —   | 12.6 | °C/W              | 4     |

**Notes:**

1. The supply voltage noise is measured at test point VDDTP shown in Figure 3.1. The ferrite bead provides filtering of power supply noise. The figure is representative and applies to other VDD pins as well.
2. The MHL VBUS voltage requirements may be more stringent than the 5 V power supply requirements for the port processor itself.
3. Airflow at 0 m/s.
4. The thermal resistance figures are based on a 4-layer PCB.
5. SiI9589 device.
6. SiI9589-3 device.
7. Voltage listed is supplied to the required 5.1 kΩ series resistor. Actual voltage measured at the LPSBV pin is approximately 2.4 V.



**Figure 3.1. Test Point VDDTP for VDD33 Noise Tolerance Specification**

### 3.3. DC Specifications

**Table 3.3. Digital I/O Specifications**

| Symbol                     | Parameter                                     | Pin Type <sup>1</sup> | Conditions               | Min | Typ | Max | Units | Notes |
|----------------------------|-----------------------------------------------|-----------------------|--------------------------|-----|-----|-----|-------|-------|
| V <sub>IH</sub>            | HIGH-level Input Voltage                      | LVTTL                 | —                        | 2.0 | —   | —   | V     | 1     |
| V <sub>IL</sub>            | LOW-level Input Voltage                       | LVTTL                 | —                        | —   | —   | 0.8 | V     | 1     |
| V <sub>th+</sub><br>RESET# | LOW-to-HIGH Threshold<br>RESET # pin          | Schmitt               | —                        | 2.0 | —   | —   | V     | —     |
| V <sub>th</sub> -RESET#    | HIGH-to-LOW Threshold<br>RESET# pin           | Schmitt               | —                        | —   | —   | 0.8 | V     | —     |
| V <sub>TH+DDC</sub>        | LOW-to-HIGH Threshold<br>DDC Bus              | Schmitt               | —                        | 3.0 | —   | —   | V     | 3     |
| V <sub>TH-DDC</sub>        | HIGH-to-LOW Threshold<br>DDC Bus              | Schmitt               | —                        | —   | —   | 1.5 | V     | 3     |
| V <sub>TH+I2C</sub>        | LOW-to-HIGH Threshold<br>I <sup>2</sup> C Bus | Schmitt               | —                        | 2.0 | —   | —   | V     | —     |
| V <sub>TH-I2C</sub>        | HIGH-to-LOW Threshold<br>I <sup>2</sup> C Bus | Schmitt               | —                        | —   | —   | 0.8 | V     | —     |
| V <sub>OH</sub>            | HIGH-level Output Voltage                     | LVTTL                 | I <sub>OH</sub> = 8 mA   | 2.4 | —   | —   | V     | 4     |
| V <sub>OL</sub>            | LOW-level Output Voltage                      | LVTTL                 | I <sub>OL</sub> = -8 mA  | —   | —   | 0.4 | V     | 4     |
| V <sub>OL_DDC</sub>        | LOW-level Output Voltage                      | Open-<br>drain        | I <sub>OL</sub> = -3 mA  | —   | —   | 0.4 | V     | 3     |
| V <sub>OL_I2C</sub>        | LOW-level Output Voltage                      | Open-<br>drain        | I <sub>OL</sub> = -3 mA  | —   | —   | 0.4 | V     | —     |
| I <sub>IL</sub>            | Input Leakage Current                         | LVTTL                 | High-impedance           | -10 | —   | 10  | μA    | —     |
| I <sub>OL</sub>            | Output Leakage Current                        | LVTTL                 | High-impedance           | -10 | —   | 10  | μA    | —     |
| I <sub>OD8</sub>           | 8 mA Digital Output Drive                     | LVTTL                 | V <sub>OUT</sub> = 2.4 V | 8   | —   | —   | mA    | 4     |
|                            |                                               |                       | V <sub>OUT</sub> = 0.4 V | 8   | —   | —   | mA    | 4     |

**Notes:**

1. Refer to the [Pin Descriptions](#) section on page 18 for pin type designations for all package pins.
2. Applies to the GPIO, SPDIF\_IN, and TPWR\_CI2CA signal pins.
3. Applies to the DDC interface.
4. Applies to the GPIO, INT, and TPWR\_CI2CA signal pins.

**Table 3.4. Power Requirements**

| Symbol                 | Parameter                                        | 297 MHz |      | 225 MHz |      | Unit | Notes |
|------------------------|--------------------------------------------------|---------|------|---------|------|------|-------|
|                        |                                                  | Typ     | Max  | Typ     | Max  |      |       |
| I <sub>AVDD12</sub>    | Supply Current for Analog VDD12                  | 390     | 411  | 314     | 334  | mA   | 1     |
| I <sub>VDD33</sub>     | Supply Current for VDD33                         | 260     | 260  | 260     | 260  | mA   | 1     |
| I <sub>VDD12</sub>     | Supply Current for Digital VDD12                 | 240     | 283  | 201     | 218  | mA   | 1     |
| I <sub>SBVCC5SB</sub>  | Supply Current for SBVCC5 during standby         | 6       | 7    | 6       | 7    | mA   | —     |
| I <sub>SBVCC5OP</sub>  | Supply Current for SBVCC5 during operation       | 8       | 9    | 8       | 9    | mA   | 1     |
| I <sub>RnPWR5V</sub>   | Supply Current for RnPWR5V during operation      | 2       | 4    | 2       | 4    | mA   | 1, 2  |
| I <sub>TCVDD12</sub>   | Supply Current for TCVDD12                       | 25      | 26   | 17      | 19   | mA   | 1     |
| I <sub>TPVDD12</sub>   | Supply Current for TPVDD12                       | 15      | 16   | 13      | 14   | mA   | 1     |
| I <sub>LPSBV SOP</sub> | Supply Current for LPSBV during normal operation | 200     | 210  | 200     | 210  | μA   | 1     |
| Total                  | Total Power                                      | 1680    | 1902 | 1543    | 1722 | mW   | 1     |

**Notes:**

1. Maximum supply currents are measured at maximum operating voltages, with all inputs and outputs switching at the measurement frequency listed.
2. The power provided by I<sub>RnPWR5V</sub> is not included in the Total Power row.

**Table 3.5. TMDS Input DC Specifications – HDMI Mode**

| Symbol           | Parameter                       | Conditions | Min          | Typ | Max           | Units |
|------------------|---------------------------------|------------|--------------|-----|---------------|-------|
| V <sub>ID</sub>  | Differential-mode Input Voltage | —          | 150          | —   | 1200          | mV    |
| V <sub>ICM</sub> | Common-mode Input Voltage       | —          | AVDD33 – 400 | —   | AVDD33 – 37.5 | mV    |

**Table 3.6. TMDS Input DC Specifications – MHL Mode**

| Symbol           | Parameter                             | Conditions | Min           | Typ | Max                                  | Units |
|------------------|---------------------------------------|------------|---------------|-----|--------------------------------------|-------|
| V <sub>IDC</sub> | Single-ended Input DC Voltage         | —          | AVDD33 – 1200 | —   | AVDD33 – 300                         | mV    |
| V <sub>IDF</sub> | Differential-mode Input Swing Voltage | —          | 200           | —   | 1000                                 | mV    |
| V <sub>ICM</sub> | Common-mode Input Swing Voltage       | —          | 170           | —   | Min<br>(720, 0.85 V <sub>IDF</sub> ) | mV    |

**Table 3.7. TMDS Output DC Specifications**

| Symbol             | Parameter                              | Conditions               | Min          | Typ | Max          | Units |
|--------------------|----------------------------------------|--------------------------|--------------|-----|--------------|-------|
| V <sub>SWING</sub> | Single-ended Output Swing Voltage      | R <sub>LOAD</sub> = 50 Ω | 400          | —   | 600          | mV    |
| V <sub>H</sub>     | Single-ended High-level Output Voltage | —                        | AVDD33 – 200 | —   | AVDD33 + 10  | mV    |
| V <sub>L</sub>     | Single-ended Low-level Output Voltage  | —                        | AVDD33 – 700 | —   | AVDD33 – 400 | mV    |

**Table 3.8. Single Mode Audio Return Channel DC Specifications**

| Symbol                | Parameter            | Conditions | Min | Typ | Max | Units | Notes |
|-----------------------|----------------------|------------|-----|-----|-----|-------|-------|
| V <sub>el</sub>       | Operating DC Voltage | —          | 0   | —   | 5   | V     | —     |
| V <sub>el swing</sub> | Swing Amplitude      | —          | 400 | —   | 600 | mV    | —     |

**Table 3.9. CBUS DC Specifications**

| Symbol                | Parameter                        | Conditions              | Min | Typ  | Max  | Units | Notes |
|-----------------------|----------------------------------|-------------------------|-----|------|------|-------|-------|
| V <sub>IH_CBUS</sub>  | High-level Input Voltage         | —                       | 1.0 | —    | —    | V     | —     |
| V <sub>IL_CBUS</sub>  | Low-level Input Voltage          | —                       | —   | —    | 0.6  | V     | —     |
| V <sub>OH_CBUS</sub>  | High-level Output Voltage        | I <sub>O</sub> = 100 μA | 1.5 | —    | —    | V     | —     |
| V <sub>OL_CBUS</sub>  | Low-level Output Voltage         | I <sub>O</sub> = 100 μA | —   | —    | 0.2  | V     | —     |
| Z <sub>DSC_CBUS</sub> | Pull-down Resistance – Discovery | —                       | 800 | 1000 | 1200 | Ω     | —     |
| Z <sub>ON_CBUS</sub>  | Pull-down Resistance – Active    | —                       | 90  | 100  | 110  | kΩ    | —     |
| I <sub>IL_CBUS</sub>  | Input Leakage Current            | High-impedance          | —   | —    | 1    | μA    | —     |
| C <sub>CBUS</sub>     | Capacitance                      | Power Off               | —   | —    | 30   | pF    | —     |

### 3.4. AC Specifications

**Table 3.10. TMDS Input Timing AC Specifications – HDMI Mode**

| Symbol                       | Parameter                                 | Conditions | Min  | Typ | Max                          | Units            | Notes |
|------------------------------|-------------------------------------------|------------|------|-----|------------------------------|------------------|-------|
| T <sub>INTRA-PAIR_SKEW</sub> | Input Intrapair Skew                      | —          | —    | —   | 0.4 T <sub>BIT</sub>         | ps               | 1     |
|                              |                                           | —          | —    | —   | 112 + 0.15 T <sub>BIT</sub>  | ps               | 2     |
| T <sub>INTER-PAIR_SKEW</sub> | Input Interpair Skew                      | —          | —    | —   | 0.2T <sub>PIXEL</sub> + 1.78 | ns               |       |
| F <sub>RXC</sub>             | Differential Input Clock Frequency        | —          | 25   | —   | 225                          | MHz              | 1     |
|                              |                                           | —          | 25   | —   | 300                          | MHz              | 2     |
| T <sub>RXC</sub>             | Differential Input Clock Period           | —          | 4.44 | —   | 40                           | ns               | 1     |
|                              |                                           | —          | 3.33 | —   | 40                           | ns               | 2     |
| T <sub>IJIT</sub>            | Differential Input Clock Jitter Tolerance | 300 MHz    | —    | —   | 0.3                          | T <sub>BIT</sub> | —     |

**Notes:**

1. SiI9589 device.
2. SiI9589-3 device.

**Table 3.11. TMDS Input Timing AC Specifications – MHL Mode**

| Symbol                 | Parameter                          | Conditions | Min   | Typ | Max                         | Units |
|------------------------|------------------------------------|------------|-------|-----|-----------------------------|-------|
| T <sub>SKEW_DF</sub>   | Input Differential Intrapair Skew  | —          | —     | —   | 93                          | ps    |
| T <sub>SKEW_CM</sub>   | Input Common-mode Intrapair Skew   | —          | —     | —   | 93                          | ps    |
| F <sub>RXC</sub>       | Differential Input Clock Frequency | —          | 25    | —   | 75                          | MHz   |
| T <sub>RXC</sub>       | Differential Input Clock Period    | —          | 13.33 | —   | 40                          | ns    |
| T <sub>CLOCK_JIT</sub> | Common-mode Clock Jitter Tolerance | —          | —     | —   | 0.3T <sub>BIT</sub> + 200   | ps    |
| T <sub>DATA_JIT</sub>  | Differential Data Jitter Tolerance | —          | —     | —   | 0.4T <sub>BIT</sub> + 88.88 | ps    |

**Table 3.12. TMDS Output Timing AC Specifications**

| Symbol             | Parameter                            | Conditions | Min  | Typ | Max  | Units            | Notes |
|--------------------|--------------------------------------|------------|------|-----|------|------------------|-------|
| T <sub>TXDPS</sub> | Intrapair Differential Output Skew   | —          | —    | —   | 0.15 | T <sub>BIT</sub> | —     |
| T <sub>TXRT</sub>  | Data/Clock Rise Time                 | 20%–80%    | 75   | —   | 144  | ps               | —     |
| T <sub>TXFT</sub>  | Data/Clock Fall Time                 | 20%–80%    | 75   | —   | 120  | ps               | —     |
| F <sub>TXC</sub>   | Differential Output Clock Frequency  | —          | 25   | —   | 225  | MHz              | 1     |
|                    |                                      | —          | 25   | —   | 300  | MHz              | 2     |
| T <sub>TXC</sub>   | Differential Output Clock Period     | —          | 4.44 | —   | 40   | ns               | —     |
| T <sub>DUTY</sub>  | Differential Output Clock Duty Cycle | —          | 40%  | —   | 60%  | T <sub>TXC</sub> | —     |
| T <sub>OJIT</sub>  | Differential Output Clock Jitter     | —          | —    | —   | 0.25 | T <sub>BIT</sub> | —     |

**Notes:**

1. SiI9589 device.
2. SiI9589-3 device.

**Table 3.13. Single Mode Audio Return Channel AC Specifications**

| Symbol              | Parameter                 | Conditions | Min   | Typ | Max  | Units | Note |
|---------------------|---------------------------|------------|-------|-----|------|-------|------|
| T <sub>ASMRT</sub>  | Rise Time                 | 10%–90%    | —     | —   | 60   | ns    | —    |
| T <sub>ASMT</sub>   | Fall Time                 | 10%–90%    | —     | —   | 60   | ns    | —    |
| T <sub>ASMJIT</sub> | Jitter Max                | —          | —     | —   | 0.05 | UI*   | —    |
| F <sub>ASMDEV</sub> | Clock Frequency Deviation | —          | –1000 | —   | 1000 | ppm   | —    |

**\*Note:** Proportional to unit time (UI), according to sample rate. Refer to the S/PDIF specification.

**Table 3.14. S/SPDIF Input Port AC Specifications**

| Symbol                | Parameter   | Conditions | Min | Typ | Max | Units | Note |
|-----------------------|-------------|------------|-----|-----|-----|-------|------|
| F <sub>I_SPDIF</sub>  | Sample Rate | To ARC     | 32  | —   | 48  | kHz   | —    |
| T <sub>I_SPCYC</sub>  | Cycle Time  | —          | —   | —   | 1.0 | UI*   | —    |
| T <sub>I_SPDUTY</sub> | Duty Cycle  | —          | 90  | —   | 110 | %UI*  | —    |

\*Note: Proportional to unit time (UI), according to sample rate. Refer to S/SPDIF specification.

**Table 3.15. CBUS AC Specifications**

| Symbol                 | Parameter                    | Conditions  | Min | Typ | Max | Units                 |
|------------------------|------------------------------|-------------|-----|-----|-----|-----------------------|
| T <sub>BIT_CBUS</sub>  | Bit Time                     | 1 MHz clock | 0.8 | —   | 1.2 | μs                    |
| T <sub>BJIT_CBUS</sub> | Bit-to-Bit Jitter            | —           | –1% | —   | +1% | T <sub>BIT_CBUS</sub> |
| T <sub>DUTY_CBUS</sub> | Duty Cycle of 1 Bit          | —           | 40% | —   | 60% | T <sub>BIT_CBUS</sub> |
| T <sub>R_CBUS</sub>    | Rise Time                    | 0.2 V–1.5 V | 5   | —   | 200 | ns                    |
| T <sub>F_CBUS</sub>    | Fall Time                    | 0.2 V–1.5 V | 5   | —   | 200 | ns                    |
| ΔT <sub>RF</sub>       | Rise-to-Fall Time Difference | —           | —   | —   | 100 | ns                    |

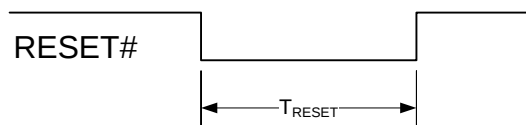
## 3.5. Miscellaneous Timing

**Table 3.16. Miscellaneous Timing**

| Symbol                | Parameter                              | Conditions | Min | Typ | Max | Unit | Figure     | Note |
|-----------------------|----------------------------------------|------------|-----|-----|-----|------|------------|------|
| T <sub>RESET</sub>    | RESET# signal LOW time for valid reset | —          | 1   | —   | —   | ms   | Figure 3.2 | —    |
| T <sub>SBVCC5RT</sub> | Rise Time                              | 10%–90%    | —   | —   | 1   | ms   | —          | —    |
| T <sub>HDDAT</sub>    | I <sup>2</sup> C data hold time        | 0–400 KHz  | 0   | —   | —   | ns   | —          | 1    |

**Note:** This minimum hold time is required by CSCL and CSDA pins as an I<sup>2</sup>C slave. The 300 ns internal delay for CSDA can be enabled by NVRAM configuration

## 3.6. Reset Timing



RESET# must be pulled LOW for  $T_{RESET}$  before accessing registers. This is done by pulling RESET# LOW from a HIGH state (shown above) for at least  $T_{RESET}$ .

**Figure 3.2. RESET# Minimum Timing**

## 4. Pin Diagram and Pin Descriptions

### 4.1. Pin Diagram

Figure 4.1 shows the pin assignments of the SiI9589 port processor. Individual pin functions are described in the [Pin Descriptions](#) section on the next page. The package is a 14 mm x 14 mm 100-pin TQFP with an ePad, which **must** be connected to ground.

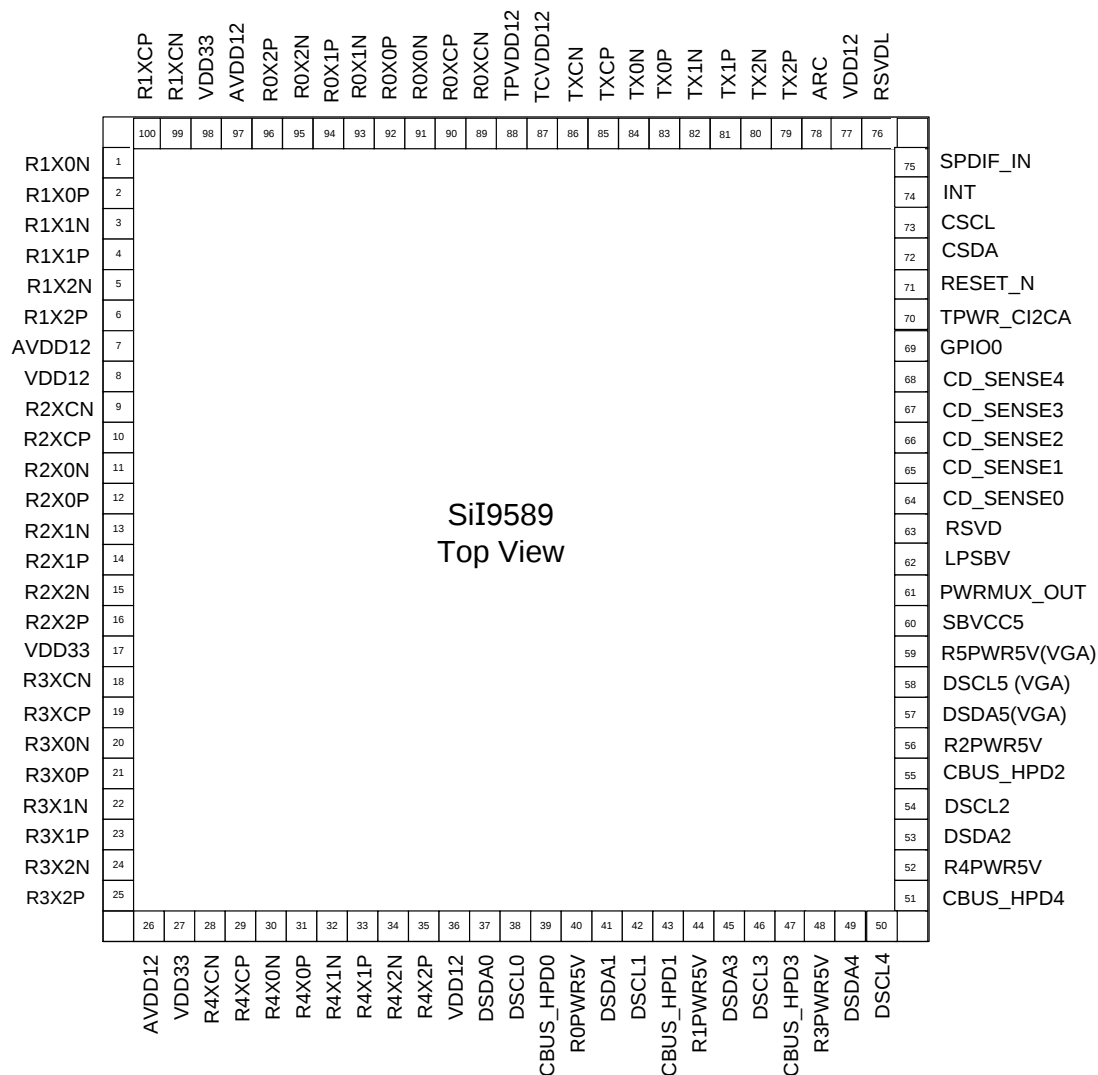


Figure 4.1. Pin Diagram (Top View)

## 4.2. Pin Descriptions

### 4.2.1. HDMI and MHL Receiver Port Pins

| Pin Name | Pin | Type | Dir   | Description                   |
|----------|-----|------|-------|-------------------------------|
| R0X0P    | 92  | TMDS | Input | TMDS input Port 0 data pairs. |
| R0X0N    | 91  |      |       |                               |
| R0X1P    | 94  |      |       |                               |
| R0X1N    | 93  |      |       |                               |
| R0X2P    | 96  |      |       |                               |
| R0X2N    | 95  |      |       |                               |
| R0XCP    | 90  | TMDS | Input | TMDS input Port 0 clock pair. |
| R0XCN    | 89  |      |       |                               |
| R1X0P    | 2   | TMDS | Input | TMDS input Port 1 data pairs. |
| R1X0N    | 1   |      |       |                               |
| R1X1P    | 4   |      |       |                               |
| R1X1N    | 3   |      |       |                               |
| R1X2P    | 6   |      |       |                               |
| R1X2N    | 5   |      |       |                               |
| R1XCP    | 100 | TMDS | Input | TMDS input Port 1 clock pair. |
| R1XCN    | 99  |      |       |                               |
| R2X0P    | 12  | TMDS | Input | TMDS input Port 2 data pairs. |
| R2X0N    | 11  |      |       |                               |
| R2X1P    | 14  |      |       |                               |
| R2X1N    | 13  |      |       |                               |
| R2X2P    | 16  |      |       |                               |
| R2X2N    | 15  |      |       |                               |
| R2XCP    | 10  | TMDS | Input | TMDS input Port 2 clock pair. |
| R2XCN    | 9   |      |       |                               |
| R3X0P    | 21  | TMDS | Input | TMDS input Port 3 data pairs. |
| R3X0N    | 20  |      |       |                               |
| R3X1P    | 23  |      |       |                               |
| R3X1N    | 22  |      |       |                               |
| R3X2P    | 25  |      |       |                               |
| R3X2N    | 24  |      |       |                               |
| R3XCP    | 19  | TMDS | Input | TMDS input Port 3 clock pair. |
| R3XCN    | 18  |      |       |                               |
| R4X0P    | 31  | TMDS | Input | TMDS input Port 4 data pairs. |
| R4X0N    | 30  |      |       |                               |
| R4X1P    | 33  |      |       |                               |
| R4X1N    | 32  |      |       |                               |
| R4X2P    | 35  |      |       |                               |
| R4X2N    | 34  |      |       |                               |
| R4XCP    | 29  | TMDS | Input | TMDS input Port 4 clock pair. |
| R4XCN    | 28  |      |       |                               |

**Note:** For the port that has been configured as a MHL input, the  $RnX0P$  and  $RnX0N$  pins carry the MHL signal. All eight TMDS lines require 5.1  $\Omega$  series resistors to meet the impedance requirements of both the MHL and HDMI Specifications. HDMI-only ports do not require 5.1  $\Omega$  series resistors on the TMDS lines.

#### 4.2.2. Audio Pins

| Pin Name | Pin | Type   | Dir    | Description                                                                                                                                                                                      |
|----------|-----|--------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARC      | 78  | Analog | Output | Audio Return Channel.<br>This pin is used to transmit an IEC60958-1 audio stream, received on the SPDIF_IN input pin, upstream to a compatible source or repeater device, using single-mode ARC. |
| SPDIF_IN | 75  | LVTTTL | Input  | S/PDIF input from the SoC.                                                                                                                                                                       |

#### 4.2.3. HDMI Transmitter Port Pins

| Pin Name | Pin | Type | Dir    | Description                                                                                    |
|----------|-----|------|--------|------------------------------------------------------------------------------------------------|
| TX0P     | 83  | TMDS | Output | HDMI Transmitter Output Port Data.<br>TMDS Low-voltage Differential Signal output data pairs.  |
| TX0N     | 84  |      |        |                                                                                                |
| TX1P     | 81  |      |        |                                                                                                |
| TX1N     | 82  |      |        |                                                                                                |
| TX2P     | 79  |      |        |                                                                                                |
| TX2N     | 80  |      |        |                                                                                                |
| TXCP     | 85  | TMDS | Output | HDMI Transmitter Output Port Clock.<br>TMDS Low-voltage Differential Signal output clock pair. |
| TXCN     | 86  |      |        |                                                                                                |

#### 4.2.4. System Switching Pins

| Pin Name     | Pin | Type                                            | Dir              | Description                                                                                                                                                                                                                            |
|--------------|-----|-------------------------------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DSDA0        | 37  | LVTTTL<br>Schmitt<br>Open-drain<br>5 V tolerant | Input/<br>Output | DDC I <sup>2</sup> C Data for respective port.<br>These signals are true open drain, and do not pull to ground when power is not applied to the device. These pins require an external pull-up resistor.                               |
| DSDA1        | 41  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSDA2        | 53  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSDA3        | 45  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSDA4        | 49  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSDA5(VGA)   | 57  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSCL0        | 38  | LVTTTL<br>Schmitt<br>Open-drain<br>5 V tolerant | Input            | DDC I <sup>2</sup> C Clock for respective port.<br>These signals are true open drain, and do not pull to ground when power is not applied to the device. These pins require an external pull-up resistor.                              |
| DSCL1        | 42  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSCL2        | 54  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSCL3        | 46  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSCL4        | 50  |                                                 |                  |                                                                                                                                                                                                                                        |
| DSCL5(VGA)   | 58  |                                                 |                  |                                                                                                                                                                                                                                        |
| R0PWR5V      | 40  | Power                                           | Input            | 5 V Port detection input for respective port.<br>Connect to 5 V signal from HDMI input connector. These pins require a 10 $\Omega$ series resistor, a 5.1 k $\Omega$ pull-down resistor, and at least a 1 $\mu$ F capacitor to ground. |
| R1PWR5V      | 44  |                                                 |                  |                                                                                                                                                                                                                                        |
| R2PWR5V      | 56  |                                                 |                  |                                                                                                                                                                                                                                        |
| R3PWR5V      | 48  |                                                 |                  |                                                                                                                                                                                                                                        |
| R4PWR5V      | 52  |                                                 |                  |                                                                                                                                                                                                                                        |
| CBUS_HPD0    | 39  | Schmitt<br>5 V tolerant<br>Analog pad           | Input/<br>Output | Hot Plug Detect Output for the respective port.<br>In MHL mode, these pins serve as the respective CTRL bus.                                                                                                                           |
| CBUS_HPD1    | 43  |                                                 |                  |                                                                                                                                                                                                                                        |
| CBUS_HPD2    | 55  |                                                 |                  |                                                                                                                                                                                                                                        |
| CBUS_HPD3    | 47  |                                                 |                  |                                                                                                                                                                                                                                        |
| CBUS_HPD4    | 51  |                                                 |                  |                                                                                                                                                                                                                                        |
| R5PWR5V(VGA) | 59  | Power                                           | Input            | VGA 5 V Detect.<br>This pin provides 5 V power from VGA connector. This pin requires a 10 $\Omega$ series resistor and at least a 1 $\mu$ F capacitor to ground.                                                                       |

#### 4.2.5. Control Pins

| Pin Name  | Pin | Type                             | Dir              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------|-----|----------------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C_SCL     | 73  | LVTTL<br>5 V tolerant<br>Schmitt | Input            | Local Configuration/Status I <sup>2</sup> C Clock.<br>Chip configuration/status is accessed using this I <sup>2</sup> C port. This pin is true open drain, so it doesn't pull to ground if power is not applied.                                                                                                                                                                                                                                                                     |
| C_SDA     | 72  | LVTTL<br>5 V tolerant<br>Schmitt | Input/<br>Output | Local Configuration/Status I <sup>2</sup> C Data.<br>Chip configuration/status is accessed using this I <sup>2</sup> C port. This pin is true open drain, so it does not pull to ground if power is not applied. See <a href="#">Figure 2.2</a> on page 8.                                                                                                                                                                                                                           |
| CD_SENSE0 | 64  | LVTTL<br>5 V tolerant<br>Schmitt | Input            | MHL cable detection pins.<br>Only one of these five pins should be connected to HDMI/MHL multi input port. The rest of unused pins should be tied to ground.<br>These pins have an internal 300 kΩ pull-down resistor which is required for CD_SENSE by the MHL specification, so an external 300 kΩ pull-down resistor is not required for these pins                                                                                                                               |
| CD_SENSE1 | 65  |                                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CD_SENSE2 | 66  |                                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CD_SENSE3 | 67  |                                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CD_SENSE4 | 68  |                                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| GPIO0     | 69  | LVTTL<br>5 V tolerant<br>Schmitt | Input/<br>Output | General Purpose I/O                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| RESET_N   | 71  | LVTTL<br>5 V tolerant<br>Schmitt | Input            | External reset.<br>Active LOW. Must be pulled-up to PWRMUX_OUT. Apply external reset only when internal POR does not work properly. Refer to the Programmer's Reference for more details about the external reset sequence. When main power is not provided to the system, the microcontroller must present a high-impedance of at least 100 kΩ to RESET_N. If this condition is not met, a circuit to block the leakage from PWRMUX_OUT to the microcontroller GPIO may be required |

#### 4.2.6. Configuration Pins

| Pin Name   | Pin | Type                             | Dir              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------|-----|----------------------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TPWR_CI2CA | 70  | LVTTL<br>5 V tolerant<br>Schmitt | Input/<br>Output | I <sup>2</sup> C Slave Address input/Transmit Power Sense Output.<br>During chip reset, either by internal Power-on-Reset (POR) or the RESET_N signal, this pin is used as an input to latch the I <sup>2</sup> C sub-address. The level on this pin is latched when the POR transitions from the asserted state to the deasserted state or on a LOW-to-HIGH transition of the RESET_N signal.<br>After completion of reset, this pin is used as the TPWR output, showing the RnPWR status of the selected port. A register setting can change this pin to show if the active port is receiving a TMDS clock.<br>This pin must be tied to ground for the 0xB0 I <sup>2</sup> C address through a 4.7 kΩ resistor. For the 0xB2 I <sup>2</sup> C address, this pin must be pulled up to PWRMUX_OUT through a 4.7 kΩ resistor. |
| INT        | 74  | LVTTL<br>5 V tolerant<br>Schmitt | Input/<br>Output | Interrupt Output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

#### 4.2.7. Power and Ground Pins

| Pin Name   | Pin        | Type   | Description                                                                                                                                                                    |
|------------|------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VDD33      | 17, 27, 98 | Power  | TMDS Core VDD. In order to prevent reverse leakage from source device through TMDS input pins, VDD33 should be isolated from other system power.<br>Must be supplied at 3.3 V. |
| PWRMUX_OUT | 61         | Output | Power Output.<br>This pin requires a 10 $\mu$ F capacitor to ground. Maximum output current is 30 mA.                                                                          |
| SBVCC5     | 60         | Power  | Local Power from TV.<br>Must be set to 5 V. This pin requires a 10 $\Omega$ series resistor.                                                                                   |
| AVDD12     | 7, 26, 97  | Power  | TMDS Receiver Core.<br>Must be supplied at 1.2 V.                                                                                                                              |
| VDD12      | 8, 36, 77  | Power  | Digital Core.<br>Must be supplied at 1.2 V.                                                                                                                                    |
| TCVDD12    | 87         | Power  | TMDS Transmitter Core.<br>Must be supplied at 1.2 V.                                                                                                                           |
| TPVDD12    | 88         | Power  | TMDS Transmitter PLL.<br>Must be supplied at 1.2 V.                                                                                                                            |
| LPSBV      | 62         | Power  | Low-power Standby Power. Always on. Must be supplied at 3.3 V. This pin requires a 5.1 k $\Omega$ series resistor.                                                             |
| GND        | ePad       | Ground | The ePad <b>must</b> be soldered to ground, as this is the only ground connection for the device.                                                                              |

#### 4.2.8. Reserved Pins

| Pin Name | Pin | Type     | Description                       |
|----------|-----|----------|-----------------------------------|
| RSVDL    | 76  | Reserved | Reserved, must be tied to ground. |
| RSVD     | 63  | Reserved | Reserved, do not connect.         |

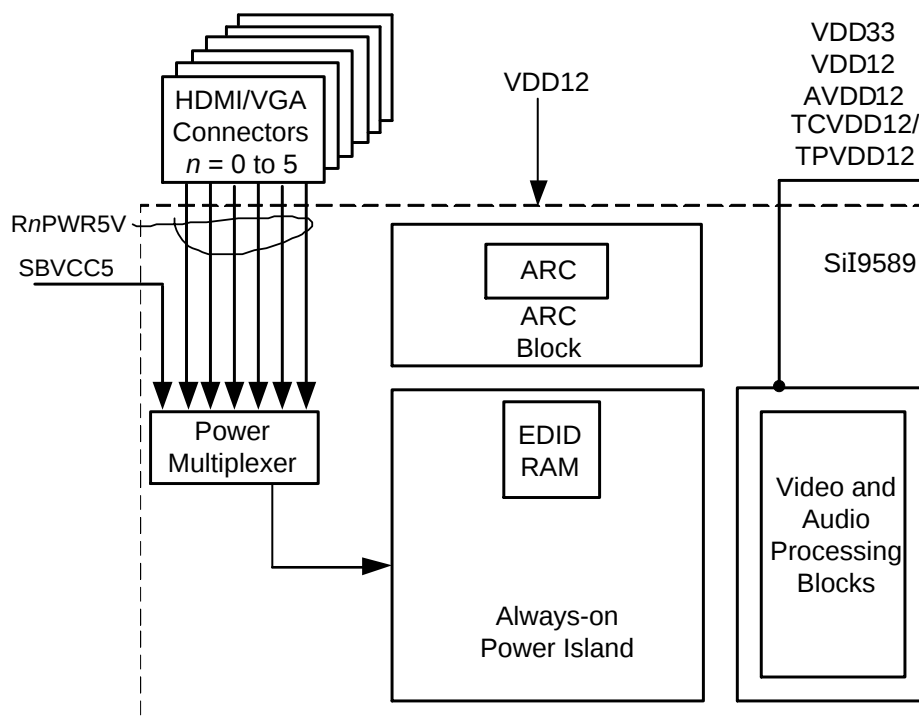
## 5. Feature Information

### 5.1. Standby and HDMI Port Power Supplies

The SiI9589 port processor incorporates a 5 V standby power supply pin (SBVCC5). SBVCC5 can be used to supply power to the EDID portions of the device when all other power supplies are turned off. This arrangement allows the EDID to be readable. [Table 5.1](#) summarizes the power modes available in the processor. [Figure 5.1](#) on the next page shows a block diagram of the standby power supply sources and the always-on power island.

**Table 5.1. Description of Power Modes**

| Power mode                               | Description                                                                                                                                                                                                                                          | SBVCC5 | RnPWR5V          | VDD33      | VDD12 |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------|------------|-------|
| Power-on mode 5 V Standby. ARC supported | All power supplies to the SiI9589 chip are on. All functions are available. The standby power supply is 5 V.                                                                                                                                         | 5 V    | Do not Care      | 3.3 V      | 1.2 V |
| Standby power mode. ARC mode             | The always-on power domain is on, supplied from the internal power MUX; ARC is supported.                                                                                                                                                            | 5 V    | 5 V on Port 1    | Don't Care | 1.2 V |
| Standby power mode. 5 V standby          | The always-on power domain is on, supplied from the internal power MUX; all other supplies are off. The standby power supply is 5 V. In this mode, EDID is functional, but both video and audio processing is not performed and all outputs are off. | 5 V    | Don't Care       | Off        | Off   |
| HDMI Port only power                     | Power is off to the device. HDMI +5 V from the HDMI cable is the only power source. For example, if the TV is unplugged from AC wall outlet, the EDID is functional in this mode.                                                                    | Off    | 5 V on any input | Off        | Off   |
| VGA Port only power                      | Power is off to the device. VGA +5 V from the VGA cable is the only power source. For example, if the TV is unplugged from AC power, the EDID is functional in this mode.                                                                            | Off    | 5 V              | Off        | Off   |



**Figure 5.1. Standby Power Supply Diagram**

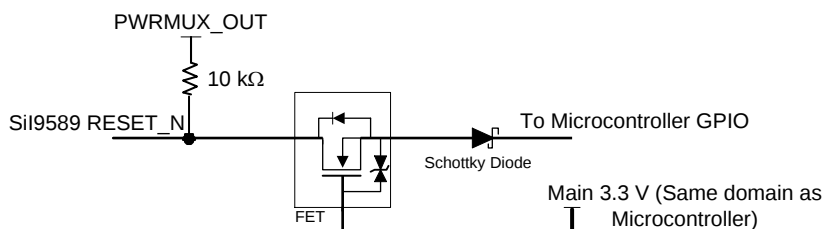
If all power is off to the device (for example, if the TV is unplugged from the AC electrical outlet), the EDID can still be read from the source by using power from the HDMI connector +5 V signal. In this case, the internal power MUX will automatically switch to the HDMI connector power to use it for powering the EDID logic. In this mode, only the EDID block is functional, with all other functions of the device in power-off mode. No damage will occur to the device in this mode.

## 5.2. Hardware Reset

Lattice Semiconductor recommends applying a hardware reset through RESET\_N pin only when a POR reset problem is detected by the indicating register (Refer to the SiI9589 Programmer's Reference). The connection for RESET\_N should meet the following conditions:

1. The microcontroller GPIO used to connect to RESET\_N must have more than 100 kΩ impedance when the microcontroller does not have power.
2. RESET\_N must be pulled HIGH at all times, except when it is necessary to be toggled.
3. The GPIO should be high-impedance by default when the microcontroller boots up, and should not toggle RESET\_N.
4. There should be no leakage between PWRMUX\_OUT and the microcontroller GPIO through RESET\_N that might disrupt the main system or the port processor when the system is in standby mode. Ensure that PWRMUX\_OUT goes HIGH earlier than the microcontroller GPIO so that the leakage from PWRMUX\_OUT through RESET\_N does not affect the main system.

For the board design to meet the above conditions, a circuit such as the one shown in Figure 5.2 on the next page may be required.



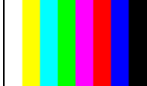
**Figure 5.2. External Reset Circuit**

After a hardware reset, the Si9589 device latches the level on the TPWR\_CI2CA pin to set the device I<sup>2</sup>C address, restores all registers to default values, and reloads the EDID data and Auto-boot data from NVRAM. Hardware reset also toggles Hot Plug.

### 5.3. Built-in Pattern Generator

The Si9589 port processor supports a built-in pattern generator that supports the eight patterns shown in Table 5.2 at 1280 x 720 resolution. Either an internal oscillator with a part-to-part accuracy of  $\pm 10\%$  or an external 74.25 MHz clock with higher accuracy can be used as the clock source for the pattern generator. These patterns are invoked through the I<sup>2</sup>C interface. See the Si9589 Programmer's Reference for details on how to activate the pattern generator.

**Table 5.2. Built-in Pattern List**

| Pattern        | RGB Description                                                                                                                                                                     | Example Picture                                                                       |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Solid Red      | 255, 0, 0                                                                                                                                                                           |    |
| Solid Green    | 0, 255, 0                                                                                                                                                                           |   |
| Solid Blue     | 0, 0, 255                                                                                                                                                                           |  |
| Solid Black    | 0, 0, 0                                                                                                                                                                             |  |
| Solid White    | 255, 255, 255                                                                                                                                                                       |  |
| 256 Grey Ramp  | 256 vertical bars, 5 pixels wide.<br>RGB value of first bar: (0, 0, 0)<br>RGB value of last bar: (255, 255, 255)<br>Increment of each bar: One RGB value (1, 1, 1), (2, 2, 2), etc. |  |
| Checkerboard   | 8 x 6 black/white squares.<br>No border<br>RGB value of white: (0, 0, 0)<br>RGB value of black: (255, 255, 255)                                                                     |  |
| RGB Color Bars | 8 vertical bars.<br>White: 255, 255, 255; Yellow: 255, 255, 0<br>Cyan: 0, 255, 255; Green: 0, 255, 0<br>Magenta: 255, 0, 255; Red: 255, 0, 0<br>Blue: 0, 0, 255; Black: 0, 0, 0     |  |

### 5.4. 3D Video Formats

The Si9589 port processor supports the pass-through of 3D video modes described in the HDMI 1.4a Specification. All modes support RGB 4:4:4, YCbCr 4:4:4, and YCbCr 4:2:2 color formats and 8-, 10-, and 12-bit data-width per color component. Table 5.3 shows only the maximum possible resolution with a given frame rate; for example, Side-by-Side

(Half) mode is defined for 1080p, 60 Hz, which implies that 720p, 60 Hz and 480p, 60 Hz are also supported. Furthermore, a frame rate of 24 Hz also means that a frame rate of 23.98 Hz is supported and a frame rate of 60 Hz also means a frame rate of 59.94 Hz is supported. The input pixel clock changes accordingly.

Pass-through of the HDMI Vendor Specific InfoFrame, which carries 3D information to the receiver, is supported by the SiI9589 device. It also supports extraction of the HDMI Vendor-specific InfoFrame, which allows the 3D information contained in the InfoFrame to be passed to the host system over the I<sup>2</sup>C port.

**Table 5.3. Supported 3D Video Formats**

| 3D Format         | Extended Definition | Resolution | Frame Rate (Hz) | Input Pixel Clock (MHz)                    |
|-------------------|---------------------|------------|-----------------|--------------------------------------------|
| Frame Packing     | —                   | 1080p      | 50/60           | 297<br>(Supported by 300 MHz version only) |
| Side-by-Side      | full                |            |                 |                                            |
| Line Alternative  | —                   |            |                 |                                            |
| L+ Depth          | —                   |            |                 |                                            |
| Frame Packing     | —                   | 1080p      | 24/30           | 148.5                                      |
|                   |                     | 720p/1080i | 50/60           |                                            |
| Side-by-Side      | full                | 1080p      | 24/30           |                                            |
|                   |                     | 720p/1080i | 50/60           |                                            |
|                   | half                | 1080p      | 50/60           |                                            |
| Top-and-Bottom    | —                   | 1080p      | 50/60           | 74.25                                      |
|                   |                     | 1080p      | 24/30           |                                            |
|                   |                     | 720p/1080i | 50/60           |                                            |
| Line Alternative  | —                   | 1080p      | 24/30           | 148.5                                      |
|                   |                     | 720p/1080i | 50/60           |                                            |
| Field Alternative | —                   | 1080i      | 50/60           |                                            |
| L + depth         | —                   | 1080p      | 24/30           |                                            |
|                   |                     | 720p/1080i | 50/60           |                                            |

## 5.5. 3D Markers and VS Insertion

The SiI9589 device features logic that can be used to assist the downstream SoC in processing 3D video for display. It can monitor the 3D video stream and insert a VS pulse in the VS signal during the Active space period for demarcating the L and R video frames. It can embed markers that identify the L active video region, the R active video region, and the Active space region directly in the video stream on either the CTL0 or CTL1 signals. Separately, the L active video region marker can also be sent on the GPIO0 pin. The port processor can be enabled to send the 3D markers when 3D video is detected, or the markers can be enabled by software manually.

Figure 5.3 on the next page shows the VS insertion mode. The front porch, pulse width, back porch, and polarity of the inserted VS signal can be individually set.

Figure 5.4 on the next page illustrates the mode that embeds 3D markers in the CTL0/CTL1 signals. The L, R, and Active space markers can be individually switched on. In addition, each marker can be embedded in CTL0, CTL1, or in both. For example, the L marker can be embedded in CTL0 and the R marker in CTL1. The polarity of the markers is also programmable. However, a delay function is not supported, nor is the pulse width of the markers adjustable; these parameters are fixed to the input timing.

3D markers are supported only for 720p frame-packed, and 1080p frame-packed video modes.

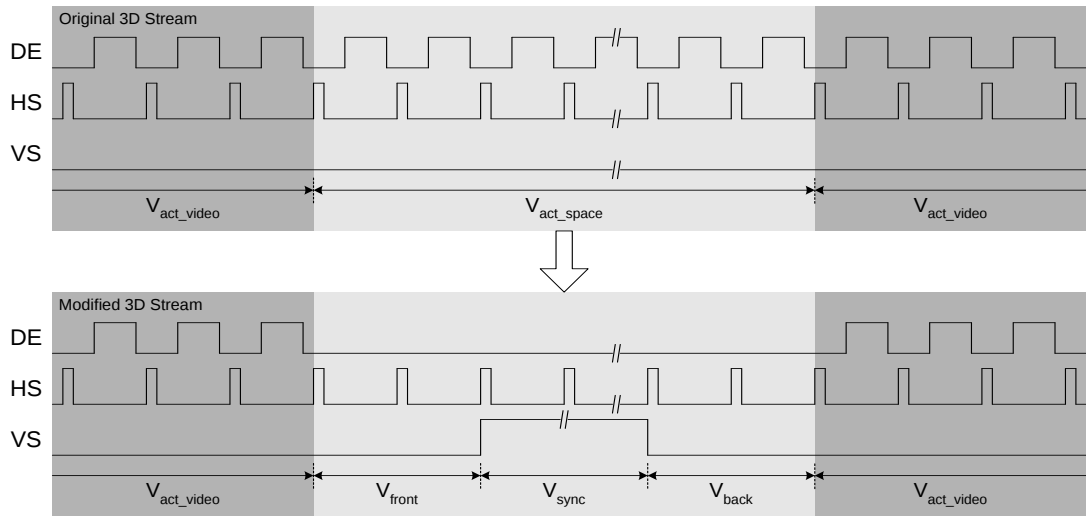


Figure 5.3. VS Insertion in Active Space

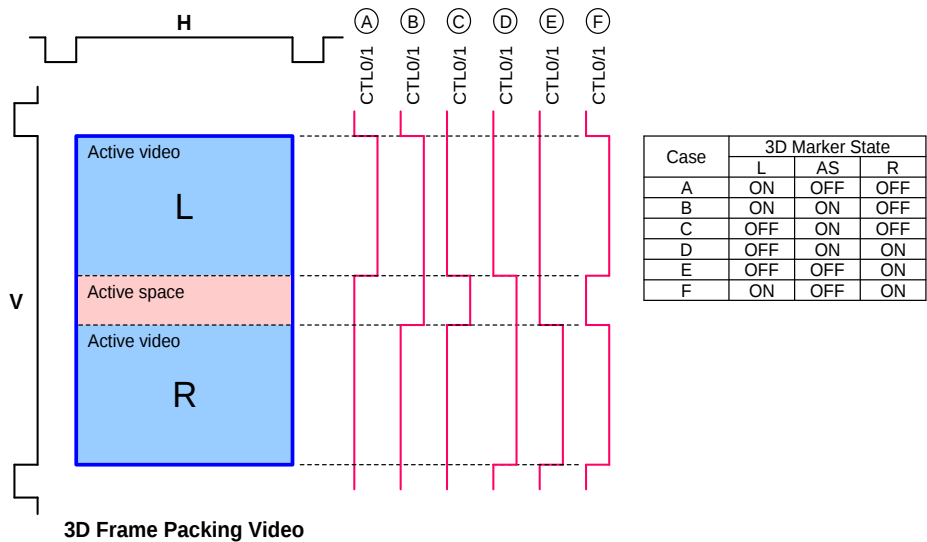


Figure 5.4. 3D Markers on CTL0/1 Signals

## 5.6. Input Video Resolution Detection and InfoFrame Extraction

InfoFrame extraction and input video resolution detection are supported for the main and roving port and are accessible port-by-port. This feature helps microcontroller reduce switching time to predetermine resolution and InfoFrame before switching.

## 5.7. Repeater Support

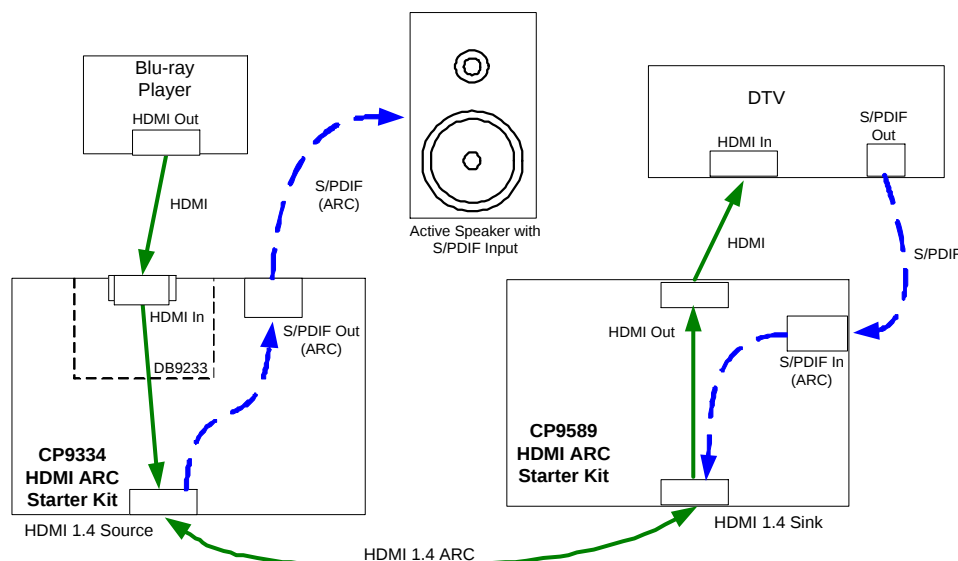
Repeater support is provided for the active port and supports up to 127 downstream devices. Repeater applications also support InstaPort S. With InstaPort S, authentication for unselected ports is accomplished in the background so when a new port that was pre-authenticated is selected, the content can be shown to the user with minimal time delay. InstaPort S can be supported when the device is used as a repeater.

## 5.8. Audio Return Channel

ARC is transmitted in single mode by using the ARCP (Utility) line. When using ARC single-mode transmission, a standard HDMI cable can be used. *Utility* is a new name for the *Reserved* pin described in earlier versions of the HDMI Specification (The SiI9589 port processor doesn't support ARC common-mode.)

The way the S/PDIF backchannel is used depends on the application. For example, in a TV application, an S/PDIF audio signal from the TV can be sent to an HDMI source device such as an A/V receiver over the Audio Return Channel.

ARC simplifies system setup because the consumer does not need to run an S/PDIF cable from the TV to the AVR. ARC also automates connectivity. When the TV input is switched to an analog source or the TV tuner, the TV can use the CEC protocol to indicate to the AVR that it should switch to playback of the ARC input.



**Figure 5.5. Audio Return Channel Example Application**

## 5.9. EDID Memory

The port processor contains 512 bytes of NVRAM that stores common EDID data used by each of the ports and information used by the Auto-Boot feature. The Auto-Boot feature initializes some of the registers used to enable the EDID for the respective port, as well as asserts Hot Plug Detect (HPD) after the EDID has loaded properly into the SRAM. For example, by changing the data in the NVRAM Auto-boot portion, EDID load and HPD state can be set HIGH in 4 of the HDMI ports while disabling this feature in the fifth port. See the associated Programmer's Reference for more detail about the format of the NVRAM Auto-boot feature. Each port has a 256-byte block of SRAM for EDID data, which allows all ports to be read simultaneously from five different sources connected to the SiI9589 device. In addition, a 128-byte block of NVRAM is reserved for the VGA EDID. Figure 5.6 shows how the NVRAM is initialized using the local I<sup>2</sup>C slave and the shadow SRAM during manufacture, and how data is loaded into the SRAM blocks from the NVRAM during normal operation.

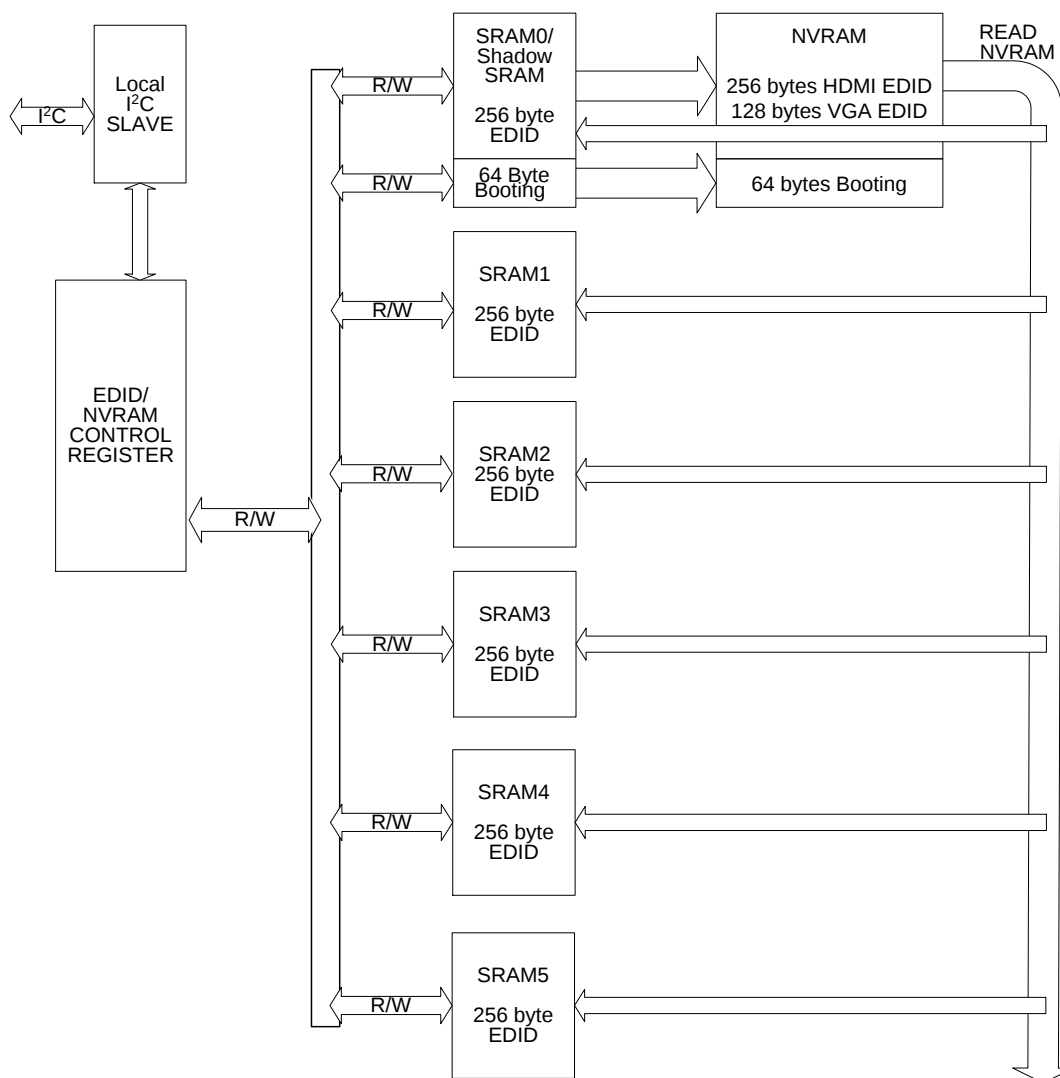


Figure 5.6. EDID Block Diagram

## 5.10. Local I<sup>2</sup>C Port

The local I<sup>2</sup>C slave port on the SiI9589 port processor (pins CSCL and CSDA) is capable of running up to 400 kHz. This port is used to configure the port processor by reading from and writing to necessary registers.

The local I<sup>2</sup>C port consists of ten separate I<sup>2</sup>C slave addresses. Therefore, the port processor appears as ten separate devices on the I<sup>2</sup>C local bus. The address for accessing the system control registers is fixed, and can only be set to one of two values by using the CI2CA pin. The remaining nine addresses have an I<sup>2</sup>C register-programmable address mapped into the system control register space so that they can be changed to any free addresses in the system. Refer to the Programmer's Reference for complete information.

**Table 5.4. I<sup>2</sup>C Register Address Groups**

| I <sup>2</sup> C Slave Address | Through                | Register Programmable | Blocks                    |
|--------------------------------|------------------------|-----------------------|---------------------------|
| 0x74                           | DDC                    | No                    | HDCP                      |
| 0xA0                           | DDC                    | No                    | EDID                      |
| 0x64                           | Local I <sup>2</sup> C | Yes                   | Rx TMDS – Rx0, Rx1        |
| 0x50                           | Local I <sup>2</sup> C | Yes                   | Preauthentication, page 0 |
| 0x52                           | Local I <sup>2</sup> C | Yes                   | Preauthentication, page 1 |
| 0x54                           | Local I <sup>2</sup> C | Yes                   | Preauthentication, page 2 |
| 0x66                           | Local I <sup>2</sup> C | Yes                   | Rx TMDS – Rx2, Rx3        |
| 0x68                           | Local I <sup>2</sup> C | Yes                   | Rx TMDS – Rx4             |
| 0x90                           | Local I <sup>2</sup> C | Yes                   | Tx TMDS /ARC              |
| 0xB0 / 0xB2                    | Local I <sup>2</sup> C | No                    | System Control            |
| 0xE0                           | Local I <sup>2</sup> C | Yes                   | EDID/NVRAM/MHL            |
| 0xE6                           | Local I <sup>2</sup> C | Yes                   | CBUS                      |

## 6. Design Recommendations

### 6.1. Audio Return Channel Design

Figure 6.1 shows a sample design circuit for using the Audio Return Channel feature. Any one of the five input ports can be wired for ARC use; connection to Port 1 for ARC is shown in the figure.

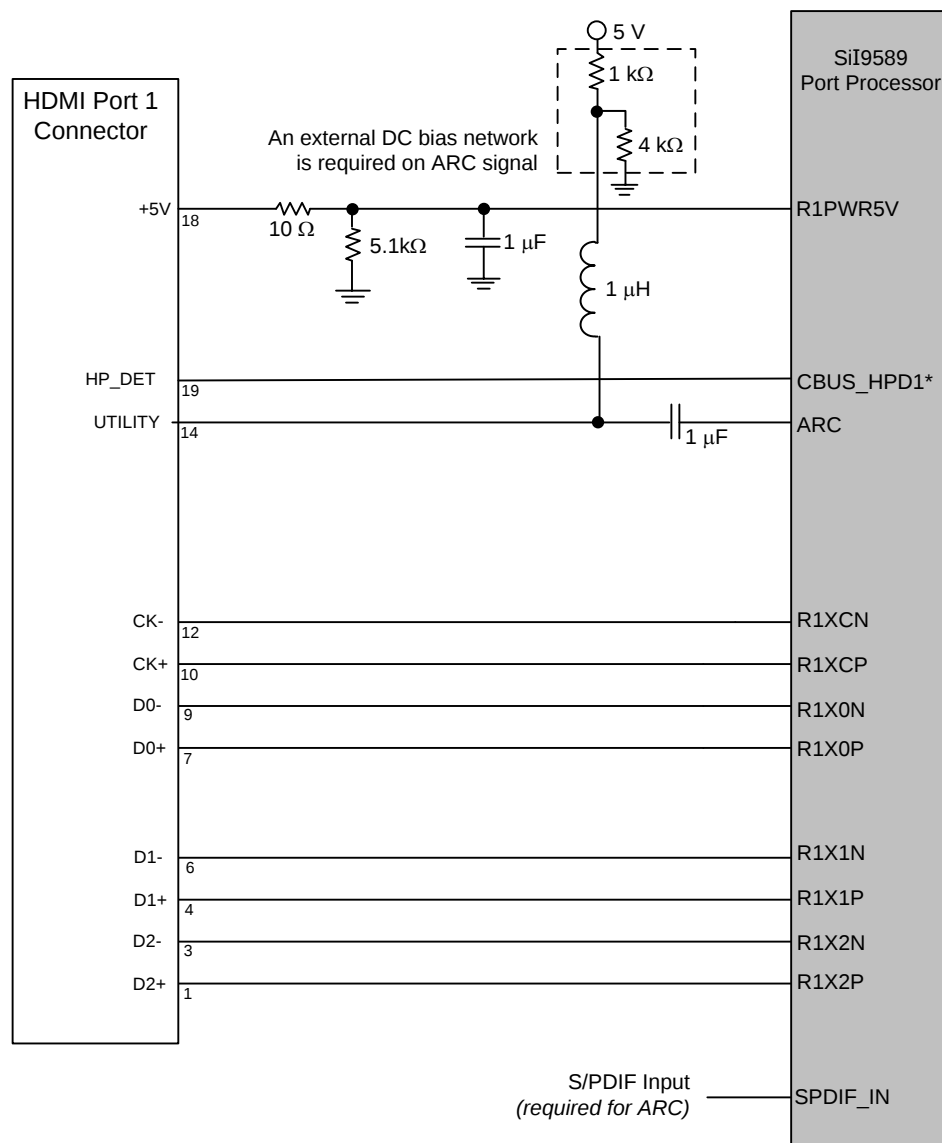


Figure 6.1. Connection of ARC to HDMI Port

## 6.2. MHL Power and Cable Detect Design

Figure 6.2 shows a sample design circuit for MHL Power and Cable Detect. All eight TMDS connections require  $5.1\ \Omega$  series resistors for ports that are wired for both MHL and HDMI. Any one of the input ports can be wired for MHL; connection to Port 4 for combined HDMI and MHL is shown in the figure.

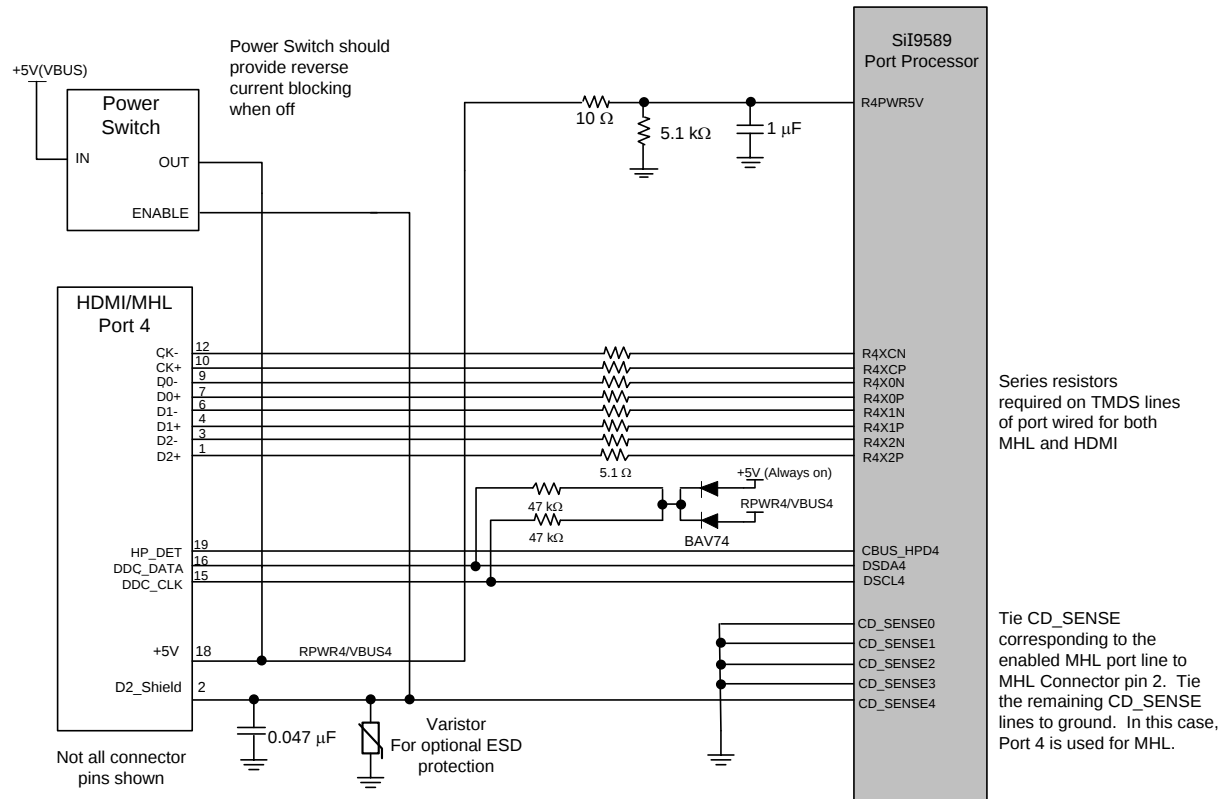


Figure 6.2. Connection of MHL Power and Cable Detect

## 6.3. Power Supply Decoupling

Designers should include decoupling and bypass capacitors at each power signal in the layout. These are shown schematically in Figure 6.3. Connections in one group (such as VDD33) can share C2, C3, and the ferrite, with each pin having a separate C1 placed as close to the pin as possible. Figure 6.4 on the next page is representative of the various types of power connections on the port processor.

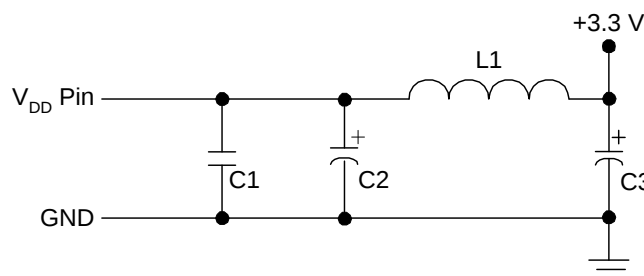
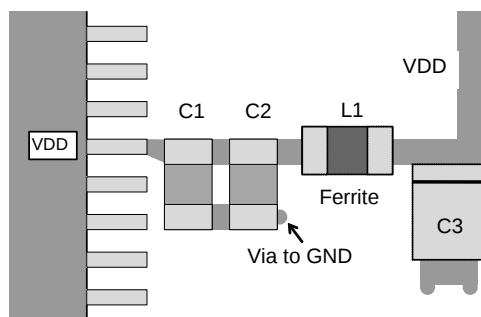


Figure 6.3. Decoupling and Bypass Schematic



**Figure 6.4. Decoupling and Bypass Capacitor Placement**

## 6.4. Power Supply Sequencing

All power supplies in the SiI9589 port processor are independent, but identical supplies must come on at the same time; for example, power to all VDD33 pins must come on together. During power up, the SBVCC5 rise time (from 10% to 90% of 5 V) should be less than 1 ms.

## 7. Package Information

### 7.1. ePad Requirements

The SiI9589 port processor chip is packaged in a 100-pin, 14 mm x 14mm TQFP package with an exposed pad (ePad) that is used for the electrical ground of the device and for improved thermal transfer characteristics. The ePad dimensions are 5 mm x 5 mm  $\pm 0.15$  mm. Soldering the ePad to the ground plane of the PCB is **required** to meet package power dissipation requirements at full speed operation, and to correctly connect the chip circuitry to electrical ground. A clearance of at least 0.25 mm should be designed on the PCB between the edge of the ePad and the inner edges of the lead pads to avoid the possibility of electrical shorts.

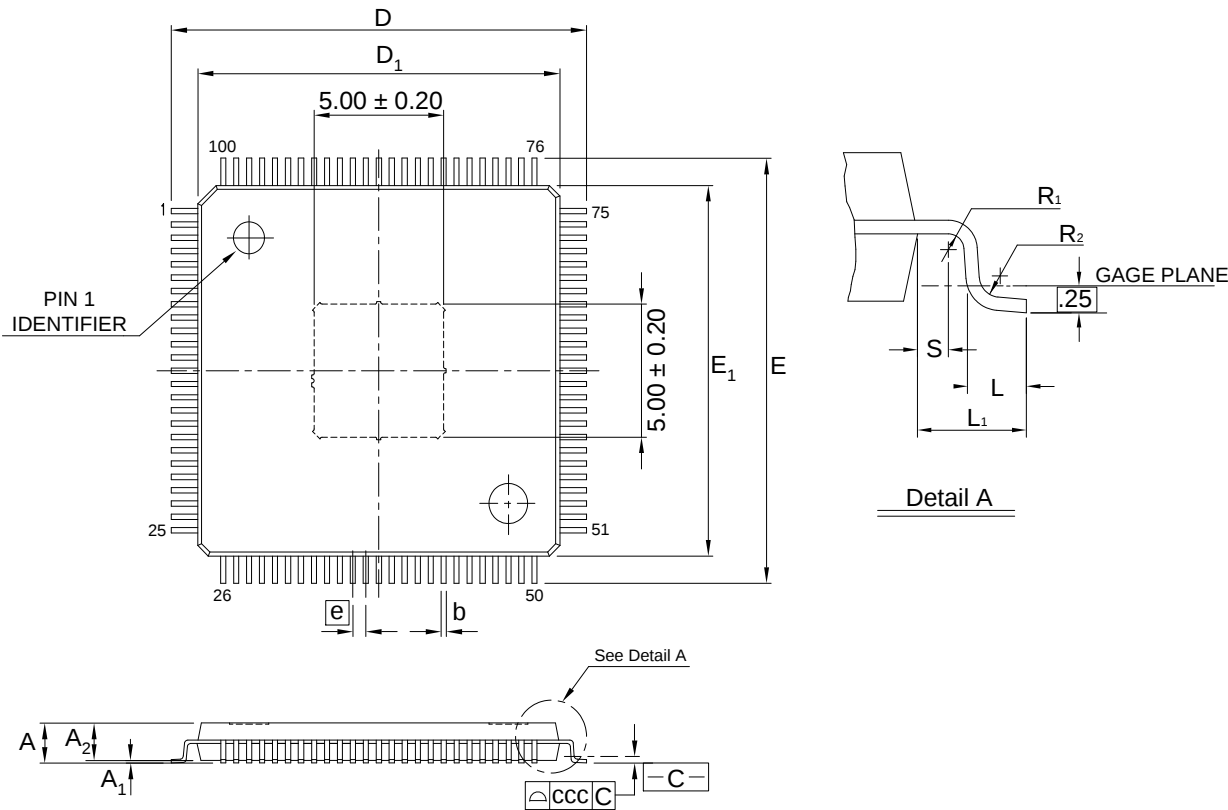
The thermal land area on the PCB may use thermal vias to improve heat removal from the package. These thermal vias also double as the ground connections of the chip and must attach internally in the PCB to the ground plane. An array of vias should be designed into the PCB beneath the package. For optimum thermal performance, the via diameter should be 12 mils to 13 mils (0.30 mm to 0.33 mm) and the via barrel should be plated with 1-ounce copper to plug the via. This design helps to avoid any solder wicking inside the via during the soldering process, which may result in voids in solder between the pad and the thermal land. If the copper plating does not plug the vias, the thermal vias can be tented with solder mask on the top surface of the PCB to avoid solder wicking inside the via during assembly. The solder mask diameter should be at least 4 mils (0.1 mm) larger than the via diameter.

Package stand-off when mounting the device also needs to be considered. For a nominal stand-off of approximately 0.1 mm the stencil thickness of 5 mils to 8 mils should provide a good solder joint between the ePad and the thermal land.

Figure 7.1 on the next page shows the package dimensions of the SiI9589 port processor.

## 7.2. Package Dimensions

These drawings are not to scale.



**Figure 7.1. Package Diagram**  
**JEDEC Package Code MS-026**

| Item           | Description    | Min       | Typ  | Max  |
|----------------|----------------|-----------|------|------|
| A              | Thickness      | —         | —    | 1.20 |
| A1             | Stand-off      | 0.05      | —    | 0.15 |
| A2             | Body thickness | 0.95      | 1.00 | 1.05 |
| D              | Footprint      | 16.00 BSC |      |      |
| E              | Footprint      | 16.00 BSC |      |      |
| D <sub>1</sub> | Body size      | 14.00 BSC |      |      |
| E <sub>1</sub> | Body size      | 14.00 BSC |      |      |
| b              | Lead width     | 0.17      | 0.22 | 0.27 |

| Item           | Description          | Min      | Typ  | Max  |
|----------------|----------------------|----------|------|------|
| C              | Lead thickness       | 0.09     | —    | 0.20 |
| e              | Lead pitch           | 0.50 BSC |      |      |
| L              | Lead foot length     | 0.45     | 0.60 | 0.75 |
| L <sub>1</sub> | Total lead length    | 1.00 REF |      |      |
| R <sub>1</sub> | Lead radius, inside  | 0.08     | —    | —    |
| R <sub>2</sub> | Lead radius, outside | 0.08     | —    | 0.20 |
| S              | Lead horizontal run  | 0.20     | —    | —    |
| ccc            | Lead coplanarity     | 0.08     |      |      |

## 7.3. Marking Specification

Figure 7.2 shows the markings of the SiI9589 port processor package. This drawing is not to scale.

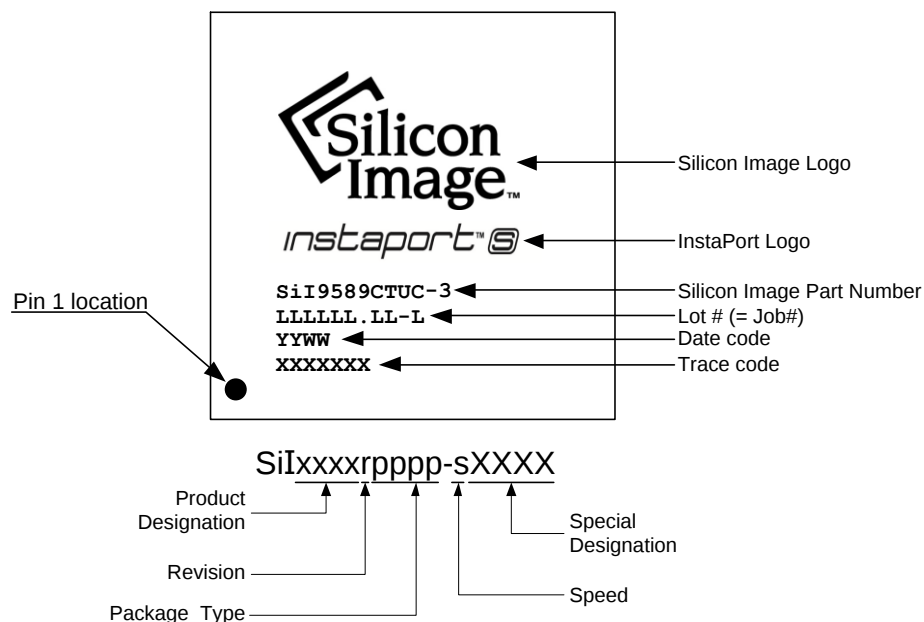


Figure 7.2. Marking Diagram

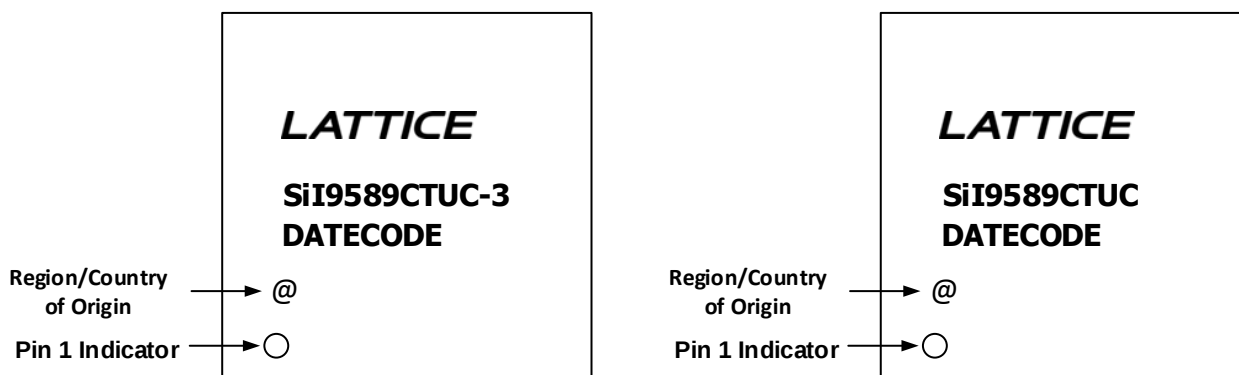


Figure 7.3. Alternate Marking Diagram

## 7.4. Ordering Information

Production Part Numbers:

| Device                                           | Part Number   |
|--------------------------------------------------|---------------|
| Port processor with ARC and InstaPort S          | SiI9589CTUC   |
| Port processor with ARC and InstaPort S, 300 MHz | SiI9589CTUC-3 |

## References

### Standards Documents

This is a list of standards abbreviations appearing in this document, and references to their respective specifications documents.

| Abbreviation | Standards publication, organization, and date                                                                   |
|--------------|-----------------------------------------------------------------------------------------------------------------|
| HDMI         | <i>High Definition Multimedia Interface</i> , Revision 1.4, Licensing, LLC, June 2009                           |
| HCTS         | <i>HDMI Compliance Test Specification</i> , Revision 1.4, Licensing, LLC, November 2009                         |
| HDCP         | <i>High-bandwidth Digital Content Protection</i> , Revision 1.3, Digital Content Protection, LLC, December 2006 |
| DVI          | <i>Digital Visual Interface</i> , Revision 1.0, Digital Display Working Group, April 1999                       |
| E-EDID       | <i>Enhanced Extended Display Identification Data Standard</i> , Release A Revision 1, VESA, Feb. 2000           |
| E-DID IG     | <i>VESA EDID Implementation Guide</i> , VESA, June 2001                                                         |
| CEA-861-E    | <i>A DTV Profile for Uncompressed High Speed Digital Interfaces</i> , EIA/CEA, March 2008                       |
| EDDC         | <i>Enhanced Display Data Channel Standard</i> , Version 1.1, VESA, September 1999                               |
| MHL          | <i>MHL (Mobile High-definition Link) Specification</i> , Version 1.0, MHL, LLC, June 2010                       |

### Standards Groups

For information on the specifications that apply to this document, contact the responsible standards groups appearing on this list.

| Standards Group | Web URL                                                                 |
|-----------------|-------------------------------------------------------------------------|
| ANSI/EIA/CEA    | <a href="http://global.ihs.com">http://global.ihs.com</a>               |
| VESA            | <a href="http://www.vesa.org">http://www.vesa.org</a>                   |
| HDCP            | <a href="http://www.digital-cp.com">http://www.digital-cp.com</a>       |
| DVI             | <a href="http://www.ddwg.org">http://www.ddwg.org</a>                   |
| MHL             | <a href="http://www.mhlconsortium.org">http://www.mhlconsortium.org</a> |

### Lattice Semiconductor Documents

This is a list of the related documents that are available from your Lattice Semiconductor sales representative. *The Programmer's Reference requires an NDA with Lattice Semiconductor.*

| Document    | Title                                                            |
|-------------|------------------------------------------------------------------|
| Sil-PR-1058 | <i>Sil9587 and Sil9589 Port Processor Programmer's Reference</i> |

### Technical Support

For assistance, submit a technical support case at [www.latticesemi.com/techsupport](http://www.latticesemi.com/techsupport).

## Revision History

### Revision E, May 2017

Figure 7.3. Alternate Marking Diagram added per PCN13A16.

### Revision D, March 2016

Updated to latest template.

### Revision D, September 2013

Updated Table 3.3. Digital I/O Specifications and Table 3.16. Miscellaneous Timing.

### Revision C, June 2012

Updated Figure 6.2. Connection of MHL Power and Cable Detect.

### Revision B, January 2012

Updated Table 3.4. Power Requirements.

### Revision A, October 2011

First production release.



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