



## Integrated Circuit Systems

# ICS1527

## Video Clock Synthesizer

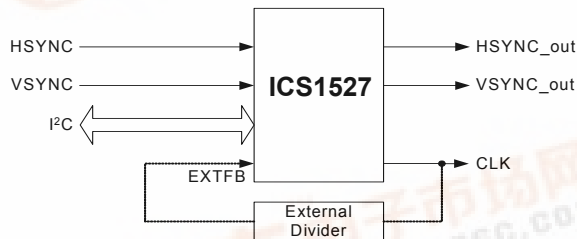
### General Description

The ICS1527 is a low-cost, high-performance frequency generator. It is suited to general purpose phase controlled clock synthesis as well as line-locked and genlocked high-resolution video applications. Using ICS's advanced low-voltage CMOS mixed-mode technology, the ICS1527 is an effective clock synthesizer that supports video projectors and displays at resolutions from VGA to beyond XGA.

The ICS1527 offers single-ended clock outputs to 60 or 110 MHz. The HSYNC\_out and VSYNC\_out pins provide the regenerated versions of the HSYNC and VSYNC inputs synchronous to the CLK output.

The advanced PLL uses either its internal programmable feedback divider or an external divider. The device is programmed by a standard I<sup>2</sup>C-bus™ serial interface and is available in a TSSOP16 package.

### ICS1527 Functional Diagram



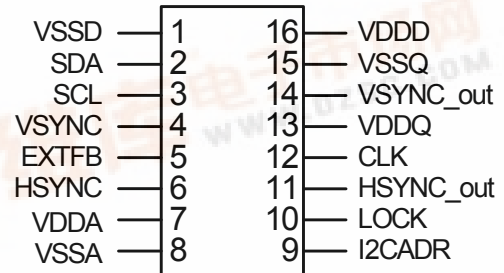
### Features

- Lead-free packaging (Pb-free)
- Low jitter (typical 27 ps short term jitter)
- LVCMOS single-ended clock outputs
  - 60/110 MHz speed grades available
- Uses 3.3 V power supply
- 5 Volt tolerant Inputs (HSYNC, VSYNC)
- Coast (ignore HSYNC) capability via VSYNC pin
- Industry standard I<sup>2</sup>C-bus programming interface
- PLL Lock detection via I<sup>2</sup>C or LOCK output pin
- 16-pin TSSOP package

### Applications

- Frequency synthesis
- LCD monitors, video projectors and plasma displays
- Genlocking multiple video subsystems

### Pin Configuration (16-pin TSSOP)





## Section 1 Overview

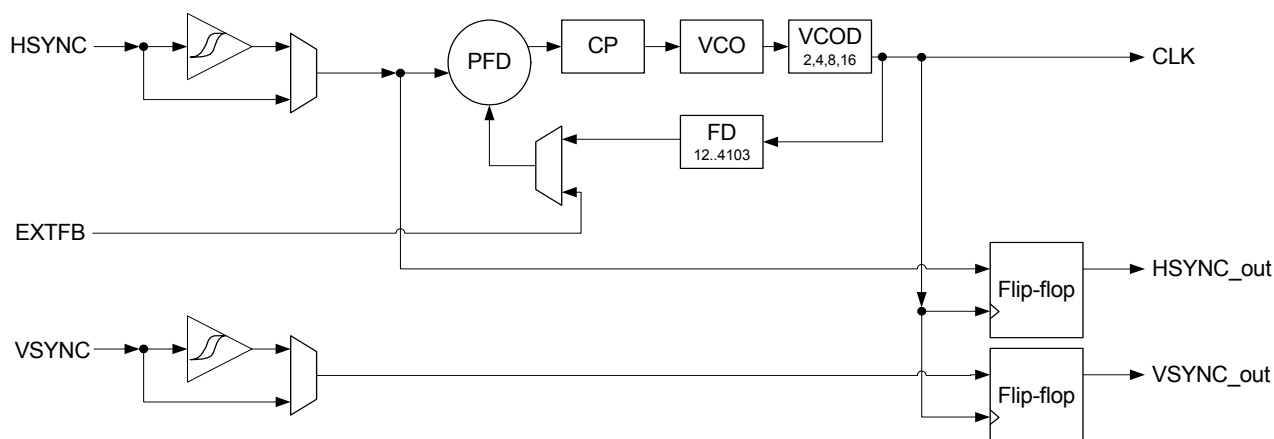
The ICS1527 is a user-programmable, high-performance general purpose clock generator. It is intended for graphics system line-locked and genlocked applications, and provides the clock signals required by high-performance analog-to-digital converters.

The ICS1527 has the ability to operate in line-locked mode with the HSYNC input.

### 1.1 Phase-Locked Loop

The phase-locked loop has a very wide input frequency range (8 kHz to 100 MHz). Not only is the ICS1527 an excellent, general purpose clock synthesizer, but it is also capable of line-locked operation. Refer to the block diagram below.

Figure 1-1 Simplified Block Diagram



Note: Polarity controls and other circuit elements are not shown in above diagram for simplicity

The heart of the ICS1527 is a voltage controlled oscillator (VCO). The VCO speed is controlled by the voltage on the loop filter. This voltage will be described later in this section.

The VCO's clock output is first passed through the VCO Divider (VCOD). The VCOD allows the VCO to operate at higher speeds than the required output clock.

**NOTE:** Under normal, locked operation the VCOD has no effect on the speed of the output clocks, just the VCO frequency.

The output of the VCOD is the full speed output frequency seen on the CLK. This clock is then sent through the 12-bit internal Feedback Divider (FD). The feedback divider controls how many clocks are seen during every cycle of the input reference.

The Phase Frequency Detector (PFD) then compares the feedback to the input and controls the filter voltage by enabling and disabling the charge pump. The charge pump has programmable current drive and will source and sink current as appropriate to keep the

input and the HSYNC\_out output aligned.

The input HSYNC and VSYNC can be conditioned by a high-performance Schmitt-trigger by sharpening the rising/falling edge.

The HSYNC\_out and VSYNC\_out signals are aligned with the output clock (CLK) via a set of flip flops.

### 1.2 Output Drivers and Logic Inputs

The ICS1527 uses low-voltage TTL (LVTTTL) inputs and LVCMOS outputs, operating at the 3.3 V supply voltage. The LVTTTL inputs are 5 V tolerant.

The LVCMOS drive resistive terminations or transmission lines.

### 1.3 Automatic Power-On Reset Detection

The ICS1527 has automatic power-on reset detection (POR) circuitry and it resets itself if the supply voltage drops below threshold values. No external connection to a reset signal is required.



## 1.4 I<sup>2</sup>C Bus Serial Interface

The ICS1527 uses a 5 volt tolerant, industry-standard I<sup>2</sup>C-bus serial interface that runs at either low-speed (100 kHz) or high-speed (400 kHz). The interface uses 12 word addresses for control and status: one write-only, eight read/write, and three read-only addresses.

Two ICS1527 devices can sit on the same I<sup>2</sup>C bus, each selected by the Master according to the state of the I2CADR pin. The 7 bit device address is 0100110 (binary) when I2CADR is low. The device address is 0100111 (binary) when I2CADR is high. See [Section 4](#), “Programming”



## Section 2 Pin Descriptions

**Table 2-1** ICS1527 Pin Descriptions

| PIN NO. | PIN NAME | TYPE           | DESCRIPTION                     | COMMENTS                                                               | Notes |
|---------|----------|----------------|---------------------------------|------------------------------------------------------------------------|-------|
| 1       | VSSD     | POWER          | Digital ground                  |                                                                        |       |
| 2       | SDA      | IN/OUT         | Serial data                     | I <sup>2</sup> C-bus                                                   | 1     |
| 3       | SCL      | IN             | Serial clock                    | I <sup>2</sup> C-bus                                                   | 1     |
| 4       | VSYN     | IN             | Vertical sync                   |                                                                        | 1 & 2 |
| 5       | EXTFB    | IN             | External feedback               | From External Divider                                                  | 1 & 2 |
| 6       | HSYN     | IN             | Horizontal sync                 | Clock input to PLL                                                     | 1 & 2 |
| 7       | VDDA     | POWER          | Analog supply                   | Power for analog circuitry                                             |       |
| 8       | VSSA     | POWER          | Analog ground                   | Ground for analog circuitry                                            |       |
| 9       | I2CADR   | IN             | I <sup>2</sup> C device address | Chip I <sup>2</sup> C address select                                   |       |
| 10      | LOCK     | LVC MOS<br>OUT | Lock                            | PLL lock                                                               |       |
| 11      | HSYN_out | LVC MOS<br>OUT | HSYN output                     | Schmitt-trigger filtered HSYN<br>realigned with the output pixel clock |       |
| 12      | CLK      | LVC MOS<br>OUT | Pixel clock output              | LVC MOS driver for full-speed clock                                    |       |
| 13      | VDDQ     | POWER          | Output driver supply            | Power for output drivers                                               |       |
| 14      | VSYN_out | LVC MOS<br>OUT | VSYN output                     | Schmitt-trigger filtered VSYN<br>realigned with the output pixel clock |       |
| 15      | VSSQ     | POWER          | Output driver ground            | Ground for output drivers                                              |       |
| 16      | VDDD     | POWER          | Digital supply                  | Power for digital sections                                             |       |

Notes: 1. These LVTTL inputs are 5 V tolerant.  
2. Connect to ground if unused.



## Section 3 Register map summary

| Word Address | Name                         | Access | Bit Name        | Bit# | Reset Value | Description                                                                                                                                                                                                                                                                                   |
|--------------|------------------------------|--------|-----------------|------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00h          | Input Control                | R / W  | CPen            | 0    | 1           | Charge Pump Enable<br>0=External Enable via VSYNC, 1=Always Enabled                                                                                                                                                                                                                           |
|              |                              |        | VSYNC_Pol       | 1    | 0           | VSYNC Polarity (Charge Pump Enable)<br>Requires 00h:0=0<br>0=Coast (charge pump disabled) while VSYNC low,<br>1=Coast (charge pump disabled) while VSYNC high                                                                                                                                 |
|              |                              |        | HSYNC_Pol       | 2    | 0           | HSYNC Polarity<br>0=Rising Edge, 1=Falling Edge                                                                                                                                                                                                                                               |
|              |                              |        | Fbk_Pol         | 3    | 0           | External Feedback Polarity<br>0=Positive Edge, 1=Negative Edge                                                                                                                                                                                                                                |
|              |                              |        | Fbk_Sel         | 4    | 0           | External Feedback Select<br>0=Internal Feedback, 1=External                                                                                                                                                                                                                                   |
|              |                              |        | Reserved        | 5    | 0           | Reserved                                                                                                                                                                                                                                                                                      |
|              |                              |        | EnPLS           | 6    | 1           | Enable PLL Lock Status Output<br>0=Disable, 1=Enable                                                                                                                                                                                                                                          |
|              |                              |        | Reserved        | 7    | 0           | Reserved                                                                                                                                                                                                                                                                                      |
| 01h          | Loop Control <sup>*</sup>    | R / W  | ICP0-2          | 0-2  |             | ICP (Charge Pump Current)<br>Bit 2,1,0 = {000 = 1 $\mu$ A, 001 = 2 $\mu$ A, 010 = 4 $\mu$ A... 110 = 64 $\mu$ A, 111 = 128 $\mu$ A}. Increasing the PF Detector Gain makes the loop respond faster, raising the loop bandwidth. The typical value when using the internal loop filter is 011. |
|              |                              |        | Reserved        | 3    |             | Reserved                                                                                                                                                                                                                                                                                      |
|              |                              |        | VCOD0-1         | 4-5  |             | VCO Divider<br>Bit 5,4 = {00 = $\div 2$ , 01 = $\div 4$ , 10 = $\div 8$ , 11 = $\div 16$ }                                                                                                                                                                                                    |
|              |                              |        | Reserved        | 6-7  |             | Reserved                                                                                                                                                                                                                                                                                      |
| 02h          | FdBk Div 0 <sup>*</sup>      | R / W  | FBD0-7          | 0-7  |             | Feedback Divider LSBs (bits 0-7)                                                                                                                                                                                                                                                              |
| 03h          | FdBk Div 1 <sup>*</sup>      | R / W  | FBD8-11         | 0-3  |             | Feedback Divider MSBs (bits 8-11)<br>Divider setting = 12 bit word + 8<br>Minimum 12 = 00000000100<br>Maximum 4103 = 111111111111                                                                                                                                                             |
|              |                              |        | Reserved        | 4-7  |             | Reserved                                                                                                                                                                                                                                                                                      |
| 04h          | Reserved                     |        | Reserved        | 0-7  | 0           | Reserved                                                                                                                                                                                                                                                                                      |
| 05h          | Schmitt-trigger <sup>*</sup> | R / W  | Schmitt control | 0    | 1           | Schmitt-trigger control<br>0=Schmitt-trigger, 1=No Schmitt-trigger                                                                                                                                                                                                                            |
|              |                              |        | Metal_Rev       | 1-7  | 0           | Metal Mask Revision Number                                                                                                                                                                                                                                                                    |
| 06h          | Output Enables               | R / W  | Reserved        | 0    | 0           | Reserved                                                                                                                                                                                                                                                                                      |
|              |                              |        | OE              | 1    | 0           | Output Enable for CLK, HSYNC_out, VSYNC_out<br>0=High Impedance (disabled), 1=Enabled                                                                                                                                                                                                         |
|              |                              |        | Reserved        | 2-7  | 0           | Reserved                                                                                                                                                                                                                                                                                      |



| Word Address | Name     | Access | Bit Name | Bit# | Reset Value | Description                                                                          |
|--------------|----------|--------|----------|------|-------------|--------------------------------------------------------------------------------------|
| 07h          | Reserved |        | Reserved | 0-6  |             | Reserved                                                                             |
|              |          |        | Reserved | 7    | 0           | Part requires a 0 for correct operation                                              |
| 08h          | Reset    | Write  | Reserved | 0-7  | 0           | Writing 5Ah resets part and commits values written to word addresses 01h-03h and 05h |
| 09-0Fh       | Reserved | Read   | Reserved | 0-7  |             | Reserved                                                                             |
| 10h          | Chip Ver | Read   | Reserved | 0-7  |             | Reserved                                                                             |
| 11h          | Chip Rev | Read   | Chip Rev | 0-7  | 01          | Reserved                                                                             |
| 12h          | Rd_Reg   | Read   | Reserved | 0    | N/A         | Reserved                                                                             |
|              |          |        | PLL_Lock | 1    | N/A         | PLL Lock Status<br>0=Unlocked, 1=Locked                                              |
|              |          |        | Reserved | 2-7  | 0           | Reserved                                                                             |

\*. Written values to these registers do not take effect immediately, but require a commit via register 08h

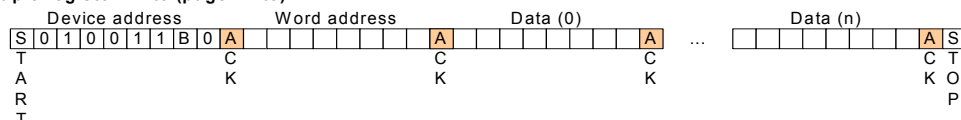


## Section 4 Programming

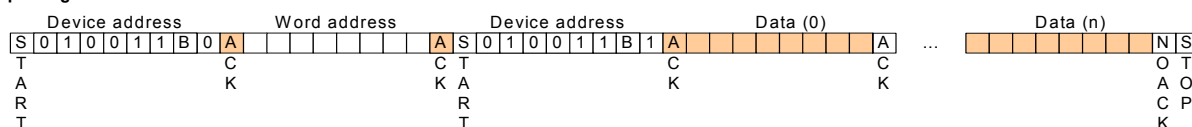
### 4.1 Industry-Standard I<sup>2</sup>C Serial Bus: Data Format

Figure 4-1 ICS1527 Data Format for I<sup>2</sup>C 2-Wire Serial Bus

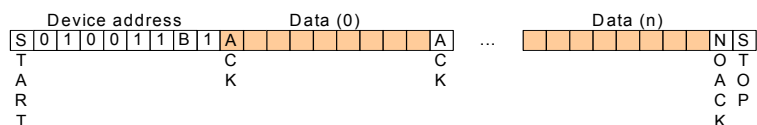
**Single/multiple register write (page write)**



**Single/multiple register read**



**Sequential single/multiple register read**



□ Master drives line

■ Slave drives line

**Notes:**

The ICS1527 uses 16 byte pages (00h-0Fh is the first page, 10h-1Fh is the second page). Writing or reading beyond the end of page yields undefined results.

The ICS1527 has a device address of 010011B, where B is the state of the I2CADR pin.



## Section 5 AC/DC Operating Conditions

### 5.1 Absolute Maximum Ratings

Table 5-1 lists absolute maximum ratings for the ICS1527. Stresses above these ratings can cause permanent damage to the device. These ratings, which are standard values for ICS commercially rated parts, are stress ratings only. Functional operation of the ICS1527 at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

**Table 5-1 ICS1527 Absolute Maximum Ratings**

| Item                               | Rating                     |
|------------------------------------|----------------------------|
| VDD, VDDA, VDDQ (measured to VSS)* | 4.3 V                      |
| Digital Inputs                     | VSS –0.3 V to 5.5 V        |
| Analog Inputs                      | VSS –0.3 V to 6.0 V        |
| Analog Outputs                     | VSSA –0.3 V to VDDA +0.3 V |
| Digital Outputs                    | VSSQ –0.3 V to VDDQ +0.3 V |
| Storage Temperature                | –65°C to +150°C            |
| Junction Temperature               | 125°C                      |
| Soldering Temperature              | 260°C                      |
| ESD Susceptibility*                | > 2 KV**                   |

\*. Measured with respect to VSS. During normal operations, the VDD supply voltage for the ICS1527 must remain within the recommended operating conditions.

\*\*. Electrostatic-sensitive devices. Do not open or handle except in a static-free workstation.

**Table 5-2 Environmental Conditions**

| Parameter                     | Min. | Typ. | Max. | Units |
|-------------------------------|------|------|------|-------|
| Ambient Operating Temperature | 0    | –    | +70  | ° C   |
| Power Supply Voltage          | +3.0 | +3.3 | +3.6 | V     |

**Table 5-3 DC Characteristics**

| Parameter                      | Symbol | Conditions                         | Min. | Max. | UNITS |
|--------------------------------|--------|------------------------------------|------|------|-------|
| Digital Supply Current         | IDDD   | VDDD = 3.6 V                       | -    | 25   | mA    |
| Output Driver Supply Current   | IDDQ   | VDDD = 3.6 V<br>No drivers enabled | -    | 6    | mA    |
| Analog Supply Current          | IDDA   | VDDA = 3.6 V                       | -    | 5    | mA    |
| Power consumption              |        |                                    |      | 300  | mW    |
| Power-On-Reset (POR) Threshold |        | VSS                                |      | 1.8  | V     |



Table 5-4 AC Characteristics

| Parameter                                                      | Symbol      | Min.      | Typical | Max.    | Units | Notes                                |
|----------------------------------------------------------------|-------------|-----------|---------|---------|-------|--------------------------------------|
| <b>General</b>                                                 |             |           |         |         |       |                                      |
| VCO Frequency                                                  | $f_{VCO}$   | 50        |         | 400     | MHz   |                                      |
| VCO Gain                                                       | K           |           | 165     |         | MHz/V |                                      |
| <b>AC Inputs</b>                                               |             |           |         |         |       |                                      |
| EXTFB Input Frequency                                          | $f_{EXTFB}$ | 8         |         | 10,000  | kHz   |                                      |
| EXTFB Input High Voltage                                       | $V_{IH}$    |           |         | 2.0     | V     |                                      |
| EXTFB Input Low Voltage                                        | $V_{IL}$    | 1.0       |         |         | V     |                                      |
| <b>Analog Input (HSYNC/VSYNC)</b>                              |             |           |         |         |       |                                      |
| HSYNC Input Frequency                                          | $f_{HSYNC}$ | 8         |         | 10,000  | kHz   |                                      |
| VSYNC Input Frequency                                          | $f_{VSYNC}$ | 30        |         | 120     | Hz    |                                      |
| Input High Voltage                                             | $V_{IH}$    | 1.7       |         | 5.5     | V     |                                      |
| Input Low Voltage                                              | $V_{IL}$    | VSS - 0.3 |         | 1.1     | V     |                                      |
| Input Hysteresis                                               |             | 0.2       |         | 0.8     | V     | Schmitt trigger active               |
| <b>SDA, SCL Digital Inputs</b>                                 |             |           |         |         |       |                                      |
| Input High Voltage                                             | $V_{IH}$    | 2         |         | 5.5     | V     |                                      |
| Input Low Voltage                                              | $V_{IL}$    | VSS - 0.3 |         | 0.8     | V     |                                      |
| <b>I<sup>2</sup>CADDR Digital Input</b>                        |             |           |         |         |       |                                      |
| Input High Voltage                                             | $V_{IH}$    | 2         |         | VDD+0.3 | V     |                                      |
| Input Low Voltage                                              | $V_{IL}$    | VSS - 0.3 |         | 0.8     | V     |                                      |
| <b>SDA Digital Output</b>                                      |             |           |         |         |       |                                      |
| SDA Output Low Voltage                                         | $V_{OL}$    |           |         | 0.4     | V     | IOUT = 3 mA                          |
| SDA Output High Voltage                                        | $V_{OH}$    |           |         | 6.0     | V     | Determined by external Rset resistor |
| <b>LVC MOS Outputs (CLK, HSYNC_out, VSYNC_out, LOCK)</b>       |             |           |         |         |       |                                      |
| Output Frequency, ICS1527-110GLF                               | $F_s$       | 2.5       |         | 110     | MHz   | VDDD = 3.3 V                         |
| Output Frequency, ICS1527-60GLF                                | $F_s$       | 2.5       |         | 60      | MHz   | VDDD = 3.3 V                         |
| Duty Cycle                                                     | $S_{DC}$    | 45        | 50      | 55      | %     | 2                                    |
| Jitter, STJ, RMS                                               | STJ         |           | 0.027   |         | ns    | 30 kHz input to 50 MHz output        |
| Jitter, STJ, pk-pk                                             | STJ         |           | 0.200   |         | ns    |                                      |
| Jitter, Input-Output                                           | IOJ         |           | 2.500   |         | ns    | HSYNC in to CLK out                  |
| Output Low Voltage                                             | $V_{OL}$    |           |         | 0.4     | V     | IOUT = 4 mA                          |
| Output High Voltage                                            | $V_{OH}$    | 2.4       |         |         | V     | IOUT = -4 mA                         |
| HSYNC to HSYNC_out propagation delay (without Schmitt-trigger) |             |           | 2       | 9       | ns    | 1                                    |



| Parameter                                                   | Symbol   | Min. | Typical | Max. | Units | Notes |
|-------------------------------------------------------------|----------|------|---------|------|-------|-------|
| HSYNC to HSYNC_out propagation delay (with Schmitt-trigger) |          |      | 6       | 10   | ns    | 1     |
| CLK to HSYNC_out/<br>VSYNC_out skew                         |          |      |         | 1.0  | ns    |       |
| Clock and<br>HSYNC_out/VSYNC_out<br>Transition Time - Rise  | $T_{CR}$ |      | 1.0     | 1.5  | ns    | 2     |
| Clock and<br>HSYNC_out/VSYNC_out<br>Transition Time - Fall  | $T_{CF}$ |      | 1.0     | 1.5  | ns    | 2     |
| LOCK Transition Time - Rise                                 | $T_{LR}$ |      |         | 3.0  | ns    | 2     |
| LOCK Transition Time - Fall                                 | $T_{LF}$ |      |         | 2.0  | ns    | 2     |

Note 1—Measured between chosen edge of HSYNC (00h:2) and rising edge of output

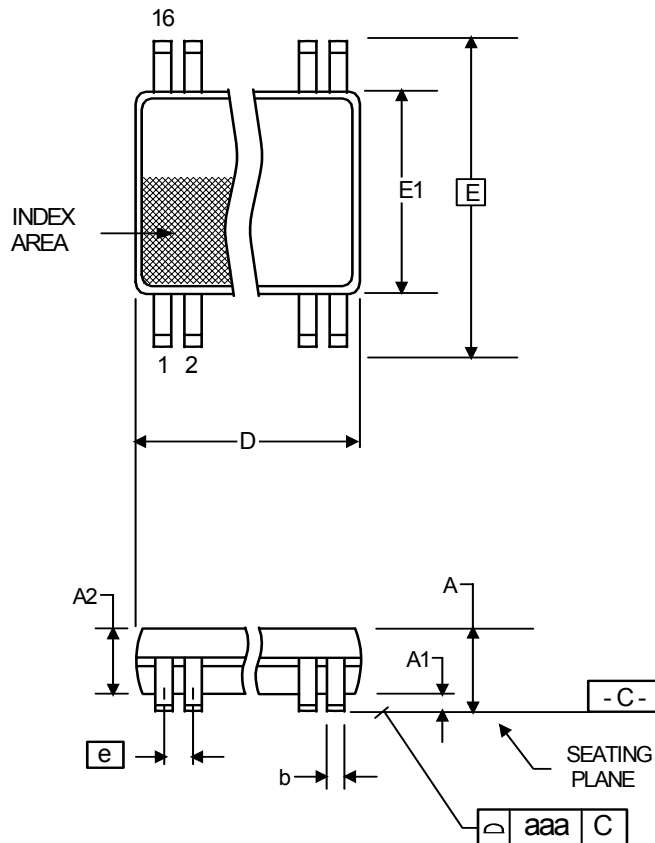
Note 2—Measured at 110 MHz, 3.3 VDC, 25°C, 15 pF, unterminated



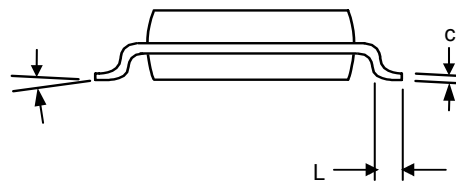
## Section 6 Package Outline and Package Dimensions

### 16-pin TSSOP 4.40 mm body, 0.65 mm pitch

Package dimensions are kept current with JEDEC Publication No. 95



| Symbol   | Millimeters |      | Inches       |       |
|----------|-------------|------|--------------|-------|
|          | Min         | Max  | Min          | Max   |
| A        | --          | 1.20 | --           | 0.047 |
| A1       | 0.05        | 0.15 | 0.002        | 0.006 |
| A2       | 0.80        | 1.05 | 0.032        | 0.041 |
| b        | 0.19        | 0.30 | 0.007        | 0.012 |
| C        | 0.09        | 0.20 | 0.0035       | 0.008 |
| D        | 4.90        | 5.1  | 0.193        | 0.201 |
| E        | 6.40 BASIC  |      | 0.252 BASIC  |       |
| E1       | 4.30        | 4.50 | 0.169        | 0.177 |
| e        | 0.65 Basic  |      | 0.0256 Basic |       |
| L        | 0.45        | 0.75 | 0.018        | 0.030 |
| $\alpha$ | 0°          | 8°   | 0°           | 8°    |
| aaa      | --          | 0.10 | --           | 0.004 |



## Section 7 Ordering Information

| Part / Order Number | Marking  | Shipping packaging | Package      | Temperature |
|---------------------|----------|--------------------|--------------|-------------|
| ICS1527G-60LF       | 1527G2LF | Tubes              | 16-pin TSSOP | 0 to +70° C |
| ICS1527G-60LFT      | 1527G2LF | Tape & Reel        | 16-pin TSSOP | 0 to +70° C |
| ICS1527G-110LF      | 1527G1LF | Tubes              | 16-pin TSSOP | 0 to +70° C |
| ICS1527G-110LFT     | 1527G1LF | Tape & Reel        | 16-pin TSSOP | 0 to +70° C |

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