

# ANTREX Electronics

Electronic Components Sourcing Information

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## Product Reference Information

**Part Number:** SI8937D-IS4R  
**Manufacturer:** Skyworks Solutions Inc.  
**Package:** 8-SOIC (0.295" 7.50mm Width)  
**Availability:** Please confirm with sales

### Product Page:

<https://antrexco.com/product/details/skyworks-solutions-inc/si8937d-is4r.html>

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### Note:

This PDF includes an ANTREX product reference cover page.

The original manufacturer datasheet follows from the next page.

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## DATA SHEET

# Si8941/Si8946/Si8947 Isolated Delta-Sigma Modulator for Current Shunt Measurement

## Applications

- Industrial, HEV and renewable energy inverters
- AC, brushless, and DC motor controls and drives
- Variable speed motor control in consumer white goods
- Isolated switch mode and UPS power supplies
- Automotive on-board chargers, battery management systems, and charging stations

## Features

- Low voltage differential input
  - $\pm 62.5$  mV and  $\pm 250$  mV options
- Modulator clock options
  - External clock up to 25 MHz (Si8941)
  - 10 MHz internal clock (Si8946)
  - 20 MHz internal clock (Si8947)
- Typical input offset:  $\pm 50$   $\mu$ V
- Typical gain error:  $\pm 0.05\%$
- Excellent drift specifications
  - $\pm 0.5$   $\mu$ V/ $^{\circ}$ C typical offset drift
  - $\pm 4$  ppm/ $^{\circ}$ C typical gain drift
- Typical 14-bit (ENOB) precision
- High common-mode transient immunity: 75 kV/ $\mu$ s
- Typical SNR: 90 dB
- Typical THD:  $-97$  dB
- Automotive-grade OPNs available
  - AEC-Q100 qualification
  - AIAG-compliant PPAP documentation support
  - IMDS and CAMDS listing support
- Compact packages
  - 8-pin wide body stretched SOIC
  - 8-pin narrow body SOIC
- $-40$  to  $125$   $^{\circ}$ C

## Safety Approvals

- UL 1577 recognized
  - Up to 5000 kV<sub>RMS</sub> for 1 minute
- CSA certification conformity
  - 62368-1 (reinforced insulation)
- VDE certification conformity (Pending)
  - 60747-17 (reinforced insulation)
- CQC certification approval
  - GB4943.1

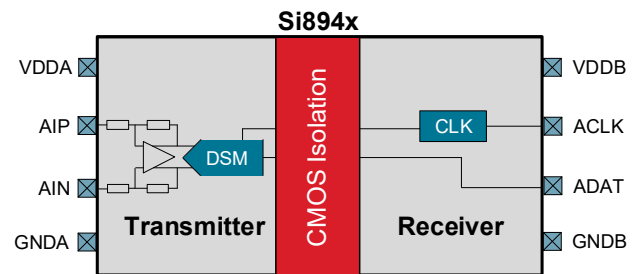


Figure 1. Si894x Block Diagram

## Description

The Si8941/46/47 are galvanically isolated delta-sigma modulators which output a digital signal proportional to the voltage level at the input. The low-voltage differential input is ideal for measuring voltage across a current shunt resistor or for any place where a sensor must be isolated from the control system. Low noise, low error, and high precision ensure an accurate measurement of system current.

The output of the Si8941/46/47 comes from a second order delta-sigma modulator. The modulator can be clocked either from an on-board oscillator (Si8946/47) or from an external clock (Si8941). The output is typically digitally filtered by an MCU or FPGA in the system.

The Si8941/46/47 isolated delta-sigma modulator utilizes Skyworks proprietary isolation technology. It supports up to 5.0 kV<sub>RMS</sub> withstand voltage per UL1577. This technology enables higher performance, reduced variation with temperature and age, tighter part-to-part matching, and longer lifetimes compared to other isolation technologies.

Automotive Grade is available for certain part numbers. These products are built using automotive-specific flows at all steps in the manufacturing process to ensure the robustness and low defectivity required for automotive applications.



Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04-0074.

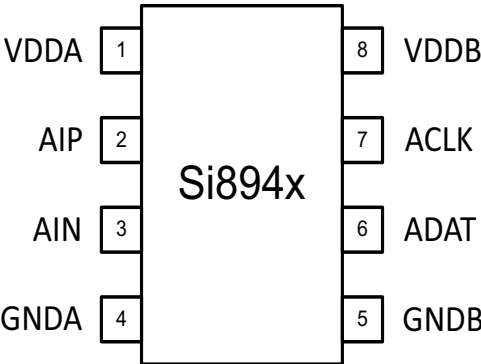


Figure 2. Si894x Pinout (Top View)

Table 1. Si894x Pin Descriptions

| Name  | Pin Number | Description                                                        |
|-------|------------|--------------------------------------------------------------------|
| VDDA  | 1          | Input side power supply                                            |
| AIP   | 2          | Analog input high                                                  |
| AIN   | 3          | Analog input low                                                   |
| GNDA  | 4          | Input side ground                                                  |
| GNDB  | 5          | Output side ground                                                 |
| ADAT  | 6          | Delta-Sigma modulator data output                                  |
| ACLK  | 7          | Delta-Sigma modulator clock (input on Si8941, output on Si8946/47) |
| VDDDB | 8          | Output side power supply                                           |

## 1. Technical Description

The input to the Si8941/46/47 is designed for low-voltage, differential signals. This is ideal for connection to low-resistance current shunt measurement resistors. The Si8941A/46A/47A has a specified full scale input range of  $\pm 62.5$  mV, and the Si8941B/46B/47B has a specified full scale input range of  $\pm 250$  mV. This allows the user to choose low-ohmic resistance value sense resistors to minimize system power loss.

The analog input stage of the Si8941/46/47 is a fully differential amplifier feeding the input of a second-order, delta-sigma modulator that digitizes the input signal into a 1-bit output stream. The isolated data output ADAT pin of the converter provides a stream of digital ones and zeros that is synchronous to the ACLK pin.

The Si8946/47 clock is generated internally while the Si8941 clock is provided externally. The time average of this serial bit-stream output is proportional to the analog input voltage.

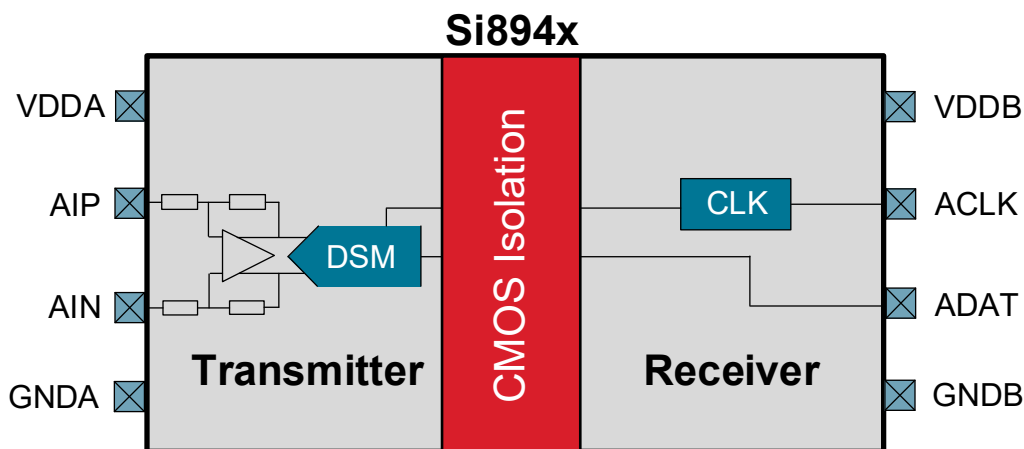


Figure 3. Si8941/Si8946/Si8947 Functional Block Diagram

### 1.1. Fail-Safe and Low-Power Modes

The Si8941/46/47 implements a fail-safe output when the high voltage-side supply voltage VDDA goes away. The fail-safe output is a steady state logic 0 on ADAT for the externally clocked Si8941. The fail-safe output is a steady state logic 1 on ADAT for the internally clocked Si8946/47.

The clock output ACLK of the Si8946/47 will stop after 256 cycles with a steady state logic 1. When the supply comes back, the clock will be turned back on and the normal DSM data stream will be output in approximately 250  $\mu$ s. To differentiate from the failsafe output, a maximum nominal input signal will generate a single 1 every 128 bits at ADAT.

In addition to the fail-safe output, when a loss of VDDA supply occurs, the part will automatically move into a lower power mode that reduces IDDB current to approximately 1 mA. Similarly, a loss of VDDB supply will reduce IDDA current to approximately 1 mA. When the supply voltage is returned, normal operation begins in approximately 250  $\mu$ s.

### 1.2. Modulator

The output of the Si8941/46/47 comes from a second order delta-sigma modulator, see Figure 3. The modulator provides 1-bit data stream whose average represents the input analog voltage. Zero volts across the inputs is represented at the output by a pulse train that has 50% ones density.

Positive specified linear full-scale at the input (e.g., +250 mV for the Si8941B/46B/47B and +62.5 mV for the Si8941A/46A/47A) produces an output datastream that has 89.06% ones density, and negative specified full scale gives an output that has 10.94% ones density. Table xx shows the values for other input levels and for both full-scale input options of the device.

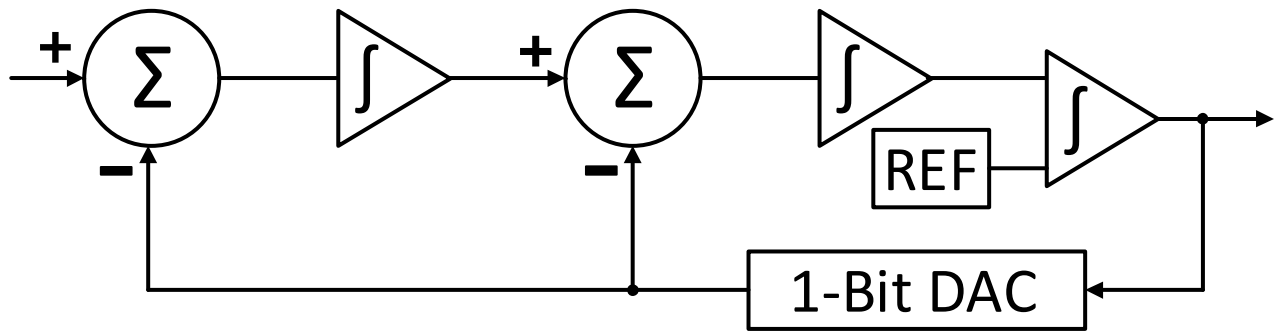


Figure 4. Typical Second Order Delta-Sigma Modulator Block Diagram

Table 2. Modulator Output

| Differential Input |                 | Bitstream % Ones |
|--------------------|-----------------|------------------|
| Si8941A/46A/47A    | Si8941B/46B/47B |                  |
| +62.5 mV           | +250 mV         | 89.06%           |
| +31.25 mV          | +125 mV         | 69.53%           |
| 0 mV               | 0 mV            | 50%              |
| -31.25 mV          | -125 mV         | 30.47%           |
| -62.5 mV           | -250 mV         | 10.94%           |

2. Current Sense Application

In the driver circuit presented below, the Si8941/46/47 is used to amplify the voltage across the sense resistor, RSENSE, where it is oversampled and converted into a 1-bit bitstream, then transmitted across the isolation barrier to be processed by the system controller/FPGA. Placing the sense resistor before the load is known as high-side sensing and isolation is needed because the voltage of RSENSE with respect to ground will swing between 0 V and the high voltage rail connected to the drain of Q1.

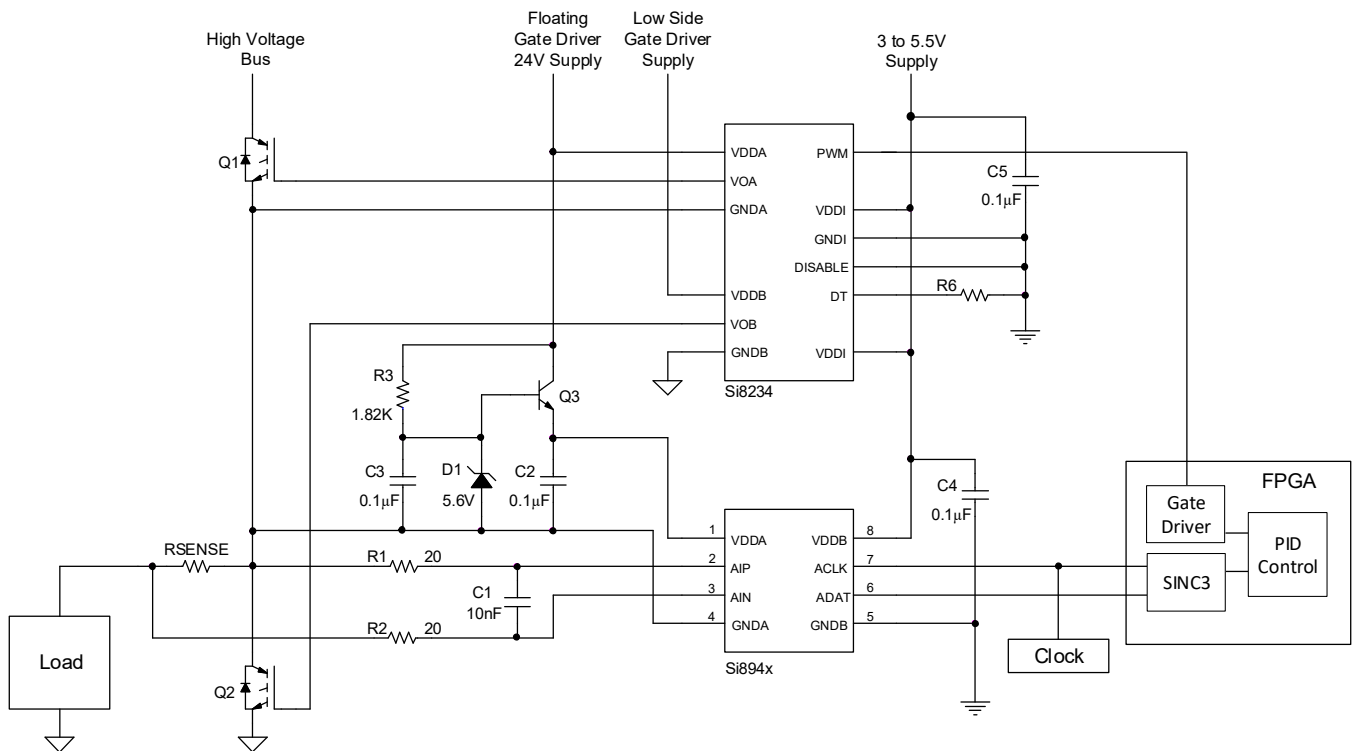


Figure 5. Current Sense Application

The load in this application can be a motor winding or a similar inductive winding. In a three-phase motor drive application, this circuit would be repeated three times, one for each phase. RSENSE should be a small value resistor to reduce power loss. However, an excessively low resistance will reduce the signal-to-noise ratio of the measurement.

Si8941/46/47 offers two specified linear full-scale input options,  $\pm 62.5$  mV (Si8941A/46A/47A) and  $\pm 250$  mV (Si8941B/46B/47B), for optimizing the value of RSENSE. Further product ordering options include whether the CLK pin is an input (Si8941) or an output (Si8946/47).

AIP and AIN connections to the RSENSE resistor should be made as close as possible to each end of the RSENSE resistor as trace resistance will add error to the measurement. The input to the Si8941/46/47 is differential, and the PCB traces back to the input pins should run in parallel. This ensures that any large noise transients that occur on the high-voltage side are coupled equally to the AIP and AIN pins and will be rejected by the Si8941/46/47 as a common-mode signal.

The Si8941/46/47 has intrinsic low-pass filtering at approximately 800 kHz. If further input filtering is required, a passive, differential RC low-pass filter can be placed between RSENSE and the input pins. Values of  $R1 = R2 = 20 \Omega$  and  $C1 = 10$  nF provides a cutoff at approximately 400 kHz. For the lowest gain error, R1 and R2 should always be less than  $33 \Omega$  to keep the source impedance sufficiently low compared to the Si8941/46/47 input impedance.

The common-mode voltage of AIN and AIP must be greater than  $-0.2$  V but less than  $1$  V with respect to GNDA. To meet this requirement, route a trace from the GNDA pin of the Si8941/46/47 to one side of the RSENSE resistor. In this circuit, GNDA, RSENSE, the source of Q1, and the drain of Q2 are connected. The ground of the gate driver (one half of the Skyworks Si8234 in this example) is also commonly connected to the same node.

The Q1 gate driver has a floating supply of 24 V. Since the input and output of the Si8941/46/47 are galvanically isolated from each other, separate power supplies are necessary on each side. Q3, R3, C3, and D1 make a regulator circuit for powering the input side of the Si8941/46/47 from this floating supply. D1 establishes a voltage of 5.6 V at the base of Q3. R3 is selected to provide a Zener current of 10 mA for D1. C3 provides filtering at the base of Q3, and the emitter output of Q3 provides approximately 5 V to VDDA. C2 is a bypass capacitor for the supply and should be placed at the VDDA pin with its return trace connecting to the GNDA connection at RSENSE.

C4, the local bypass capacitor for the B-side of Si8941/46/47, should be placed close to the VDDDB supply pin with its return close to GNDB. The output signal typically goes directly to a digital filter for additional processing. The digital filter may be implemented by a dedicated FPGA in the system or may be a peripheral in the main system controller.

The Si8941 expects an external clock to provide the clock signal for the modulator. That external clock can be provided by the same device that implements the digital filtering or another device that syncs both the modulator and the digital filter. The Si8946/47 generates an internal clock to the digital filter.

### 3. Electrical and Mechanical Specifications

The absolute maximum ratings of the Si8941/Si8946/Si8947 are provided below, followed by electrical specifications, performance graphs, and mechanical specifications.

**Table 3. Si8941/Si8946/Si8947 Absolute Maximum Ratings<sup>1</sup>**

| Parameter                       | Symbol      | Min  | Max        | Unit |
|---------------------------------|-------------|------|------------|------|
| Storage temperature             | $T_{STG}$   | -65  | 150        | °C   |
| Ambient temperature under bias  | $T_A$       | -40  | 125        | °C   |
| Junction temperature            | $T_J$       |      | 150        | °C   |
| Supply voltage                  | VDDA, VDDDB | -0.5 | 6.0        | V    |
| Input voltage respect to GNDA   | $V_{IN}$    | -0.5 | VDDA + 0.5 | V    |
| Output sink or source current   | $I_O$       |      | 5          | mA   |
| Total power dissipation         | $P_T$       |      | 212        | mW   |
| Lead solder temperature (10 s)  |             |      | 260        | °C   |
| Human Body Model ESD rating     |             | 6000 |            | V    |
| Charged Device Model ESD rating |             | 2000 |            | V    |

1. Exposure to maximum rating conditions for extended periods may reduce device reliability. Exceeding any of the limits listed here may result in permanent damage to the device.

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**ESD Handling: Industry-standard ESD handling precautions must be adhered to at all times to avoid damage to this device.**

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**Table 4. Si8941/Si8946/Si8947 Electrical Specifications<sup>1</sup>**

$T_A = -40$  to  $+125$  °C,  $A_{IN} = GNDA$ , SINC3 filter with 256 oversampling ratio and 20 MHz clock;  
typical specs at 25 °C with  $V_{DDA} = V_{DDB} = 5$  V unless specified differently under Test Condition

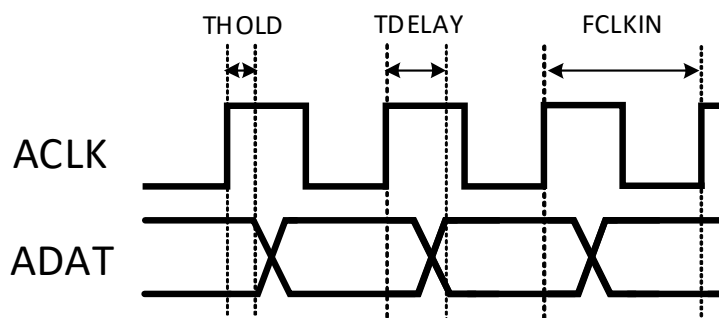
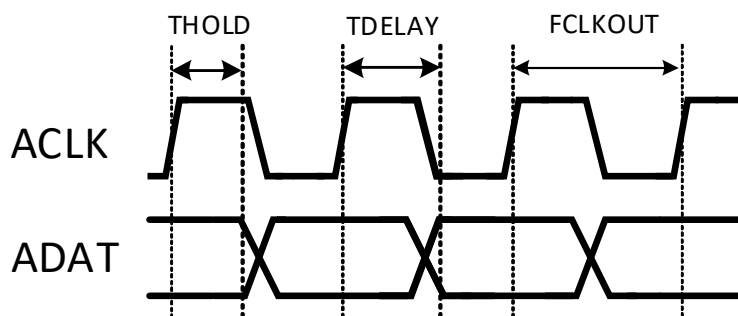
| Parameter                             |                 | Symbol              | Test Condition                                                | Min              | Typ   | Max              | Units  |
|---------------------------------------|-----------------|---------------------|---------------------------------------------------------------|------------------|-------|------------------|--------|
| Input side supply voltage             |                 | VDDA                |                                                               | 3.0              |       | 5.5              | V      |
| Input supply current                  | Si8941          | IDDA                | VDDA = 3.3 V                                                  |                  | 6.9   | 8.2              | mA     |
|                                       | Si8946          | IDDA                | VDDA = 3.3 V                                                  |                  | 6.7   | 8.1              | mA     |
|                                       | Si8947          | IDDA                | VDDA = 3.3 V                                                  |                  | 6.6   | 8.8              | mA     |
| Output side supply voltage            |                 | VDDB                |                                                               | 3.0              |       | 5.5              | V      |
| Output supply current                 | Si8941          | IDDB                | VDDB = 3.3 V                                                  |                  | 4     | 4.8              | mA     |
|                                       | Si8946          | IDDB                | VDDB = 3.3 V                                                  |                  | 3.5   | 6.6              | mA     |
|                                       | Si8947          | IDDB                | VDDB = 3.3 V                                                  |                  | 7.2   | 9.7              | mA     |
| <b>Amplifier Input</b>                |                 |                     |                                                               |                  |       |                  |        |
| Specified linear input range          | Si8941A/46A/47A | $V_{AIP} - V_{AIN}$ |                                                               | -62.5            |       | 62.5             | mV     |
|                                       | Si8941B/46B/47B |                     |                                                               | -250             |       | 250              | mV     |
| Maximum input voltage before clipping | Si8941A/46A/47A | $V_{AIP} - V_{AIN}$ |                                                               |                  | ±80   |                  | mV     |
|                                       | Si8941B/46B/47B |                     |                                                               |                  | ±320  |                  | mV     |
| Common-mode operating range           |                 | $V_{CM}$            | $A_{IN} \neq GNDA$                                            | -0.2             |       | 1                | V      |
| Input offset                          |                 | $V_{OS}$            | $T_A = 25$ °C, $A_{IP} = A_{IN} = 0$                          | -0.18            | ±0.05 | 0.18             | mV     |
| Input offset drift                    |                 | $V_{OST}$           |                                                               | -2               | ±0.5  | 2                | µV/°C  |
| Gain error                            |                 | $E_G$               | $T_A = 25$ °C                                                 | -0.18            | ±0.05 | 0.18             | %      |
| Gain error drift                      |                 | $E_{GT}$            |                                                               | -25              | -4    | 25               | ppm/°C |
| Differential input impedance          | Si8941A/46A/47A | $R_{IN}$            |                                                               |                  | 6.3   |                  | kΩ     |
|                                       | Si8941B/46B/47B |                     |                                                               |                  | 21.4  |                  | kΩ     |
| Differential input impedance drift    |                 | $R_{INT}$           |                                                               |                  | 850   |                  | ppm/°C |
| <b>Dynamic Characteristics</b>        |                 |                     |                                                               |                  |       |                  |        |
| SNR                                   | Si8941A/46A/47A | SNR                 | $F_{IN} = 5$ kHz BW = 40 kHz (Si8941/47) BW = 20 kHz (Si8946) | 80               | 86    |                  | dB     |
|                                       | Si8941B/46B/47B |                     |                                                               | 84               | 90    |                  | dB     |
| Nonlinearity                          | Si8941A/46A/47A |                     | $T_A = 25$ °C                                                 | -0.008           | 0.002 | 0.008            | %      |
|                                       | Si8941B/46B/47B |                     |                                                               | -0.004           | 0.001 | 0.004            | %      |
| Nonlinearity drift                    |                 |                     | $T_A = 25$ °C                                                 | -0.6             |       | 0.6              | ppm/°C |
| Total Harmonic distortion             | Si8941A/46A/47A | THD                 | $F_{IN} = 5$ kHz BW = 40 kHz (Si8941/47) BW = 20 kHz (Si8946) |                  | -95   | -81              | dB     |
|                                       | Si8941B/46B/47B | THD                 | $F_{IN} = 5$ kHz BW = 40 kHz (Si8941/47) BW = 20 kHz (Si8946) |                  | -97   | -81              | dB     |
| Power-supply rejection ratio          |                 | PSRR                | VDDA at DC                                                    |                  | -100  |                  | dB     |
|                                       |                 |                     | VDDA at 100 mV and 10 kHz ripple                              |                  | -100  |                  | dB     |
|                                       |                 |                     | VDDB at DC                                                    |                  | -100  |                  | dB     |
|                                       |                 |                     | VDDB at 100 mV and 10 kHz ripple                              |                  | -100  |                  | dB     |
| Common-mode transient immunity        |                 | CMTI                |                                                               | 50               | 75    |                  | kV/µs  |
| <b>Digital</b>                        |                 |                     |                                                               |                  |       |                  |        |
| Logic high input threshold (Si8941)   |                 | $V_{IH}$            |                                                               | 85% of $V_{DDB}$ |       |                  | V      |
| Logic low input threshold (Si8941)    |                 | $V_{IL}$            |                                                               |                  |       | 15% of $V_{DDB}$ | V      |
| Input hysteresis                      |                 | $V_{IHYST}$         |                                                               |                  | 120   |                  | mV     |
| Output load capacitance               |                 | $C_{LOAD}$          |                                                               |                  | 15    |                  | pF     |

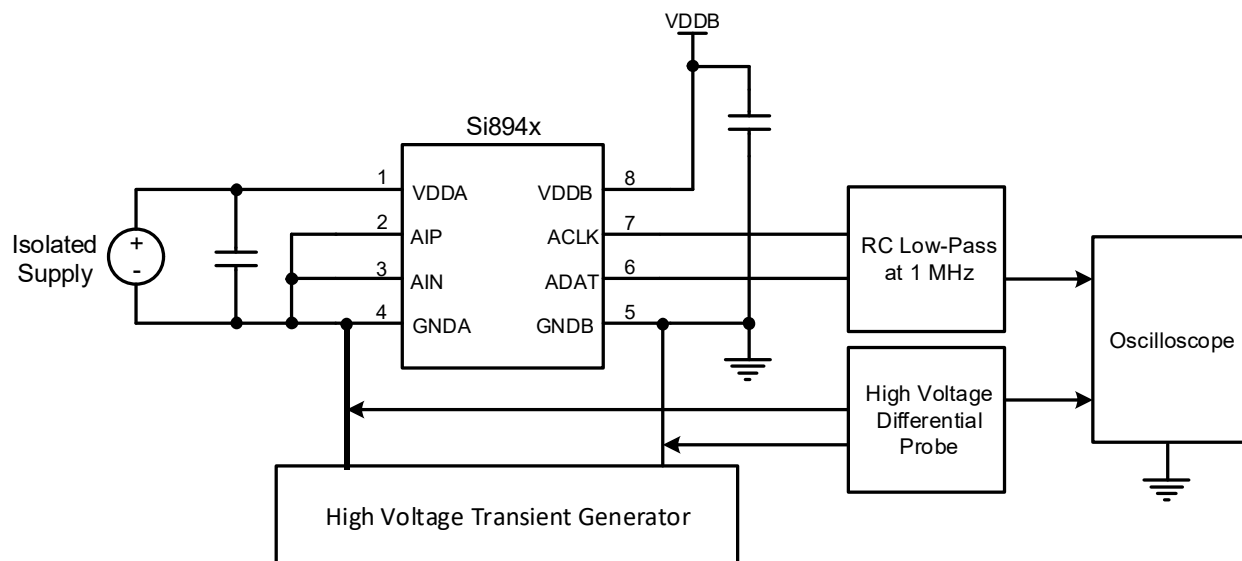
**Table 4. Si8941/Si8946/Si8947 Electrical Specifications<sup>1</sup> (Continued)**

$T_A = -40$  to  $+125$  °C,  $A_{IN} = GND_A$ , SINC3 filter with 256 oversampling ratio and 20 MHz clock;  
typical specs at 25 °C with  $V_{DDA} = V_{DDB} = 5$  V unless specified differently under Test Condition

| Parameter                      | Symbol  | Test Condition           | Min  | Typ | Max  | Units |
|--------------------------------|---------|--------------------------|------|-----|------|-------|
| <b>External Clock (Si8941)</b> |         |                          |      |     |      |       |
| Clock frequency                | FCLKIN  |                          | 5    |     | 25   | MHz   |
| Duty cycle                     | FDUTY   |                          | 45   | 50  | 55   | %     |
| Delay to data valid            | TDELAY  |                          |      |     | 23   | ns    |
| Data hold time                 | THOLD   |                          | 6    |     |      | ns    |
| <b>Internal Clock (Si8946)</b> |         |                          |      |     |      |       |
| Clock frequency                | FCLKOUT | $T_A = 25$ °C            | 9.9  | 10  | 10.1 | MHz   |
|                                |         | $T_A = -40$ °C to 125 °C | 9.8  | 10  | 10.2 | MHz   |
| Duty cycle                     | FDUTY   |                          | 45   | 50  | 55   | %     |
| Delay to data valid            | TDELAY  |                          |      |     | 60   | ns    |
| Data hold time                 | THOLD   |                          | 40   |     |      | ns    |
| <b>Internal Clock (Si8947)</b> |         |                          |      |     |      |       |
| Clock frequency                | FCLKOUT | $T_A = 25$ °C            | 19.8 | 20  | 20.2 | MHz   |
|                                |         | $T_A = -40$ °C to 125 °C | 19.6 | 20  | 20.4 | MHz   |
| Duty cycle                     | FDUTY   |                          | 45   | 50  | 55   | %     |
| Delay to data valid            | TDELAY  |                          |      |     | 30   | ns    |
| Data hold time                 | THOLD   |                          | 20   |     |      | ns    |

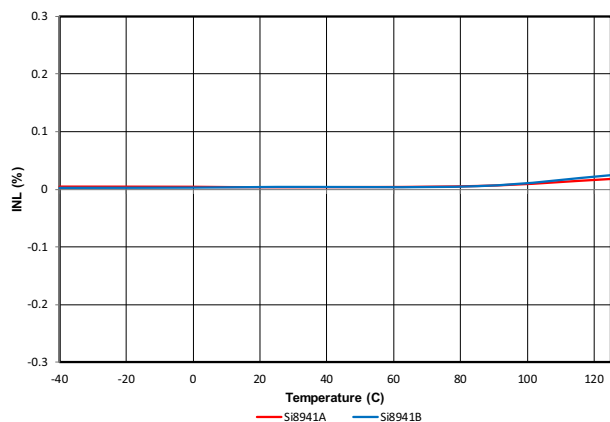
1. Performance is guaranteed only under the conditions listed in this Table and is not guaranteed over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.

**Figure 6. Si8941 Clock Input****Figure 7. Si8946/47 Clock Output**

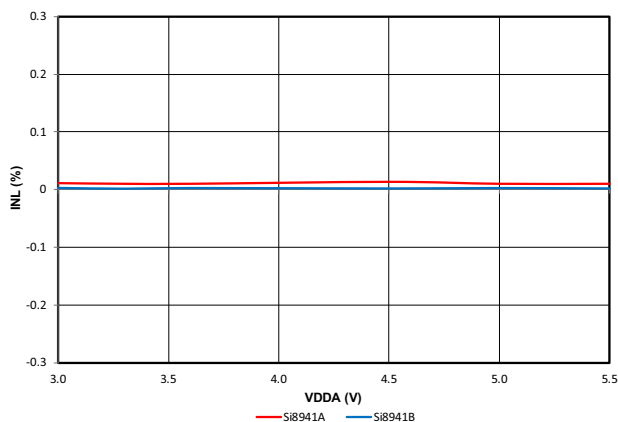


**Figure 8. Common-Mode Transient Immunity Characterization Circuit**

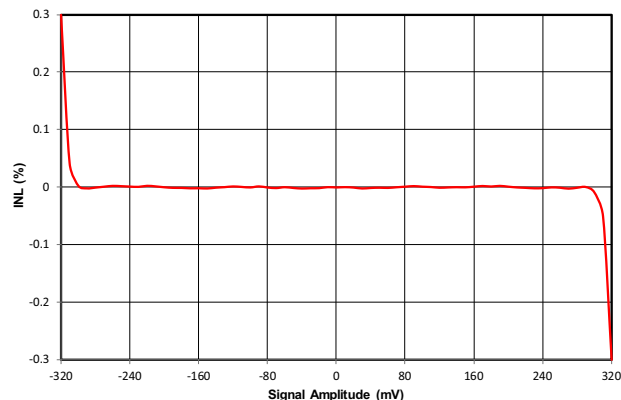
## 4. Typical Performance Characteristics



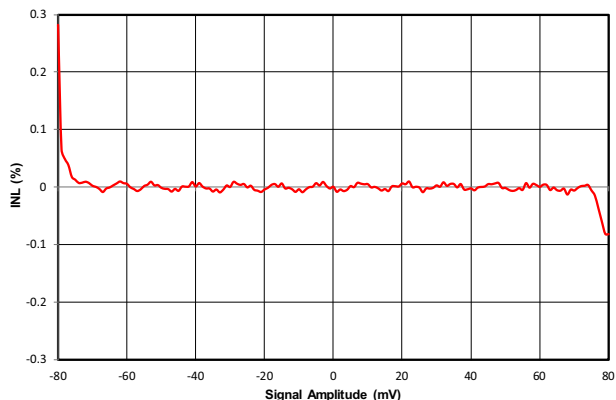
**Figure 9. Si8941 Nonlinearity (%) vs. Temperature (°C)**



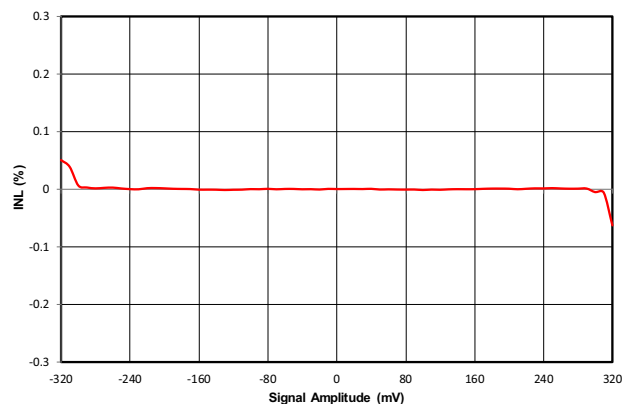
**Figure 10. Si8941 Nonlinearity (%) vs. VDDA Supply (V)**



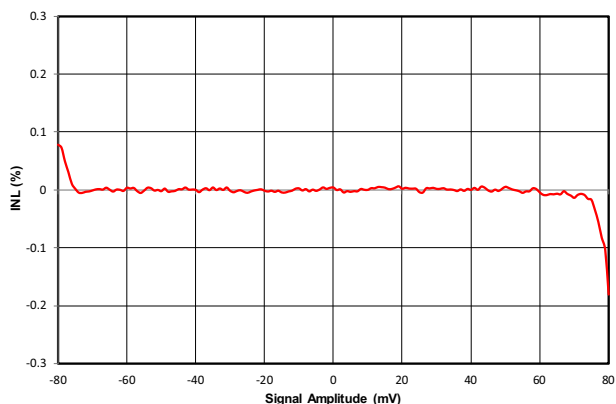
**Figure 11. Si8941B Nonlinearity (%) vs. Input Signal Amplitude (mV)**



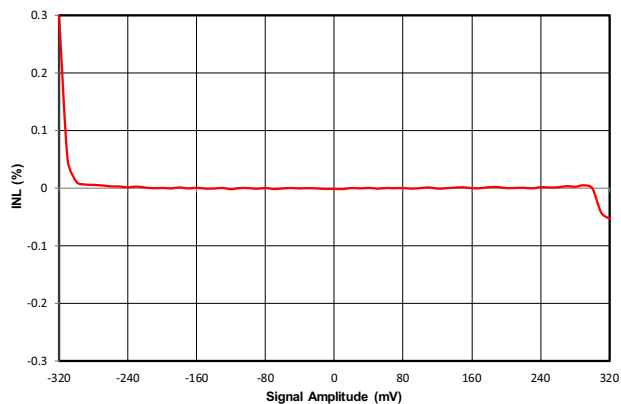
**Figure 12. Si8941A Nonlinearity (%) vs. Input Signal Amplitude (mV)**



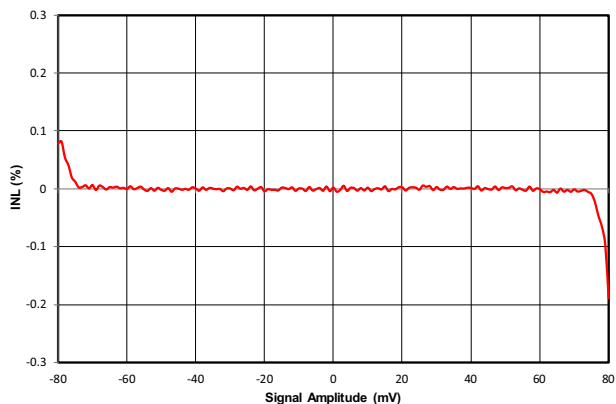
**Figure 13. Si8946B Nonlinearity (%) vs. Input Signal Amplitude (mV)**



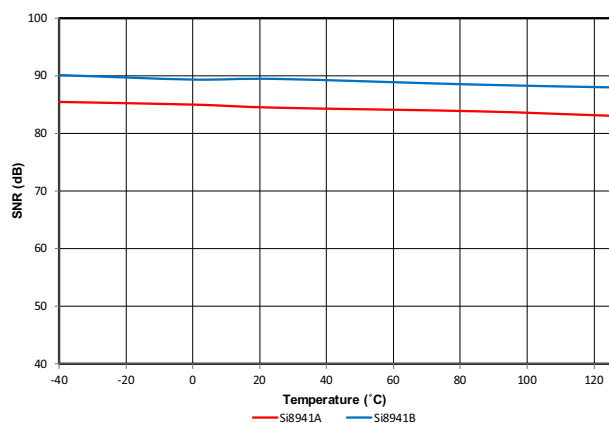
**Figure 14. Si8946A Nonlinearity (%) vs. Input Signal Amplitude (mV)**



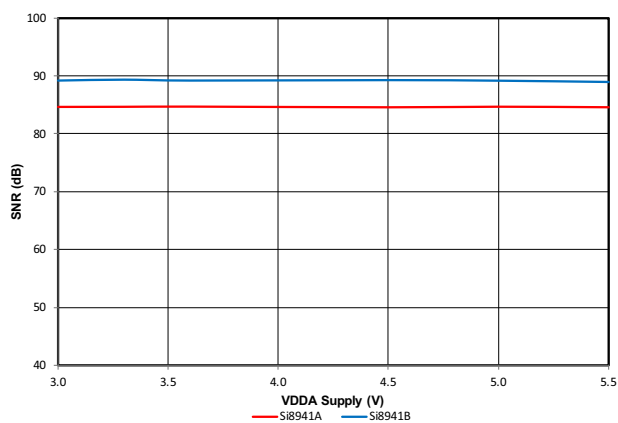
**Figure 15. Si8947B Nonlinearity (%) vs. Input Signal Amplitude (mV)**



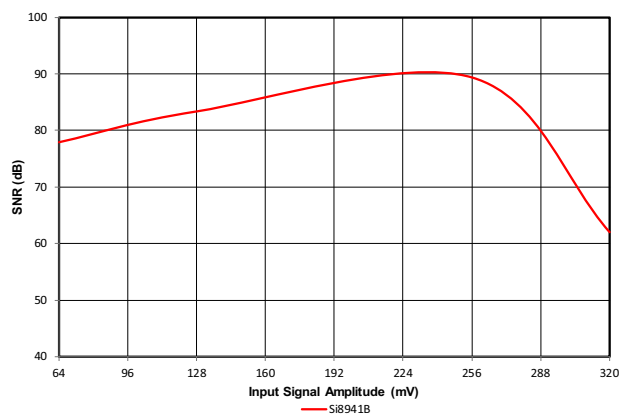
**Figure 16. Si8947A Nonlinearity (%) vs. Input Signal Amplitude (mV)**



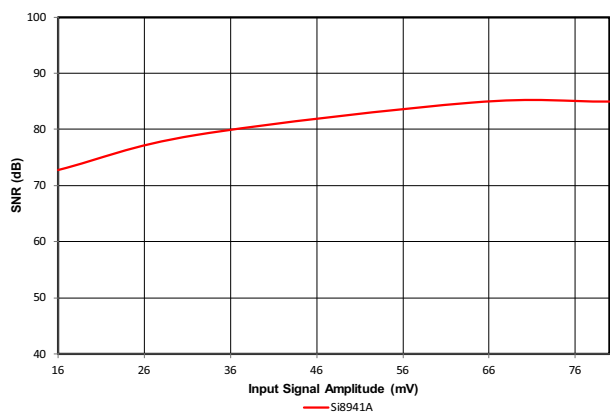
**Figure 17. Si8941 Signal-to-Noise Ratio (dB) vs. Temperature (°C)**



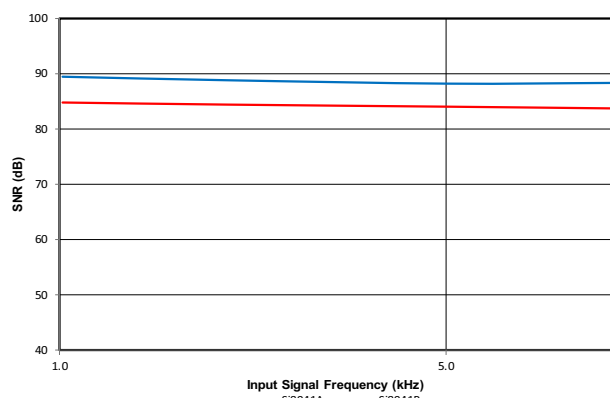
**Figure 18. Si8941 Signal-to-Noise Ratio (dB) vs. VDDA Supply (V)**



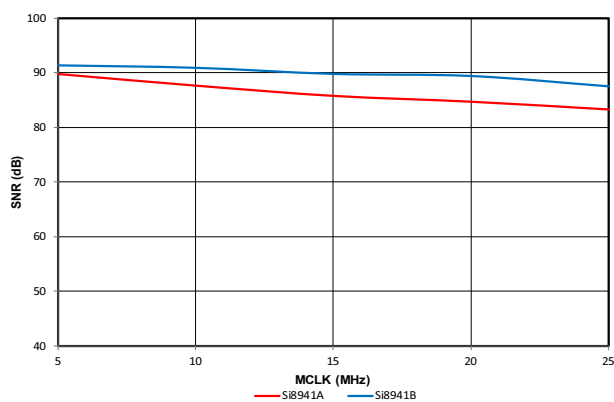
**Figure 19. Si8941B Signal-to-Noise Ratio (dB) vs. Input Signal Amplitude (mV)**



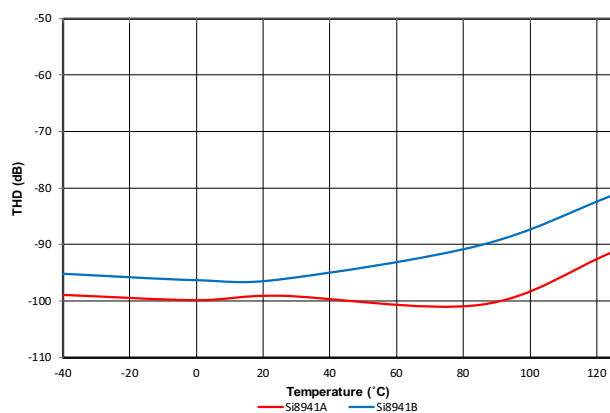
**Figure 20. Si8941A Signal-to-Noise Ratio (dB) vs. Input Signal Amplitude (mV)**



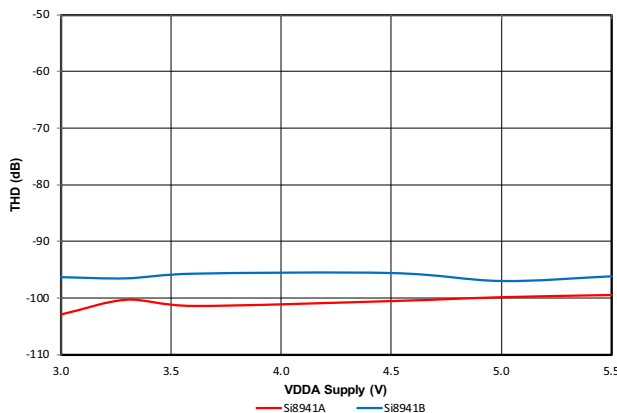
**Figure 21. Si8941 Signal-to-Noise Ratio (dB) vs. Input Signal Frequency (kHz)**



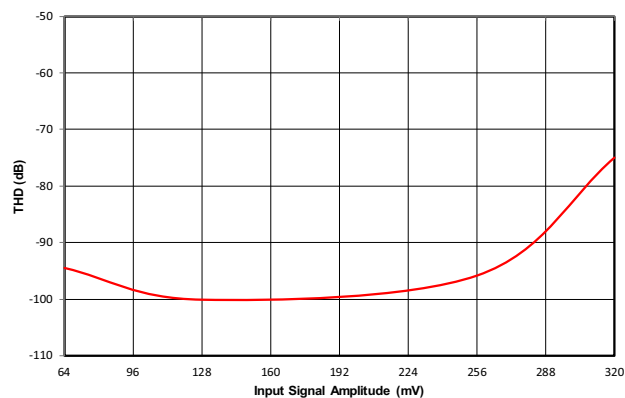
**Figure 22. Si8941 Signal-to-Noise Ratio (dB) vs. MCLK (MHz)**



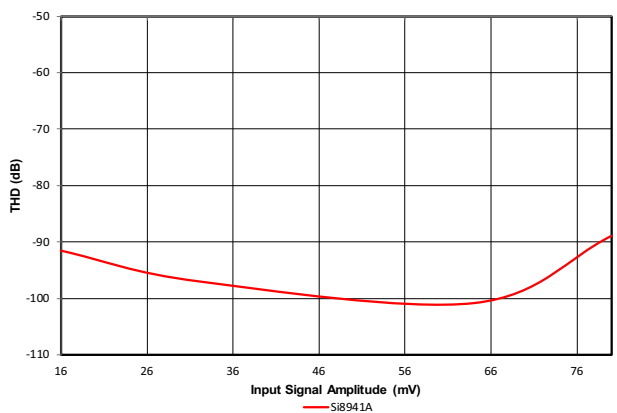
**Figure 23. Si8941 Total Harmonic Distortion (dB) vs. Temperature (°C)**



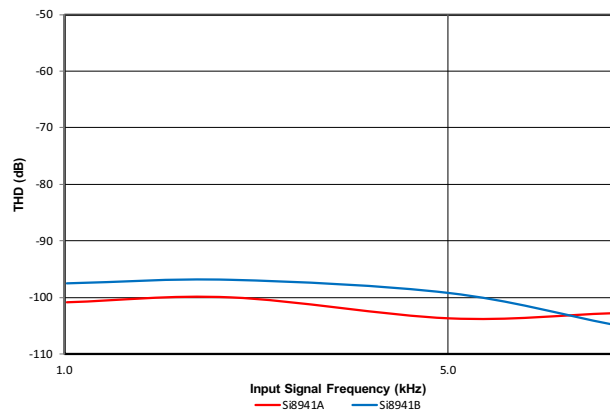
**Figure 24. Si8941 Total Harmonic Distortion (dB) vs. VDDA Supply (V)**



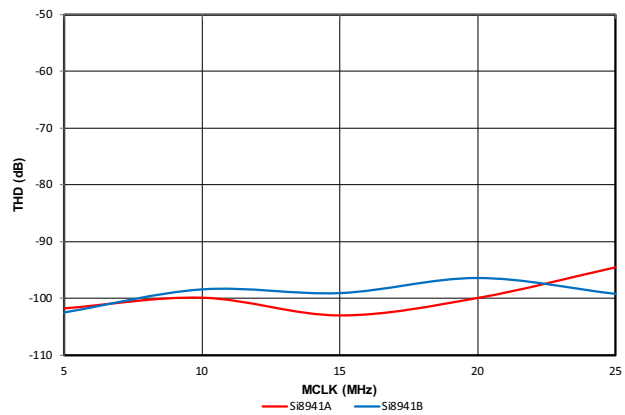
**Figure 25. Si8941B Total Harmonic Distortion (dB) vs. Input Signal Amplitude (mV)**



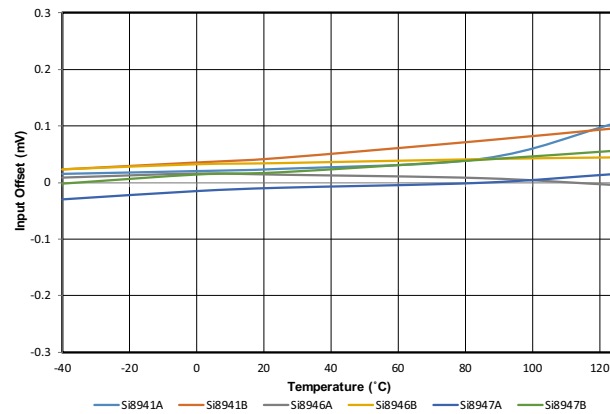
**Figure 26. Si8941A Total Harmonic Distortion (dB) vs. Input Signal Amplitude (mV)**



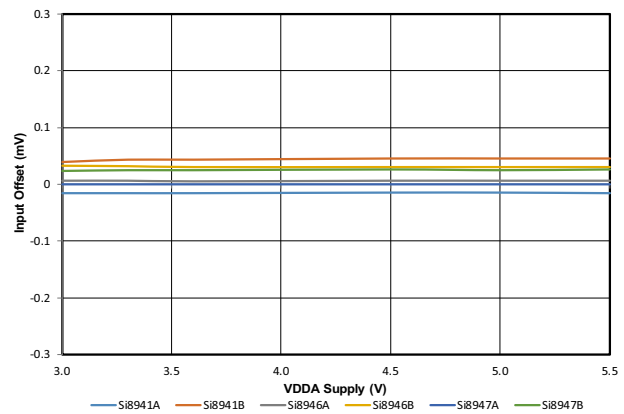
**Figure 27. Si8941 Total Harmonic Distortion (dB) vs. Input Signal Frequency (kHz)**



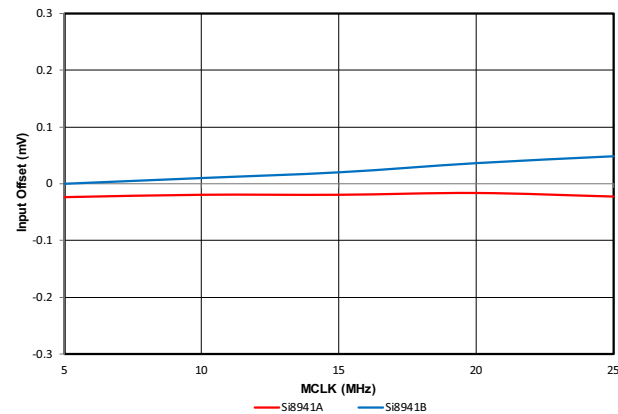
**Figure 28. Si8941 Total Harmonic Distortion (dB) vs. MCLK (MHz)**



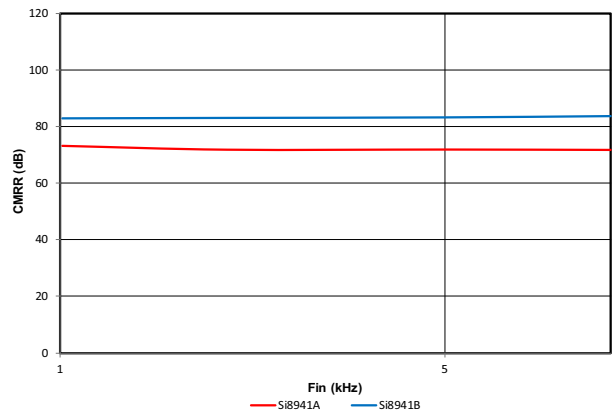
**Figure 29. Input Offset (mV) vs. Temperature (°C)**



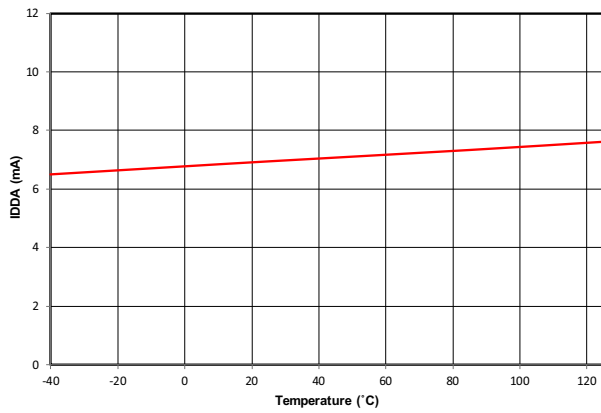
**Figure 30. Input Offset (mV) vs. VDDA Supply (V)**



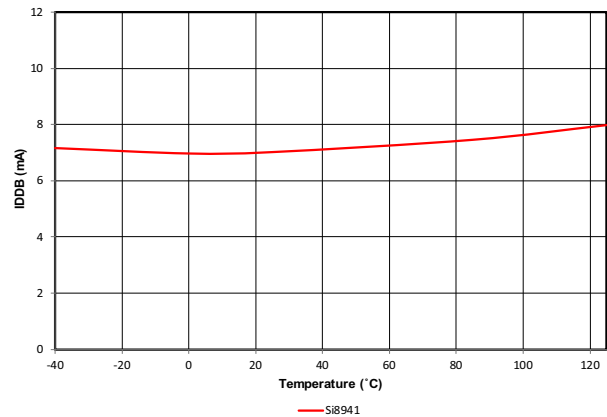
**Figure 31. Si8941 Input Offset (mV) vs. MCLK (MHz)**



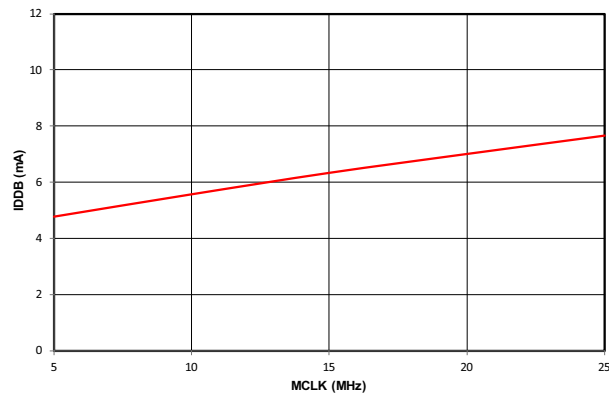
**Figure 32. Si8941 Common-Mode Rejection Ratio (dB) vs. Input Signal Frequency (kHz)**



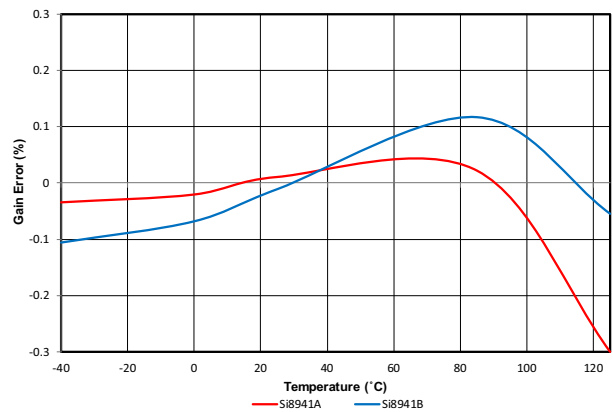
**Figure 33. IDDA (mA)  
vs. Temperature (°C)**



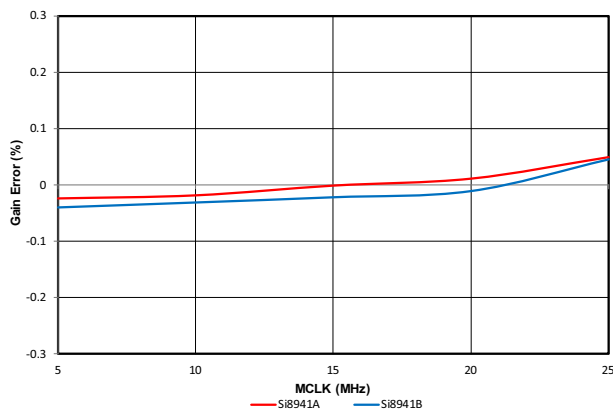
**Figure 34. Si8941 IDDB (mA)  
vs. Temperature (°C)**



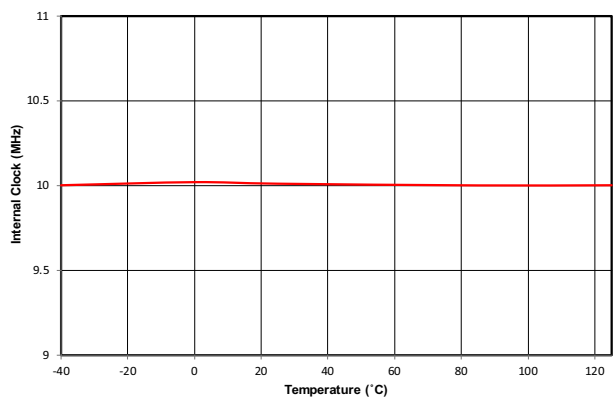
**Figure 35. Si8941 IDDB (mA)  
vs. MCLK (MHz)**



**Figure 36. Si8941 Gain Error (%)  
vs. Temperature (°C)**



**Figure 37. Si8941 Gain Error (%)  
vs. MCLK (MHz)**



**Figure 38. Si8946 Internal Clock Frequency (MHz)  
vs. Temperature (°C)**

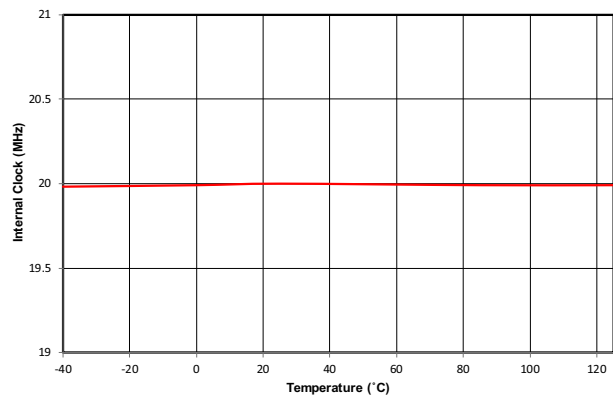


Figure 39. Si8947 Internal Clock Frequency (MHz) vs. Temperature (°C)

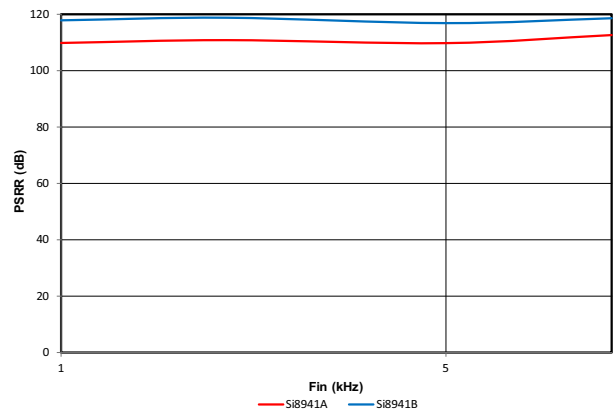


Figure 40. Si8941 Power Supply Rejection Ratio (dB) vs. Input Signal Frequency (kHz)

## 5. Safety Certifications and Specifications

**Table 5. Regulatory Information<sup>1</sup>**

|                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CSA</b>                                                                                                                               |
| The Si8941/Si8946/Si8947 is certified under CSA. For more details, see Master Contract File 232873.                                      |
| 62368-1: Up to 600 V <sub>RMS</sub> reinforced insulation working voltage; up to 1000 V <sub>RMS</sub> basic insulation working voltage. |
| <b>VDE</b>                                                                                                                               |
| The Si8941/Si8946/Si8947 is certified under VDE. For more details, see File 5028467.                                                     |
| 60747-17: Up to 2121 V <sub>peak</sub> for reinforced insulation working voltage.                                                        |
| <b>UL</b>                                                                                                                                |
| The Si8941/Si8946/Si8947 is certified under UL1577 component recognition program. For more details, see File E257455.                    |
| Rated up to 5000 V <sub>RMS</sub> V <sub>ISO</sub> isolation voltage for basic protection.                                               |
| <b>CQC</b>                                                                                                                               |
| The Si8941/Si8946/Si8947 is certified under GB4943.1.                                                                                    |
| Rated up to 250 V <sub>RMS</sub> reinforced insulation working voltage at 5000 meters tropical climate.                                  |

1. For more information, see Section 15. [Ordering Information](#)

**Table 6. Insulation and Safety-Related Specifications**

| Parameter                                 | Symbol          | Test Condition                 | Value               |                  | Unit             |
|-------------------------------------------|-----------------|--------------------------------|---------------------|------------------|------------------|
|                                           |                 |                                | WB Stretched SOIC-8 | NB SOIC-8        |                  |
| Nominal external air gap (clearance)      | CLR             |                                | 8.0                 | 4.0              | mm               |
| Nominal external tracking (creepage)      | CRP             |                                | 8.0                 | 4.0              | mm               |
| Minimum internal gap (internal clearance) | DTI             |                                | 0.036               | 0.036            | mm               |
| Tracking resistance                       | PTI or CTI      | IEC60112                       | 600                 | 600              | V <sub>RMS</sub> |
| Erosion depth                             | ED              |                                | 0.04                | 0.04             | mm               |
| Resistance (input-output) <sup>1</sup>    | R <sub>IO</sub> | Test voltage = 500 V,<br>25 °C | 10 <sup>12</sup>    | 10 <sup>12</sup> | Ω                |
| Capacitance (input-output) <sup>1</sup>   | C <sub>IO</sub> | f = 1 MHz                      | 1                   | 1                | pF               |

1. To determine resistance and capacitance, the Si8941/Si8946/Si8947 is converted into a two-terminal device. Pins 1 to 4 are shorted together to form the first terminal, and pins 5 to 8 are shorted together to form the second terminal. The parameters are then measured between these two terminals.

Table 7. IEC 60664-1 Ratings

| Parameter            | Test Conditions                         | Specification       |           |
|----------------------|-----------------------------------------|---------------------|-----------|
|                      |                                         | WB Stretched SOIC-8 | NB SOIC-8 |
| Material group       |                                         | I                   | I         |
| Overvoltage category | Rated mains voltage $\leq 150 V_{RMS}$  | I-IV                | I-IV      |
|                      | Rated mains voltage $\leq 300 V_{RMS}$  | I-IV                | I-III     |
|                      | Rated mains voltage $\leq 600 V_{RMS}$  | I-IV                | I-II      |
|                      | Rated mains voltage $\leq 1000 V_{RMS}$ | I-III               | I         |

Table 8. IEC 60747-17 Insulation Characteristics<sup>1</sup>

| Parameter                            | Symbol      | Test Condition                                                                                                                                                                                                                                                 | Characteristic      |           | Unit       |
|--------------------------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------|------------|
|                                      |             |                                                                                                                                                                                                                                                                | WB Stretched SOIC-8 | NB SOIC-8 |            |
| Maximum working isolation voltage    | $V_{IOWM}$  | According to Time-Dependent Dielectric Breakdown (TDDb) Test                                                                                                                                                                                                   | 1500                | 445       | $V_{RMS}$  |
| Maximum repetitive isolation voltage | $V_{IORM}$  | According to Time-Dependent Dielectric Breakdown (TDDb) Test                                                                                                                                                                                                   | 2121                | 630       | $V_{peak}$ |
| Apparent charge                      | $q_{pd}$    | Method b: At routine test (100% production) and preconditioning (type test);<br>$V_{ini} = 1.2 \times V_{IOTM}$ , $t_{ini} = 1 s$ ;<br>$V_{pd(m)} = 1.875 \times V_{IORM}$ , $t_m = 1 s$<br>(method b1) or $V_{pd(m)} = V_{ini}$ , $t_m = t_{ini}$ (method b2) | $\leq 5$            | $\leq 5$  | pC         |
| Maximum transient isolation voltage  | $V_{IOTM}$  | $V_{TEST} = V_{IOTM}$ ,<br>$t = 60 s$ (qualification);<br>$V_{TEST} = 1.2 \times V_{IOTM}$ ,<br>$t = 1 s$ (100% production)                                                                                                                                    | 7070                | 3535      | $V_{peak}$ |
| Maximum surge isolation voltage      | $V_{IOSM}$  | Tested in oil with $1.3 \times V_{IMP}$ or 10 kV minimum and $1.2 \mu s/50 \mu s$ profile                                                                                                                                                                      | 10400               | 10400     | $V_{peak}$ |
| Maximum impulse voltage              | $V_{IMP}$   | Tested in air with $1.2 \mu s/50 \mu s$ profile                                                                                                                                                                                                                | 8000                | 5000      | $V_{peak}$ |
| Isolation resistance                 | $R_{IO\_S}$ | $T_{AMB} = T_S$ , $V_{IO} = 500 V$                                                                                                                                                                                                                             | $>10^9$             | $>10^9$   | $\Omega$   |
| Pollution degree                     |             |                                                                                                                                                                                                                                                                | 2                   | 2         |            |
| Climatic category                    |             |                                                                                                                                                                                                                                                                | 40/125/21           | 40/125/21 |            |

1. This coupler is suitable for "safe electrical insulation" only within the safety ratings. Compliance with the safety ratings shall be ensured by means of suitable protective circuits.

Table 9. UL 1577 Insulation Characteristics

| Parameter                              | Symbol    | Test Condition                                                                                                            | Characteristic      |           | Unit      |
|----------------------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------|---------------------|-----------|-----------|
|                                        |           |                                                                                                                           | WB Stretched SOIC-8 | NB SOIC-8 |           |
| Maximum withstanding isolation voltage | $V_{ISO}$ | $V_{TEST} = V_{ISO}$ ,<br>$t = 60 s$ (qualification);<br>$V_{TEST} = 1.2 \times V_{ISO}$ ,<br>$t = 1 s$ (100% production) | 5000                | 2500      | $V_{RMS}$ |

Table 10. IEC 60747-17 Safety Limiting Values<sup>1</sup>

| Parameter                                                    | Symbol | Test Condition                                                                                                          | Characteristic | Unit |
|--------------------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------|----------------|------|
| Safety temperature                                           | $T_S$  |                                                                                                                         | 150            | °C   |
| Safety input, output or supply current (WB stretched SOIC-8) | $I_S$  | $\theta_{JA} = 90^\circ\text{C/W}$<br>$V_{DD} = 5.5\text{ V}$<br>$T_J = 150^\circ\text{C}$<br>$T_A = 25^\circ\text{C}$  | 253            | mA   |
|                                                              |        | $\theta_{JA} = 90^\circ\text{C/W}$<br>$V_{DD} = 3.6\text{ V}$<br>$T_J = 150^\circ\text{C}$<br>$T_A = 25^\circ\text{C}$  | 386            | mA   |
| Safety input, output or supply current (NB SOIC-8)           | $I_S$  | $\theta_{JA} = 112^\circ\text{C/W}$<br>$V_{DD} = 5.5\text{ V}$<br>$T_J = 150^\circ\text{C}$<br>$T_A = 25^\circ\text{C}$ | 203            | mA   |
|                                                              |        | $\theta_{JA} = 112^\circ\text{C/W}$<br>$V_{DD} = 3.6\text{ V}$<br>$T_J = 150^\circ\text{C}$<br>$T_A = 25^\circ\text{C}$ | 310            | mA   |
| Safety input, output or total power (WB stretched SOIC-8)    | $P_S$  | $\theta_{JA} = 90^\circ\text{C/W}$<br>$T_J = 150^\circ\text{C}$<br>$T_A = 25^\circ\text{C}$                             | 1389           | mW   |
| Safety input, output or total power (NB SOIC-8)              | $P_S$  | $\theta_{JA} = 112^\circ\text{C/W}$<br>$T_J = 150^\circ\text{C}$<br>$T_A = 25^\circ\text{C}$                            | 1116           | mW   |

1. Maximum value allowed in the event of a failure. Refer to the derating curves Figure 41, "WB Stretched SOIC-8 Thermal Derating Curve (Dependence of Safety Limiting Current)," on page 19 and Figure 42, "NB SOIC-8 Thermal Derating Curve (Dependence of Safety Limiting Current)," on page 20.

Table 11. Thermal Characteristics

| Parameter                             | Symbol        | WB Stretched SOIC-8 | NB SOIC-8 | Unit |
|---------------------------------------|---------------|---------------------|-----------|------|
| IC Junction-to-air thermal resistance | $\theta_{JA}$ | 90                  | 112       | °C/W |

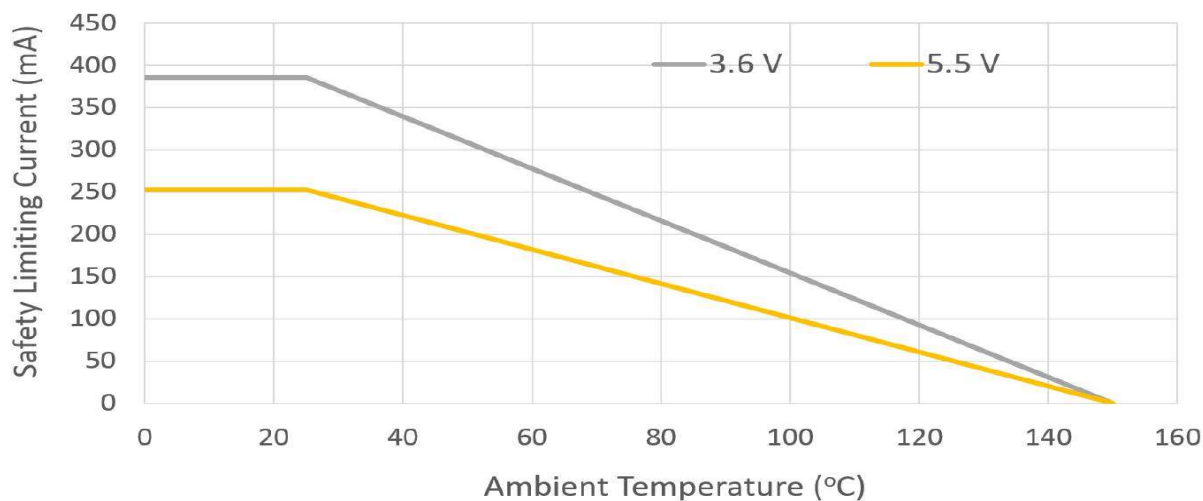


Figure 41. WB Stretched SOIC-8 Thermal Derating Curve (Dependence of Safety Limiting Current)

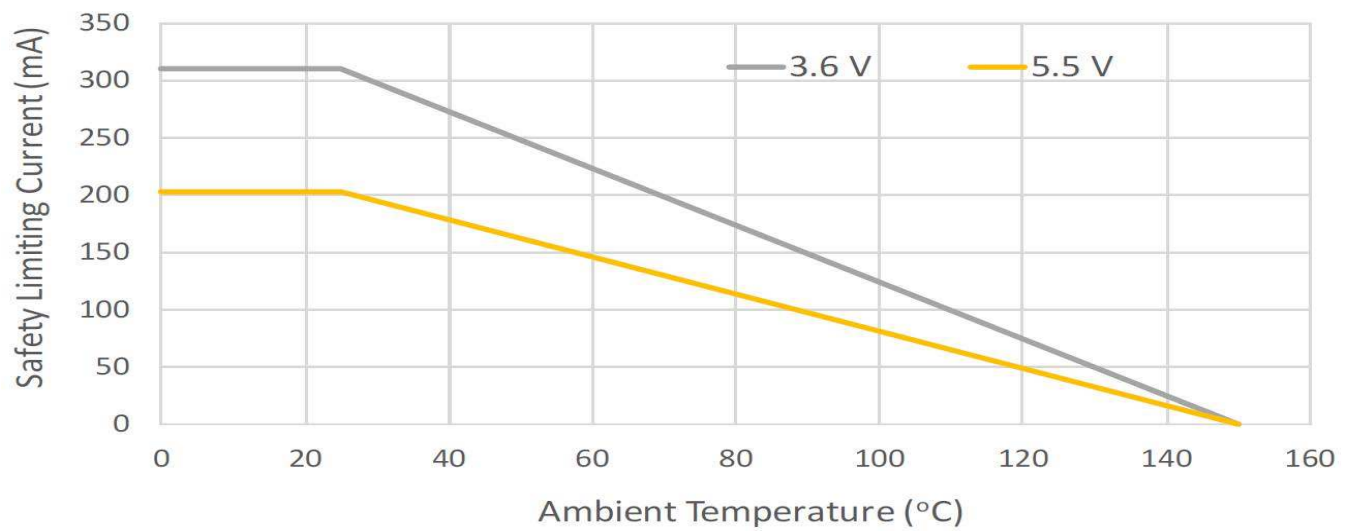


Figure 42. NB SOIC-8 Thermal Derating Curve (Dependence of Safety Limiting Current)

## 6. Package Handling Information

Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The Si8941AD-IS4, Si8941BD-IS4, Si8946AD-IS4, Si8946BD-IS4, Si8947AD-IS4, Si8947BD-IS4, Si8941AD-AS4, Si8941BD-AS4, Si8946AD-AS4, Si8946BD-AS4, Si8947AD-AS4, and Si8947BD-AS4 are rated to Moisture Sensitivity Level 2A (MSL2A) at 260°C.

The Si8941AB-IS, Si8941BB-IS, Si8946AB-IS, Si8946BB-IS, Si8947AB-IS, Si8947BB-IS, Si8941AB-AS, Si8941BB-AS, Si8946AB-AS, Si8946BB-AS, Si8947AB-AS, Si8947BB-AS are rated to MSL 2 at 260°C.

They can be used for lead or lead-free soldering. For additional information, refer to Skyworks Application Note, "PCB Design and SMT Assembly/Rework Guidelines," Document Number 101752.

Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Refer to Standard SMT Reflow Profiles: JEDEC Standard J-STD-020.

## 7. Package Outline: 8-Pin Wide Body Stretched SOIC

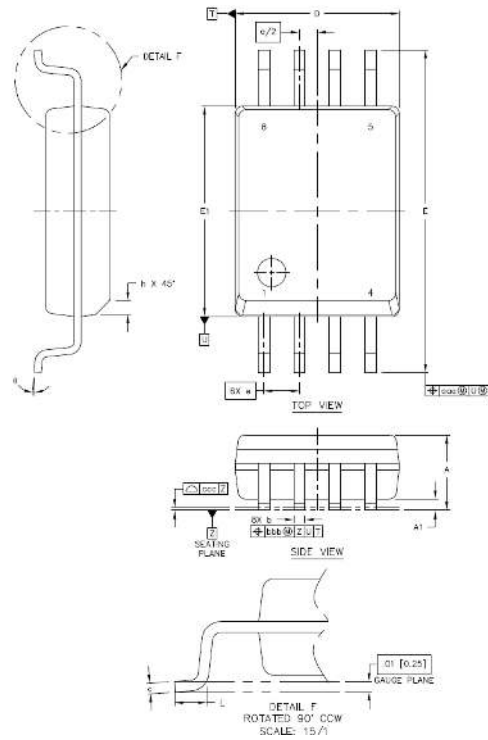


Figure 43. 8-Pin Wide Body Stretched SOIC Package

Table 12. 8-Pin Wide Body Stretched SOIC Package Dimensions

| Dimension | Millimeters |       | Notes                                                                                                                                                         |
|-----------|-------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
|           | Min         | Max   |                                                                                                                                                               |
| A         | 2.49        | 2.79  | Dimensioning and tolerancing per ANSI Y14.5M-1994.<br><br>Recommended reflow profile per JEDEC J-STD-020C specification for small body, lead-free components. |
| A1        | 0.36        | 0.46  |                                                                                                                                                               |
| b         | 0.30        | 0.51  |                                                                                                                                                               |
| c         | 0.20        | 0.33  |                                                                                                                                                               |
| D         | 5.74        | 5.94  |                                                                                                                                                               |
| E         | 11.25       | 11.76 |                                                                                                                                                               |
| E1        | 7.39        | 7.59  |                                                                                                                                                               |
| e         | 1.27 BSC    |       |                                                                                                                                                               |
| L         | 0.51        | 1.02  |                                                                                                                                                               |
| h         | 0.25        | 0.76  |                                                                                                                                                               |
| θ         | 0°          | 8°    |                                                                                                                                                               |
| aaa       |             | 0.25  |                                                                                                                                                               |
| bbb       |             | 0.25  |                                                                                                                                                               |
| ccc       |             | 0.10  |                                                                                                                                                               |

## 8. Package Outline: 8-Pin Narrow Body SOIC

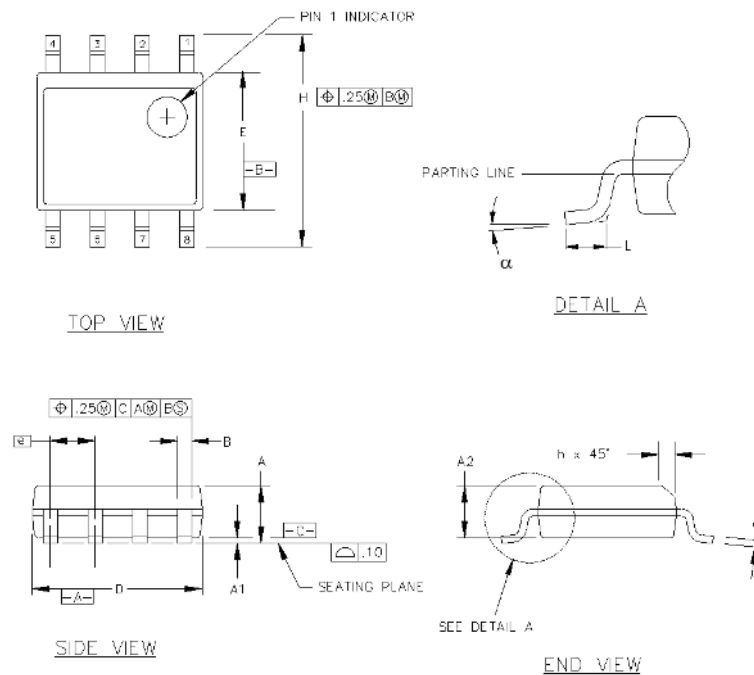


Figure 44. 8-Pin Narrow Body SOIC Package

Table 13. 8-Pin Narrow Body SOIC Package Dimensions

| Dimension | Millimeters |          | Notes                                                                                                                                                                                                                    |
|-----------|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|           | Min         | Max      |                                                                                                                                                                                                                          |
| A         | 1.35        | 1.75     | Dimensioning and tolerancing per ANSI Y14.5M-1982.<br><br>This drawing conforms to JEDEC Outline MS-012.<br><br>Recommended card reflow profile is per the JEDEC/IPC J-STD-020B specification for small body components. |
| A1        | 0.10        | 0.25     |                                                                                                                                                                                                                          |
| A2        | 1.40 REF    | 1.55 REF |                                                                                                                                                                                                                          |
| B         | 0.33        | 0.51     |                                                                                                                                                                                                                          |
| C         | 0.19        | 0.25     |                                                                                                                                                                                                                          |
| D         | 4.80        | 5.00     |                                                                                                                                                                                                                          |
| E         | 3.80        | 4.00     |                                                                                                                                                                                                                          |
| e         | 1.27 BSC    |          |                                                                                                                                                                                                                          |
| H         | 5.80        | 6.20     |                                                                                                                                                                                                                          |
| h         | 0.25        | 0.50     |                                                                                                                                                                                                                          |
| L         | 0.40        | 1.27     |                                                                                                                                                                                                                          |
| α         | 0°          | 8°       |                                                                                                                                                                                                                          |

9. Land Pattern: 8-Pin Wide Body Stretched SOIC

General Guidelines

- 1. All dimensions shown are at Maximum Material Condition (MMC). Least Material Condition (LMC) is calculated based on a fabrication allowance of 0.05 mm.
- 2. This land pattern design is based on the IPC-7351 guidelines.

Solder Mask Design

- 1. All metal pads are to be non-solder mask defined (NSMD).
- 2. Clearance between the solder mask and the metal pad is to be 60 μm minimum, all the way around the pad.

Stencil Design

- 1. A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.
- 2. The stencil thickness should be 0.125 mm (5 mils).
- 3. The ratio of stencil aperture to land pad size should be 1:1 for all perimeter pins.

Card Assembly

- 1. A No-clean, Type-3 solder paste is recommended.
- 2. The recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.

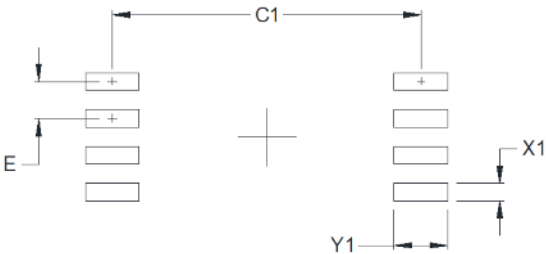


Figure 45. 8-Pin Wide Body Stretched SOIC Land Pattern

Table 14. 8-Pin Wide Body Stretched SOIC Land Pattern Dimensions<sup>1</sup>

| Dimension | (mm)  |
|-----------|-------|
| C1        | 10.60 |
| E         | 1.27  |
| X1        | 0.60  |
| Y1        | 1.85  |

1. See General Guidelines

10. Land Pattern: 8-Pin Narrow Body SOIC

General Guidelines

- 1. All feature sizes shown are at Maximum Material Condition (MMC) and a card fabrication tolerance of 0.05 mm is assumed.
- 2. This Land Pattern Design is based on IPC-7351 pattern SOIC127P600X173-8N for Density Level B (Median Land Protrusion).

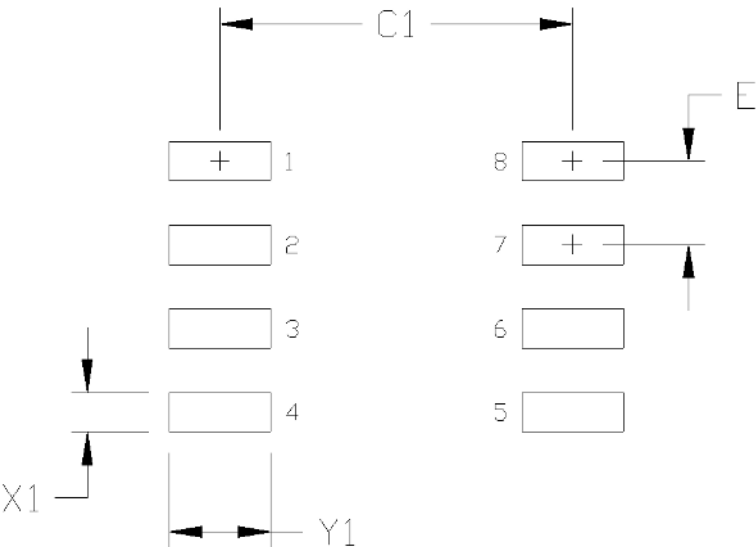


Figure 46. 8-Pin Narrow Body SOIC Land Pattern

Table 15. 8-Pin Narrow Body SOIC Land Pattern Dimensions<sup>1</sup>

| Dimension | mm   |
|-----------|------|
| C1        | 5.40 |
| E         | 1.27 |
| X1        | 0.60 |
| Y1        | 1.55 |

1. See General Guidelines

11. Top Marking: 8-Pin Wide Body Stretched SOIC

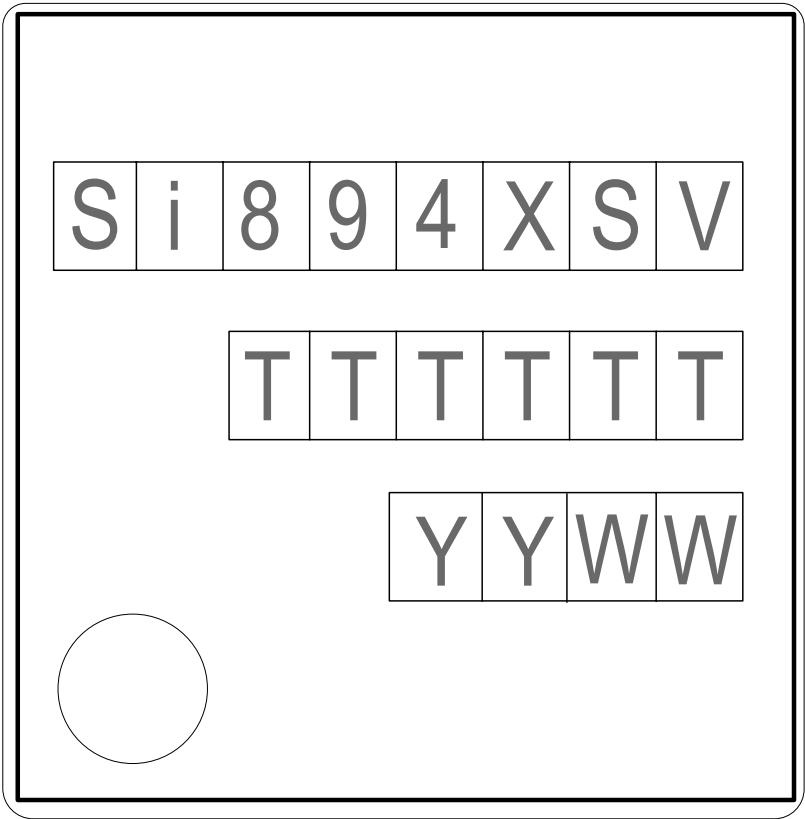


Figure 47. Si894x Typical Package Marking, 8-Pin Wide Body Stretched SOIC

Table 16: 8-Pin Wide Body Stretched SOIC Top Marking Explanation

|        |                                                                         |                                                                                                                                                                                                                                                                                                  |
|--------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Line 1 | Part Number                                                             | Si8941 or Si8946 or Si8947 Delta-Sigma Modulators<br>X = Clock Source/Speed<br>1 = External (Si8941)<br>6 = Internal 10 MHz (Si8946)<br>7 = Internal 20 MHz (Si8947)<br><br>S = Input range:<br>A = $\pm 62.5$ mV<br>B = $\pm 250$ mV<br><br>V = Insulation rating:<br>D = 5.0 kV <sub>RMS</sub> |
| Line 2 | TTTTTT                                                                  | Manufacturing code                                                                                                                                                                                                                                                                               |
| Line 3 | YY = Year<br>WW = Work Week<br>Circle = 43 mils diameter left justified | Year and work week                                                                                                                                                                                                                                                                               |

12. Top Marking: 8-Pin Narrow Body SOIC

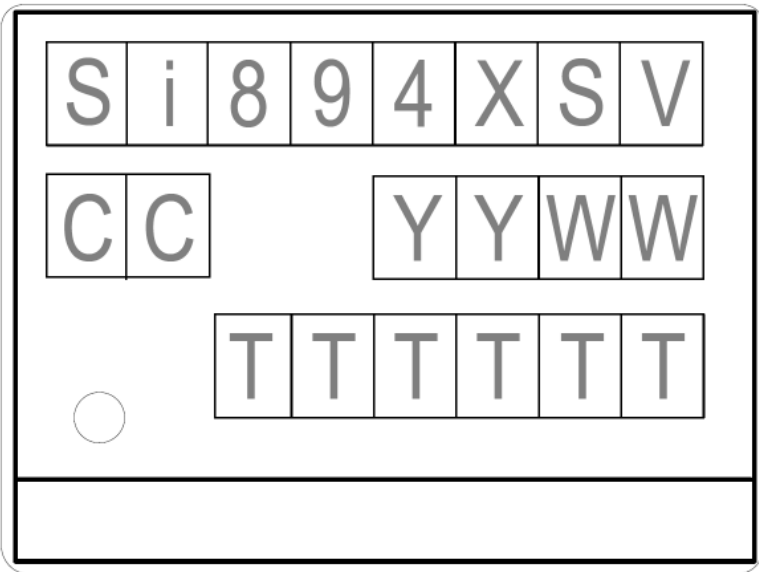


Figure 48. Si894x Typical Package Marking, 8-Pin Narrow Body SOIC

Table 17. 8-Pin Narrow Body SOIC Top Marking Explanation

|        |                                              |                                                                                                                                                                                                                                                                                                                                                                            |
|--------|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Line 1 | Part Number                                  | <p>Si8941 or Si8946 or Si8947 Delta-Sigma Modulators</p> <p>X = Clock Source/Speed</p> <p>1 = External (Si8941)</p> <p>6 = Internal 10 MHz (Si8946)</p> <p>7 = Internal 20 MHz (Si8947)</p> <p>S = Input range:</p> <p>A = <math>\pm 62.5</math> mV</p> <p>B = <math>\pm 250</math> mV</p> <p>V = Insulation rating</p> <p>B = <math>2.5\text{ kV}_{\text{RMS}}</math></p> |
| Line 2 | CC = Country of origin ISO code abbreviation |                                                                                                                                                                                                                                                                                                                                                                            |
|        | YY = Year<br>WW = Work Week                  | Year and work week                                                                                                                                                                                                                                                                                                                                                         |
| Line 3 | Circle = 19.7 mils diameter left justified   | Manufacturing code                                                                                                                                                                                                                                                                                                                                                         |

13. Tape and Reel Information, Wide Body

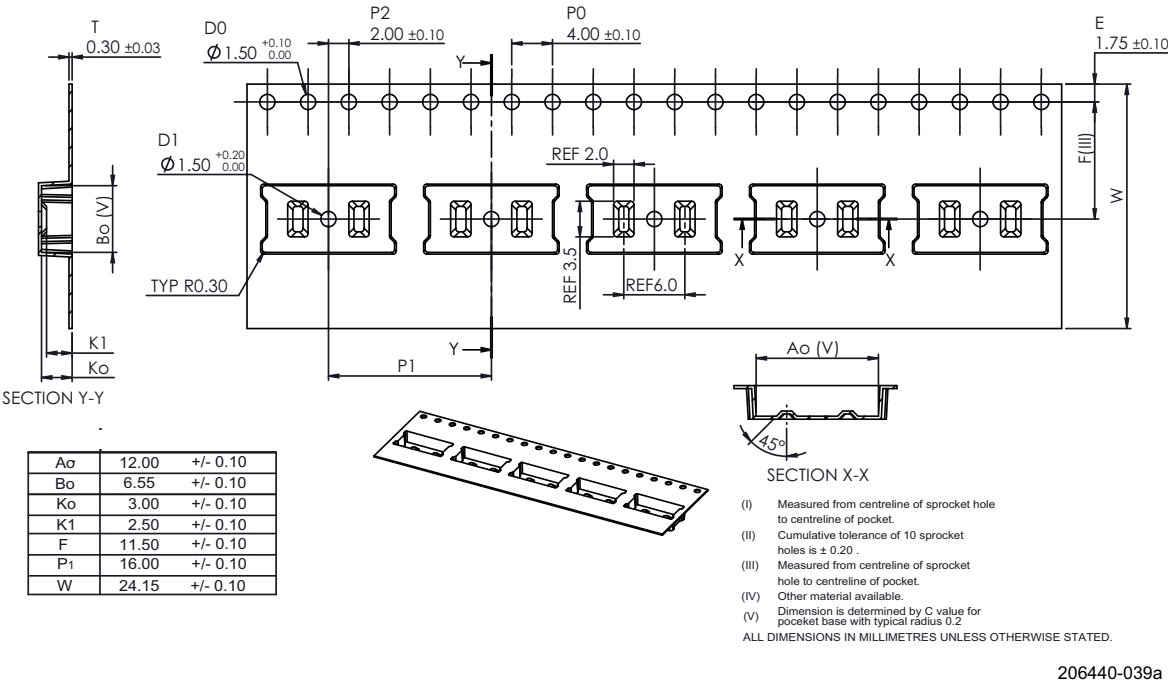


Figure 49. Wide Body Carrier Tape Information

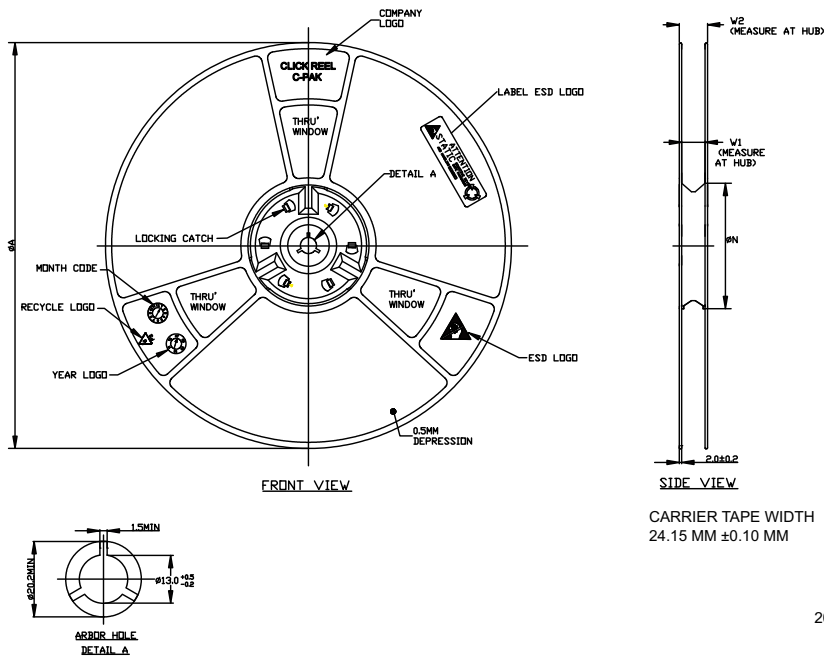
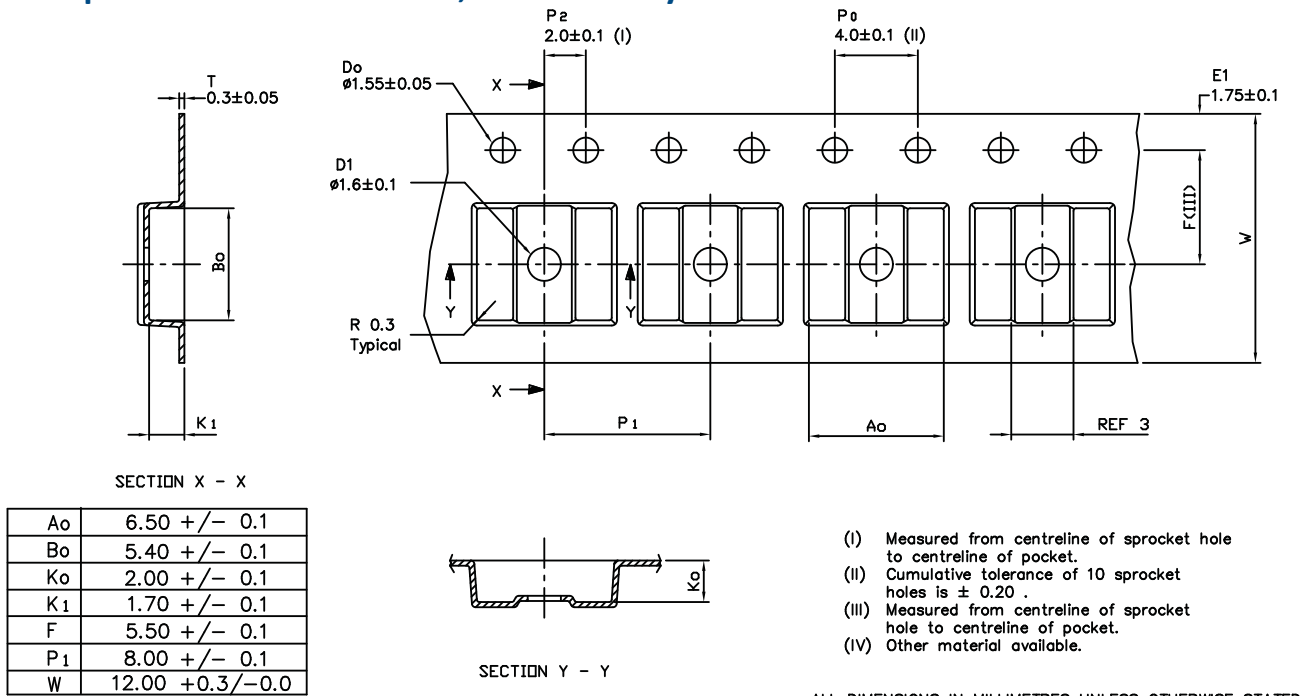


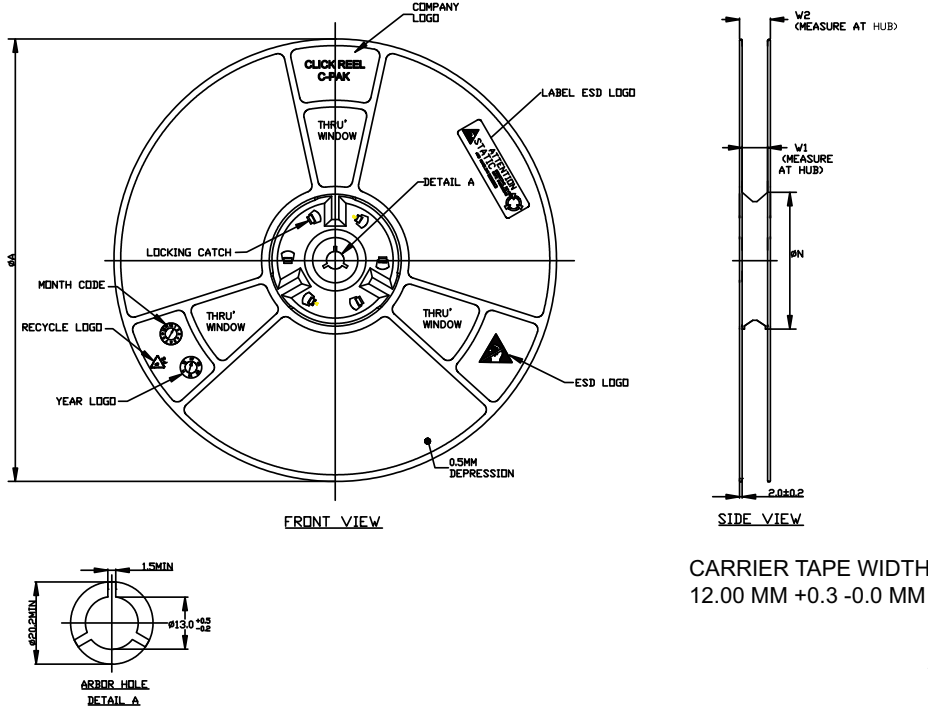
Figure 50. Wide Body Reel Information

14. Tape and Reel Information, Narrow Body



206440-044a

Figure 51. Narrow Body Carrier Tape Information



206440-045

Figure 52. Narrow Body Reel Information

## 15. Ordering Information

### Industrial and Automotive Grade Ordering Part Numbers (OPNs)

Industrial-grade devices (part numbers with an “-I” in their suffix) are built using well-controlled, high-quality manufacturing flows to ensure robustness and reliability. Qualifications are compliant with JEDEC, and defect reduction methodologies are used throughout definition, design, evaluation, qualification, and mass production steps.

Automotive-grade devices (part numbers with an “-A” in their suffix) are built using automotive-specific flows at all steps in the manufacturing process to ensure robustness and low defectivity. These devices are supported with AIAG-compliant Production Part Approval Process (PPAP) documentation, and feature International Material Data System (IMDS) and China Automotive Material Data System (CAMDS) listings. Qualifications are compliant with AEC-Q100, and a zero-defect methodology is maintained throughout definition, design, evaluation, qualification, and mass production steps.

| Ordering Part Number <sup>1, 2, 3</sup> | Automotive Ordering Part Number <sup>1, 2, 3, 4, 5</sup> | Ordering Options      |                       |               |                     |
|-----------------------------------------|----------------------------------------------------------|-----------------------|-----------------------|---------------|---------------------|
|                                         |                                                          | Specified Input Range | Isolation Rating      | Clock         | Package Type        |
| Si8941AD-IS4                            | Si8941AD-AS4                                             | ±62.5 mV              | 5.0 kV <sub>RMS</sub> | Input         | WB stretched SOIC-8 |
| Si8941BD-IS4                            | Si8941BD-AS4                                             | ±250 mV               | 5.0 kV <sub>RMS</sub> | Input         | WB stretched SOIC-8 |
| Si8946AD-IS4                            | Si8946AD-AS4                                             | ±62.5 mV              | 5.0 kV <sub>RMS</sub> | 10 MHz output | WB stretched SOIC-8 |
| Si8946BD-IS4                            | Si8946BD-AS4                                             | ±250 mV               | 5.0 kV <sub>RMS</sub> | 10 MHz output | WB stretched SOIC-8 |
| Si8947AD-IS4                            | Si8947AD-AS4                                             | ±62.5 mV              | 5.0 kV <sub>RMS</sub> | 20 MHz output | WB stretched SOIC-8 |
| Si8947BD-IS4                            | Si8947BD-AS4                                             | ±250 mV               | 5.0 kV <sub>RMS</sub> | 20 MHz output | WB stretched SOIC-8 |
| Si8941AB-IS                             | Si8941AB-AS                                              | ±62.5 mV              | 2.5 kV <sub>RMS</sub> | Input         | NB SOIC-8           |
| Si8941BB-IS                             | Si8941BB-AS                                              | ±250 mV               | 2.5 kV <sub>RMS</sub> | Input         | NB SOIC-8           |
| Si8946AB-IS                             | Si8946AB-AS                                              | ±62.5 mV              | 2.5 kV <sub>RMS</sub> | 10 MHz output | NB SOIC-8           |
| Si8946BB-IS                             | Si8946BB-AS                                              | ±250 mV               | 2.5 kV <sub>RMS</sub> | 10 MHz output | NB SOIC-8           |
| Si8947AB-IS                             | Si8947AB-AS                                              | ±62.5 mV              | 2.5 kV <sub>RMS</sub> | 20 MHz output | NB SOIC-8           |
| Si8947BB-IS                             | Si8947BB-AS                                              | ±250 mV               | 2.5 kV <sub>RMS</sub> | 20 MHz output | NB SOIC-8           |

1. All packages are RoHS-compliant.
2. “Si” and “SI” are used interchangeably.
3. An “R” at the end of the part number denotes tape and reel packaging option.
4. Automotive-grade devices (“-A” suffix) are identical in construction materials, topside marking, and electrical parameters to their Industrial Grade (“-I suffix”) version counterparts. Automotive-Grade products are produced utilizing full automotive process flows and additional statistical process controls throughout the manufacturing flow. The Automotive-Grade part number is included on shipping labels.
5. In the top markings of each device, the Manufacturing Code represented by “TTTTT” contains as its first character a letter in the range N through Z to indicate Automotive Grade.

## Revision History

### Revision B

October 2, 2023

Re-formatted to new standards. Added new text for Automotive Grade products, AEC-Q100 qualification, updated regulatory information, updated absolute maximum note 1, removed not needed IDD minimum specs, added tape and reel information, and added MSL ratings.

### Revision 206439A

December, 2022

- Updated decimal-based revision number to alphanumeric code.

### Revision 0.8

September, 2022

- Updated Safety Approvals on front page.
- Updated minimum supply currents in Electrical Specifications.
- Updated Regulatory Information.

### Revision 0.7

April, 2021

- Updated Applications and Key Features on front page.
- Updated Electrical Specifications after full characterization.
- Added Automotive OPNs to Ordering Guide.
- Updated Insulation and Safety-Related Specifications table.
- Numerous clarifications throughout.

### Revision 0.5

March, 2019

- Updated specifications.
- Added narrow body SOIC package.
- Added timing diagram.

### Revision 0.1

January, 2018

- Initial release.

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