

DUAL PROSLIC[®] WITH DC-DC CONTROLLER

Features

- Performs all BORSCHT functions
- Ideal for short- or long-loop applications
- Internal balanced or unbalanced ringing
- Low power consumption
- Software-programmable parameters:
 - Ringing frequency, amplitude, cadence, and waveshape
 - Two-wire ac impedance
 - Transhybrid balance
 - DC current loop feed (10–45 mA)
 - Loop closure and ring trip thresholds
 - Ground key detect threshold
- Integrated dc-dc controller
- Wideband CODEC (Si3227)
- Low-power sleep mode
- On-hook transmission
- Loop or ground start operation
- Smooth polarity reversal
- DTMF generator/decoder
- A-Law/ μ -Law companding, linear PCM
- PCM and SPI bus digital interfaces with programmable interrupts
- GCI/IOM-2 mode support
- 3.3 V operation
- GR-909 loop diagnostics
- Audio diagnostics with loopback
- Pb-free/RoHS-compliant packaging

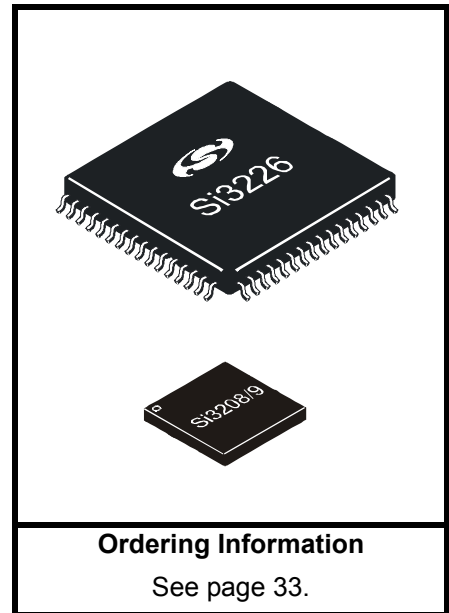
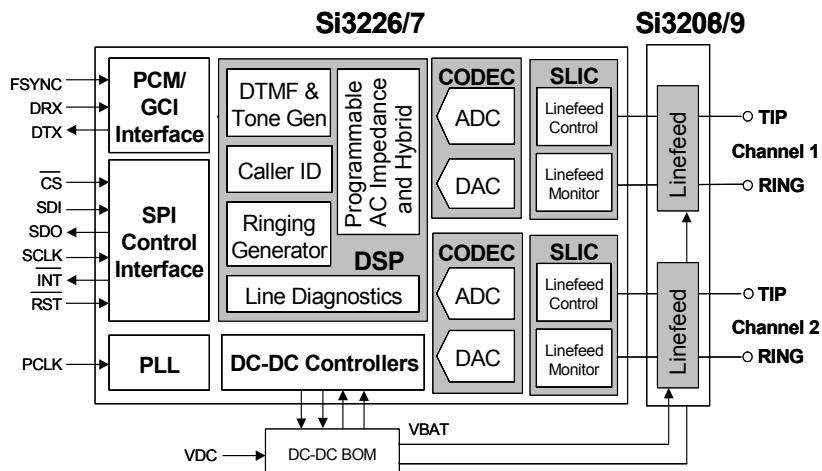
Applications

- Customer Premises Equipment (CPE)
- Optical Network Terminals (ONT)
- Private Branch Exchange (PBX)
- Cable EMTAs, ATAs, VoIP Gateways

Description

The Dual ProSLIC[®] is a family of low-voltage CMOS devices that integrate both SLIC and CODEC functionality into a single IC. In combination with a linefeed IC (LFIC), they provide a complete two-channel analog telephone interface in accordance with all relevant LSSGR, ITU, and ETSI specifications. The Dual ProSLIC devices (Si3226/7) operate from a single 3.3 V supply and interface to standard PCM/SPI or GCI bus digital interfaces. The LFICs (Si3208/9) perform all high-voltage functions and operate from a 3.3 V supply as well as high-voltage battery supplies. The Si3208 is rated for –110 V, and the Si3209 is rated for –135 V. The Dual ProSLIC devices are available in a 64-pin thin quad flat package (TQFP), and the LFICs are available in a 40-pin, quad flat no-lead package (QFN).

Functional Block Diagram



Patents pending

Si3226/7
Si3208/9

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1. Electrical Specifications

Table 1. Absolute Maximum Ratings and Thermal Information¹

| Parameter | Symbol | Test Condition | Value | Unit |
|---|---------------------|----------------------|--------------|------|
| Operating Temperature Range | T_A | | -40 to 85 | °C |
| Storage Temperature Range | T_{STG} | | -55 to 150 | °C |
| Thermal Resistance, Typical ² TQFP-64 | θ_{JA} | | 25 | °C/W |
| Continuous Power Dissipation ³ TQFP-64 | P_D | $T_A = 85\text{ °C}$ | 1.6 | W |
| Thermal Resistance, Typical ² QFN-40 | θ_{JA} | | 32 | °C/W |
| Continuous Power Dissipation ⁴ QFN-40 | P_D | $T_A = 85\text{ °C}$ | 1.7 | W |
| Si3226/7 | | | | |
| Supply Voltage | $V_{DD1} - V_{DD4}$ | | -0.5 to 4.0 | V |
| Digital Input Voltage | V_{IND} | | -0.3 to 3.6 | V |
| Si3208 | | | | |
| Supply Voltage | V_{DD} | | -0.5 to 4.0 | V |
| Battery Supply Voltage ⁵ | V_{BAT} | Continuous | +0.4 to -110 | V |
| | | Pulse < 10 μ s | +0.4 to -118 | V |
| TIP, RING Current | I_{TIP}, I_{RING} | | ± 100 | mA |
| Si3209 | | | | |
| Supply Voltage | V_{DD} | | -0.5 to 4.0 | V |
| High Battery Supply Voltage ⁵ | V_{BAT} | Continuous | +0.4 to -135 | V |
| | | Pulse < 10 μ s | +0.4 to -143 | V |
| TIP, RING Current | I_{TIP}, I_{RING} | | ± 100 | mA |
| Notes: | | | | |
| <ol style="list-style-type: none"> 1. Permanent device damage may occur if the absolute maximum ratings are exceeded. Functional operation should be restricted to the conditions as specified in the operational sections of this data sheet. 2. The thermal resistance of an exposed pad package is assured when the recommended printed circuit board layout guidelines are followed correctly. The specified performance requires that the exposed pad be soldered to an exposed copper surface of at least equal size and that multiple vias are added to enable heat transfer between the top-side copper surface and a large internal/bottom copper plane. 3. Operation of the Si3226 or Si3227 above 125 °C junction temperature may degrade device reliability. 4. Si3208 and Si3209 are equipped with on-chip thermal limiting circuitry that shuts down the circuit when the junction temperature exceeds the thermal shutdown threshold. The thermal shutdown threshold should normally be set to 145 °C; when in the ringing state the thermal shutdown may be set to 200 °C. For optimal reliability long term operation of the Si3208/Si3209 above 150 °C junction temperature should be avoided. 5. The dv/dt of the voltage applied to the VBAT pins must be limited to 10 V/μs. | | | | |

Table 2. Recommended Operating Conditions

| Parameter | Symbol | Test Condition | Min* | Typ | Max* | Unit |
|-------------------------------|-------------------|----------------|------|-----|------|------|
| Ambient Temperature | T_A | F-grade | 0 | 25 | 70 | °C |
| Ambient Temperature | T_A | G-grade | -40 | 25 | 85 | °C |
| Supply Voltage, Si3226/7 | $V_{DD1}-V_{DD4}$ | | 3.13 | 3.3 | 3.47 | V |
| Supply Voltage, Si3208/Si3209 | V_{DD} | | 3.13 | 3.3 | 3.47 | V |
| Battery Voltage, Si3208 | V_{BAT} | | -9 | — | -110 | V |
| Battery Voltage, Si3209 | V_{BAT} | | -9 | — | -135 | V |

***Note:** All minimum and maximum specifications are guaranteed and apply across the recommended operating conditions. Typical values apply at nominal supply voltages and an operating temperature of 25 °C unless otherwise stated.

Table 3. 3.3 V Power Supply Characteristics¹

($V_{DD} = 3.3$ V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|------------|--|-----|------------------|-----|------|
| High Impedance, Reset | I_{DD} | V_T and $V_R = \text{Hi-Z}$ $\overline{\text{RST}} = 0$ | — | 2.4 | — | mA |
| | I_{VBAT} | | — | 0 | — | mA |
| High Impedance, Open Current | I_{DD} | V_T and $V_R = \text{Hi-Z}$ | — | 9.7 | — | mA |
| | I_{VBAT} | | — | 0.6 | — | mA |
| Forward/Reverse Sleep, On-hook Current | I_{DD} | $V_{TR} = -48$ V | — | 15 | — | mA |
| | I_{VBAT} | | — | 1.2 | — | mA |
| Forward/Reverse Active, On-hook Current | I_{DD} | $V_{TR} = -48$ V | — | 24 | — | mA |
| | I_{VBAT} | | — | 1.2 | — | mA |
| Forward/Reverse Active, Off-hook Current | I_{DD} | $I_{LOOP} = 30$ mA $R_{LOAD} = 50$ Ω | — | 43 | — | mA |
| | I_{VBAT} | | — | $3.1 + I_{LOOP}$ | — | mA |
| Forward/Reverse OHT, On-hook Current | I_{DD} | $V_{TR} = -48$ V | — | 43 | — | mA |
| | I_{VBAT} | | — | 1.6 | — | mA |
| Tip/Ring Open, On-hook Current | I_{DD} | V_T or $V_R = -48$ V V_R or $V_T = \text{Hi-Z}$ | — | 23 | — | mA |
| | I_{VBAT} | | — | 0.6 | — | mA |
| Ringing Current | I_{DD} | $V_{TR} = 55 V_{RMS} + 0 V_{DC}$ balanced, sinusoidal, $f = 20$ Hz $R_{LOAD} = 5 \text{ REN} = 1400$ Ω | — | 26 | — | mA |
| | I_{VBAT} | | — | $2.3 + I_{AVE}$ | — | mA |

Notes:

1. All specifications are for a single channel of Si3226/7 using Si3208/9 linefeed IC and based on measurements with all channels in the same operating state.
2. I_{LOOP} is the dc current in the subscriber loop during the off-hook state.
3. I_{AVE} is the average of the full-wave rectified current in the subscriber loop during ringing ($I_{AVE} = I_{PEAK} \times 2/\pi$).

Si3226/7

Si3208/9

Table 4. AC Characteristics

($V_{DD} = 3.13$ to 3.47 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Test Condition | Min | Typ | Max | Unit |
|--|---|-----------|-----|------|----------|
| TX/RX Performance | | | | | |
| Overload Level | | 2.5 | — | — | V_{PK} |
| Overload Compression | 2-Wire – PCM | Figure 6 | — | — | |
| Single Frequency Distortion ¹ | 2-Wire – PCM or PCM – 2-Wire: 200 Hz to 3.4 kHz | — | — | -65 | dB |
| | PCM – 2-Wire – PCM: 200 Hz – 3.4 kHz, 16-bit Linear mode | — | — | -65 | dB |
| Signal-to-(Noise + Distortion) Ratio ² | 200 Hz to 3.4 kHz D/A or A/D 8-bit Active off-hook, and OHT, any Z_T | Figure 5 | — | — | |
| Audio Tone Generator Signal-to-Distortion Ratio ² | 0 dBm0, Active off-hook, and OHT, any Z_T | 46 | — | — | dB |
| Intermodulation Distortion | | — | — | -41 | dB |
| Gain Accuracy ² | 2-Wire to PCM or PCM to 2-Wire 1014 Hz, Any gain setting $V_{DD1} - V_{DD4} = 3.3$ V \pm 5% | -0.2 | — | 0.2 | dB |
| Attenuation Distortion vs. Freq. | 0 dBm 0 | See AN317 | | | |
| Group Delay vs. Frequency | | See AN317 | | | |
| Gain Tracking ³ | 1014 Hz sine wave, reference level -10 dBm Signal level: | — | — | — | — |
| | 3 dB to -37 dB | — | — | 0.25 | dB |
| | -37 dB to -50 dB | — | — | 0.5 | dB |
| | -50 dB to -60 dB | — | — | 1.0 | dB |
| Round-Trip Group Delay | 1014 Hz, Within same time-slot | — | 450 | 500 | μ s |
| Crosstalk between channels TX or RX to TX TX or RX to RX | 0 dBm0, 300 Hz to 3.4 kHz | — | — | -75 | dB |
| | 300 Hz to 3.4 kHz | — | — | -75 | dB |
| 2-Wire Return Loss ⁴ | 200 Hz to 3.4 kHz | 26 | 30 | — | dB |
| Transhybrid Balance ⁴ | 300 Hz to 3.4 kHz | 26 | 30 | — | dB |
| Noise Performance | | | | | |
| Idle Channel Noise ⁵ | C-Message weighted | — | 8 | 12 | dBrnC |
| | Psophometric weighted | — | -80 | -78 | dBmP |
| PSRR from $V_{DD1} - V_{DD4}$ | RX and TX, dc to 3.4 kHz | 40 | — | — | dB |
| Notes: | | | | | |
| 1. The input signal level should be 0 dBm0 for frequencies greater than 100 Hz. For 100 Hz and below, the level should be -10 dBm0. The output signal magnitude at any other frequency is smaller than the maximum value specified. | | | | | |
| 2. Analog signal measured as $V_{TIP} - V_{RING}$. Assumes ideal line impedance matching. | | | | | |
| 3. The quantization errors inherent in the μ /A-law companding process can generate slightly worse gain tracking performance in the signal range of 3 to -37 dB for signal frequencies that are integer divisors of the 8 kHz PCM sampling rate. | | | | | |
| 4. $V_{DD1} - V_{DD4} = 3.3$ V, $V_{BAT} = -52$ V, no fuse resistors; $R_L = 600$ Ω , $Z_S = 600$ Ω synthesized using RS register coefficients. | | | | | |
| 5. The level of any unwanted tones within the bandwidth of 0 to 4 kHz does not exceed -55 dBm. | | | | | |

Table 4. AC Characteristics (Continued)

($V_{DD} = 3.13$ to 3.47 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Test Condition | Min | Typ | Max | Unit |
|--|--------------------------------------|-----|-----|-----|----------|
| Longitudinal Performance | | | | | |
| Longitudinal to Metallic/PCM Balance (forward or reverse) | 200 Hz to 1 kHz | 58 | 60 | — | dB |
| | 1 kHz to 3.4 kHz | 53 | 58 | — | dB |
| Metallic/PCM to Longitudinal Balance | 200 Hz to 3.4 kHz | 40 | — | — | dB |
| Longitudinal Impedance | 200 Hz to 3.4 kHz at TIP or RING | — | 50 | — | Ω |
| Longitudinal Current per Pin | Active off-hook 200 Hz to 3.4 kHz | — | — | 30 | mA |
| DC Current | Differential | — | — | 45 | mA |
| | Common Mode | — | — | 30 | mA |
| | Differential + Common Mode | — | — | 45 | mA |
| Notes: | | | | | |
| <ol style="list-style-type: none"> 1. The input signal level should be 0 dBm0 for frequencies greater than 100 Hz. For 100 Hz and below, the level should be -10 dBm0. The output signal magnitude at any other frequency is smaller than the maximum value specified. 2. Analog signal measured as $V_{TIP} - V_{RING}$. Assumes ideal line impedance matching. 3. The quantization errors inherent in the μ/A-law companding process can generate slightly worse gain tracking performance in the signal range of 3 to -37 dB for signal frequencies that are integer divisors of the 8 kHz PCM sampling rate. 4. $V_{DD1} - V_{DD4} = 3.3$ V, $V_{BAT} = -52$ V, no fuse resistors; $R_L = 600 \Omega$, $Z_S = 600 \Omega$ synthesized using RS register coefficients. 5. The level of any unwanted tones within the bandwidth of 0 to 4 kHz does not exceed -55 dBm. | | | | | |

Table 5. Linefeed Characteristics

($V_{DD} = 3.13$ to 3.47 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|------------|--|-----|-----|------|------------|
| Maximum Loop Resistance | R_{LOOP} | $R_{DC,MAX} = 430 \Omega$ $I_{LOOP} = 18$ mA, $V_{BAT} = -52$ V | — | — | 2000 | Ω |
| DC Loop Current Accuracy | | $I_{LIM} = 18$ mA | — | — | 10 | % |
| DC Open Circuit Voltage Accuracy | | Active Mode; $V_{OC} = 48$ V, $V_{TIP} - V_{RING}$ | — | — | 4 | V |
| DC Differential Output Resistance | R_{DO} | $I_{LOOP} < I_{LIM}$ | 160 | — | 640 | Ω |
| DC On-Hook Voltage Accuracy—Ground Start | V_{OHTO} | $I_{RING} < I_{LIM}$; V_{RING} wrt ground, $V_{RING} = -51$ V | — | — | 4 | V |
| DC Output Resistance—Ground Start | R_{ROTO} | $I_{RING} < I_{LIM}$; RING to ground | 160 | — | 640 | Ω |
| DC Output Resistance—Ground Start | R_{TOTO} | TIP to ground | 400 | — | — | k Ω |
| Loop Closure Detect Threshold Accuracy | | $I_{THR} = 13$ mA | — | — | 10 | % |
| Ground Key Detect Threshold Accuracy | | $I_{THR} = 13$ mA | — | — | 10 | % |
| Ring Trip Threshold Accuracy | | AC detection, $V_{RING} = 70$ Vpk, no offset, $I_{TH} = 80$ mA | — | — | 4 | mA |
| | | DC detection, 20 V dc offset, $I_{TH} = 13$ mA | — | — | 1 | mA |
| | | DC Detection, 48 V DC offset, $R_{loop} = 1500 \Omega$ | — | — | 3 | mA |
| Ringing Amplitude | V_{RING} | Open circuit, $V_{BAT} = -110$ V | 108 | — | — | V_{PK} |
| | | 5 REN load, $R_{LOOP} = 0 \Omega$, $V_{BAT} = -110$ V, $R_{DO} = 160 \Omega$ | 99 | — | — | V_{PK} |
| | | Open Circuit, $V_{BAT} = -135$ V | 133 | — | — | V_{PK} |
| | | 5 REN load, $R_{LOOP} = 0 \Omega$, $V_{BAT} = -130$ V, $R_{DO} = 160 \Omega$ | 121 | — | — | V_{PK} |
| Sinusoidal Ringing Total Harmonic Distortion | R_{THD} | | — | 2 | — | % |
| Ringing Frequency Accuracy | | $f = 16$ Hz to 100 Hz | — | — | 1 | % |
| Ringing Cadence Accuracy | | Accuracy of ON/OFF times | — | — | 50 | ms |
| Calibration Time | | \uparrow CAL to \downarrow CAL bit | — | — | TBD | ms |
| Loop Voltage Sense Accuracy | | Accuracy of boundaries for each output Code; $V_{TIP} - V_{RING} = 48$ V | — | 2 | 4 | % |

***Note:** Ringing amplitude is set for 93 V peak and measured at TIP-RING using no series protection resistance.

Table 5. Linefeed Characteristics (Continued)

($V_{DD} = 3.13$ to 3.47 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--------------------------------|--------|--|-----|-----|-----|------|
| Loop Current Sense Accuracy | | Accuracy of boundaries for each output code; $I_{LOOP} = 18$ mA | — | 7 | 10 | % |
| Power Alarm Threshold Accuracy | | Power Threshold = 300 mW | — | — | 25 | % |

***Note:** Ringing amplitude is set for 93 V peak and measured at TIP-RING using no series protection resistance.

Table 6. Monitor ADC Characteristics

($V_{DD} = 3.13$ to 3.47 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|--------|----------------|-----|-----|-----|------|
| Differential Nonlinearity (8-bit resolution) | DNLE | | — | — | 1 | LSB |
| Integral Nonlinearity (8-bit resolution) | INLE | | — | — | 1 | LSB |
| Gain Error | | | — | — | 5 | % |

Table 7. Si3208/Si3209 Characteristics

($V_{DD} = 3.13$ to 3.47 V, $V_{BAT} = -15$ to -130 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|-----------|--------------------------------|-----|-----|-----|---------|
| TIP/RING Pull-down Transistor Saturation Voltage | V_{CM} | $V_{RING} - V_{BAT}$ (Forward) | — | 3 | — | V |
| | | $V_{TIP} - V_{BAT}$ (Reverse) | — | — | 3.5 | V |
| TIP/RING Pull-up Transistor Saturation Voltage | V_{OV} | GND – V_{TIP} (Forward) | — | 3 | — | V |
| | | GND – V_{RING} (Reverse) | — | — | 3.5 | V |
| OPEN State TIP/RING Leakage Current | I_{LKG} | $R_L = 0\Omega$ | — | — | 150 | μ A |

Table 8. DC Characteristics

($V_{DD} = 3.13$ to 3.47 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|------------------------------------|-----------|---|---------------------|-----|---------------------|------------|
| High Level Input Voltage | V_{IH} | | $0.7 \times V_{DD}$ | — | 5.25 | V |
| Low Level Input Voltage | V_{IL} | | — | — | $0.3 \times V_{DD}$ | V |
| High Level Output Voltage | V_{OH} | $I_O = 4$ mA | $V_{DD} - 0.6$ | — | — | V |
| Low Level Output Voltage | V_{OL} | DTX, SDO, \overline{INT} , SDITHRU: $I_O = -4$ mA | — | — | 0.4 | V |
| | | GPIO1 a/b, GPIO2 a/b: $I_O = -40$ mA | — | — | 0.72 | |
| SDITHRU internal pullup resistance | | | 35 | 50 | — | k Ω |
| Relay Driver Source Impedance | R_{OUT} | $V_{DD1} - V_{DD4} = 3.13$ V $I_O < 28$ mA | — | 63 | — | Ω |
| Relay Driver Sink Impedance | R_{IN} | $V_{DD1} - V_{DD4} = 3.13$ V $I_O < 85$ mA | — | 11 | — | Ω |
| Input Leakage Current | I_L | | — | — | 10 | μ A |

Table 9. Switching Characteristics—General Inputs¹

($V_{DD} = 3.13$ to 5.25 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade, $C_L = 20$ pF)

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|----------|---------|-----|-----|---------|
| Rise Time, \overline{RESET} | t_r | — | — | 5 | ns |
| \overline{RESET} Pulse Width, GCI Mode ^{2,3} | t_{rl} | 33/PCLK | — | — | μ s |
| \overline{RESET} Pulse Width, SPI Daisy Chain Mode ³ | t_{rl} | 33/PCLK | — | — | μ s |

Notes:

- All timing (except Rise and Fall time) is referenced to the 50% level of the waveform. Input test levels are $V_{IH} = V_{DD} - 0.4$ V, $V_{IL} = 0.4$ V. Rise and Fall times are referenced to the 20% and 80% levels of the waveform.
- The minimum \overline{RESET} pulse width assumes the SDITHRU pin is tied to ground via a pulldown resistor no greater than 10 k Ω per device.
- The minimum \overline{RESET} pulse width is 33/PCLK frequency (i.e. $33/8.192$ MHz = 4 μ s).

Table 10. Switching Characteristics—SPI

($V_{DDA} = 3.13$ to 5.25 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade, $C_L = 20$ pF)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|-----------|-----------------|-----|-----|-----|------|
| Cycle Time SCLK | t_c | | 62 | — | — | ns |
| Rise Time, SCLK | t_r | | — | — | 25 | ns |
| Fall Time, SCLK | t_f | | — | — | 25 | ns |
| Delay Time, SCLK Fall to SDO Active | t_{d1} | | — | — | 20 | ns |
| Delay Time, SCLK Fall to SDO Transition | t_{d2} | | — | — | 20 | ns |
| Delay Time, \overline{CS} Rise to SDO Tri-state | t_{d3} | | — | — | 20 | ns |
| Setup Time, \overline{CS} to SCLK Fall | t_{su1} | | 25 | — | — | ns |
| Hold Time, \overline{CS} to SCLK Rise | t_{h1} | | 20 | — | — | ns |
| Setup Time, SDI to SCLK Rise | t_{su2} | | 25 | — | — | ns |
| Hold Time, SDI to SCLK Rise | t_{h2} | | 20 | — | — | ns |
| Delay Time between Chip Selects | t_{cs} | | 220 | — | — | ns |
| SDI to SDITHRU Propagation Delay | t_{d4} | | — | 4 | 10 | ns |

Note: All timing is referenced to the 50% level of the waveform. Input test levels are $V_{IH} = V_{DD} - 0.4$ V, $V_{IL} = 0.4$ V

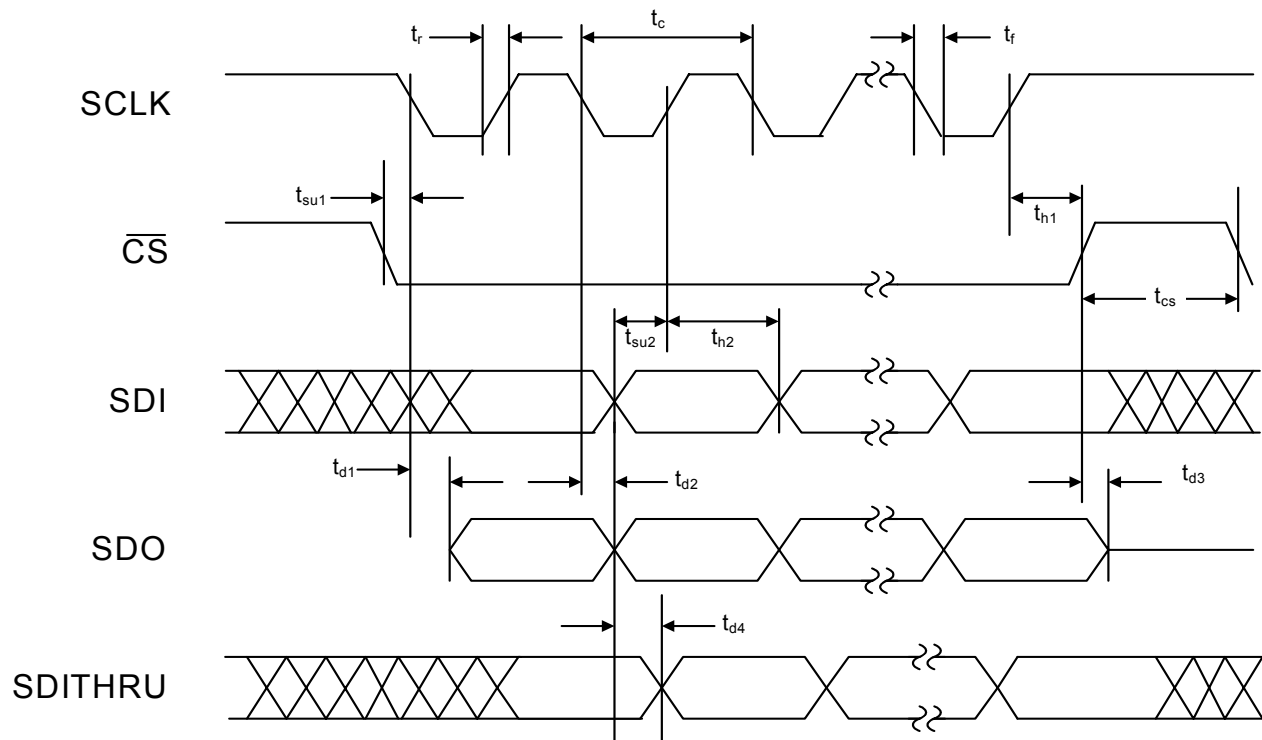


Figure 1. SPI Timing Diagram

Table 11. Switching Characteristics—PCM Highway Interface

($V_{DD} = 3.13$ to 5.25 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade, $C_L = 20$ pF)

| Parameter | Symbol | Test Conditions | Min ¹ | Typ ¹ | Max ¹ | Units |
|--|--------------|-----------------|------------------|------------------|-------------------|-------|
| PCLK Period | t_p | | 122 | — | 3906 | ns |
| Valid PCLK Inputs | | | — | 512 | — | kHz |
| | | | — | 768 | — | kHz |
| | | | — | 1.024 | — | MHz |
| | | | — | 1.536 | — | MHz |
| | | | — | 1.544 | — | MHz |
| | | | — | 2.048 | — | MHz |
| | | | — | 4.096 | — | MHz |
| | | | — | 8.192 | — | MHz |
| FSYNC Period ² | t_{fs} | | — | 125 | — | μs |
| PCLK Duty Cycle Tolerance | t_{dty} | | 40 | 50 | 60 | % |
| FSYNC Jitter Tolerance | t_{jitter} | | — | — | ±120 | ns |
| Rise Time, PCLK | t_r | | — | — | 25 | ns |
| Fall Time, PCLK | t_f | | — | — | 25 | ns |
| Delay Time, PCLK Rise to DTX Active | t_{d1} | | — | — | 20 | ns |
| Delay Time, PCLK Rise to DTX Transition | t_{d2} | | — | — | 20 | ns |
| Delay Time, PCLK Rise to DTX Tristate ³ | t_{d3} | | — | — | 20 | ns |
| Setup Time, FSYNC to PCLK Fall | t_{su1} | | 25 | — | — | ns |
| Hold Time, FSYNC to PCLK Fall | t_{h1} | | 20 | — | — | ns |
| Setup Time, DRX to PCLK Fall | t_{su2} | | 25 | — | — | ns |
| Hold Time, DRX to PCLK Fall | t_{h2} | | 20 | — | — | ns |
| FSYNC Pulse Width | t_{wfs} | | t_p | — | $125 \mu s - t_p$ | |
| Notes: | | | | | | |
| 1. All timing is referenced to the 50% level of the waveform. Input test levels are $V_{IH} - V_{IO} - 0.4$ V, $V_{IL} = 0.4$ V. | | | | | | |
| 2. FSYNC source is assumed to be 8 kHz under all operating conditions. | | | | | | |
| 3. Spec applies to PCLK fall to DTX tristate when that mode is selected. | | | | | | |

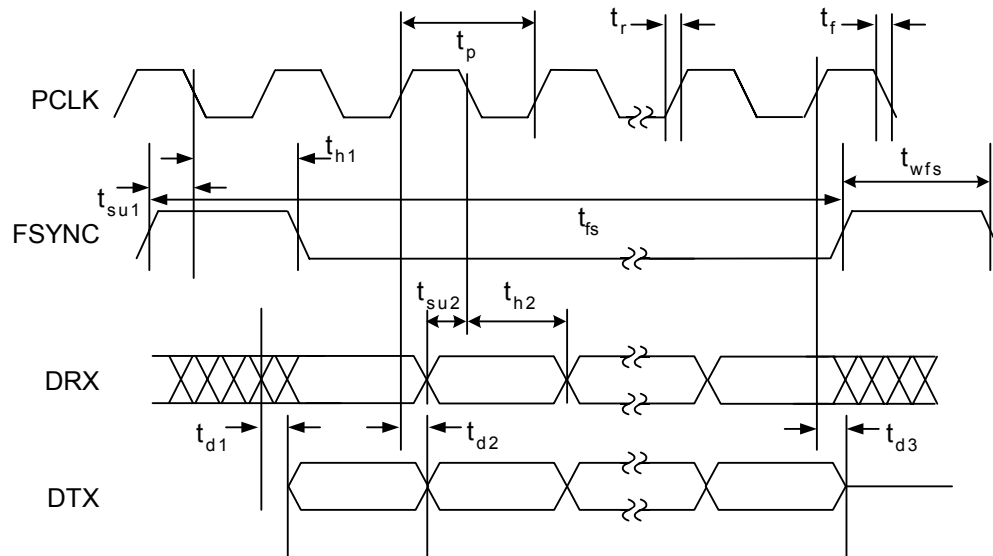


Figure 2. PCM Highway Interface Timing Diagram

Table 12. Switching Characteristics—GCI Highway Serial Interface

($V_{DD} = 3.13$ to 5.25 V, $T_A = 0$ to 70 °C for F-Grade, -40 to 85 °C for G-Grade)

| Parameter ¹ | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|--------------|-----------------|---------|-----|------|-------|
| PCLK Period (2.048 MHz PCLK Mode) | t_p | | — | 488 | — | ns |
| PCLK Period (4.096 MHz PCLK Mode) | t_p | | — | 244 | — | ns |
| FSYNC Period ² | t_{fs} | | — | 125 | — | μs |
| PCLK Duty Cycle Tolerance | t_{dty} | | 40 | 50 | 60 | % |
| FSYNC Jitter Tolerance | t_{jitter} | | — | — | ±120 | ns |
| Rise Time, PCLK | t_r | | — | — | 25 | ns |
| Fall Time, PCLK | t_f | | — | — | 25 | ns |
| Delay Time, PCLK Rise to DTX Active | t_{d1} | | — | — | 20 | ns |
| Delay Time, PCLK Rise to DTX Transition | t_{d2} | | — | — | 20 | ns |
| Delay Time, PCLK Rise to DTX Tristate ³ | t_{d3} | | — | — | 20 | ns |
| Setup Time, $\overline{\text{FSYNC}}$ Rise to PCLK Fall | t_{su1} | | 25 | — | — | ns |
| Hold Time, PCLK Fall to FSYNC Fall | t_{h1} | | 20 | — | — | ns |
| Setup Time, DRX Transition to PCLK Fall | t_{su2} | | 25 | — | — | ns |
| Hold Time, PCLK Falling to DRX Transition | t_{h2} | | 20 | — | — | ns |
| FSYNC Pulse Width | t_{wfs} | | $t_p/2$ | — | — | ns |

Notes:

1. All timing is referenced to the 50% level of the waveform. Input test levels are $V_{IH} = V_O - 0.4$ V and $V_{IL} = 0.4$ V. Rise and fall times are referenced to the 20% and 80% levels of the waveform.
2. FSYNC source is assumed to be 8 kHz under all operating conditions.
3. Specification applies to PCLK fall to DTX tristate when that mode is selected.

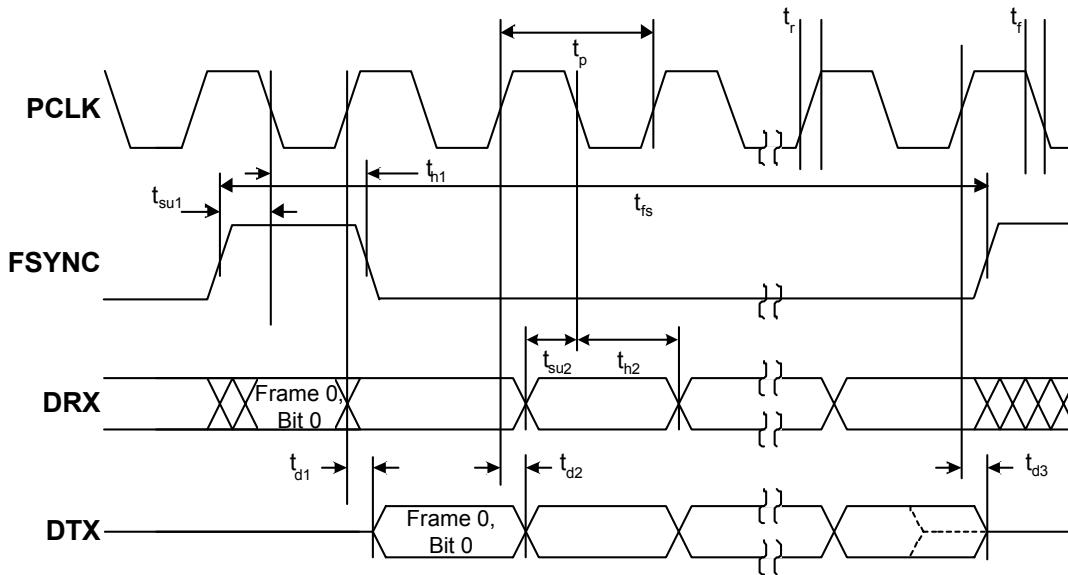


Figure 3. GCI Highway Interface Timing Diagram (2.048 MHz PCLK Mode)

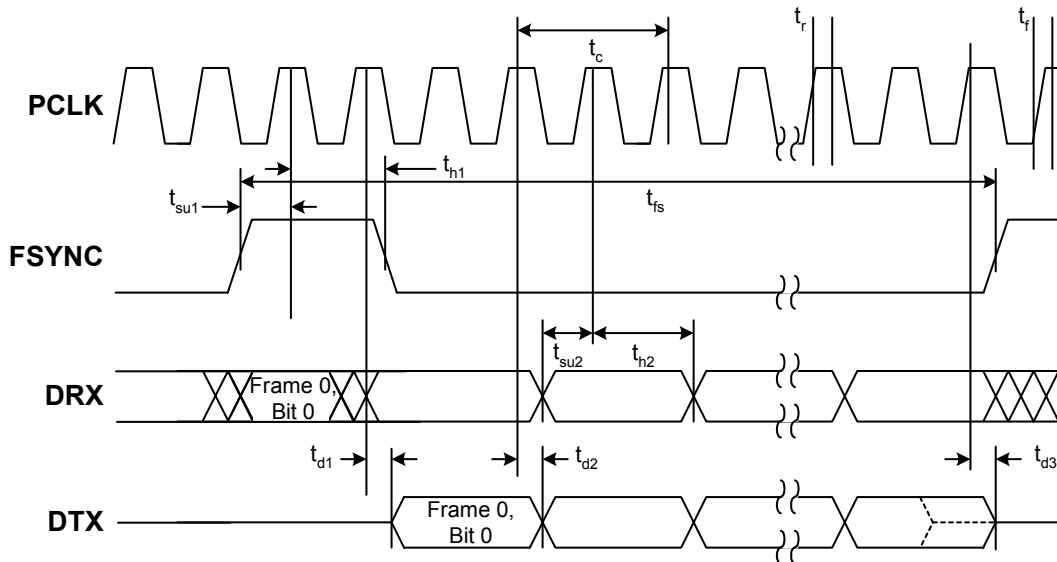


Figure 4. GCI Highway Interface Timing Diagram (4.096 MHz PCLK Mode)

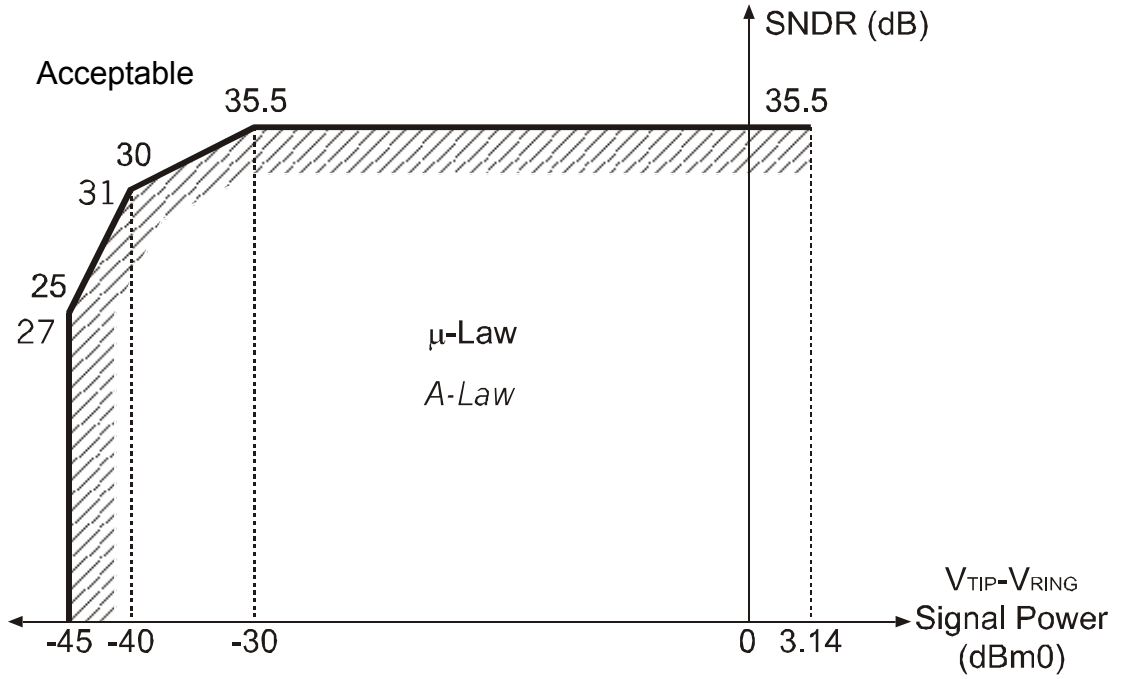


Figure 5. Transmit and Receive Path SNDR

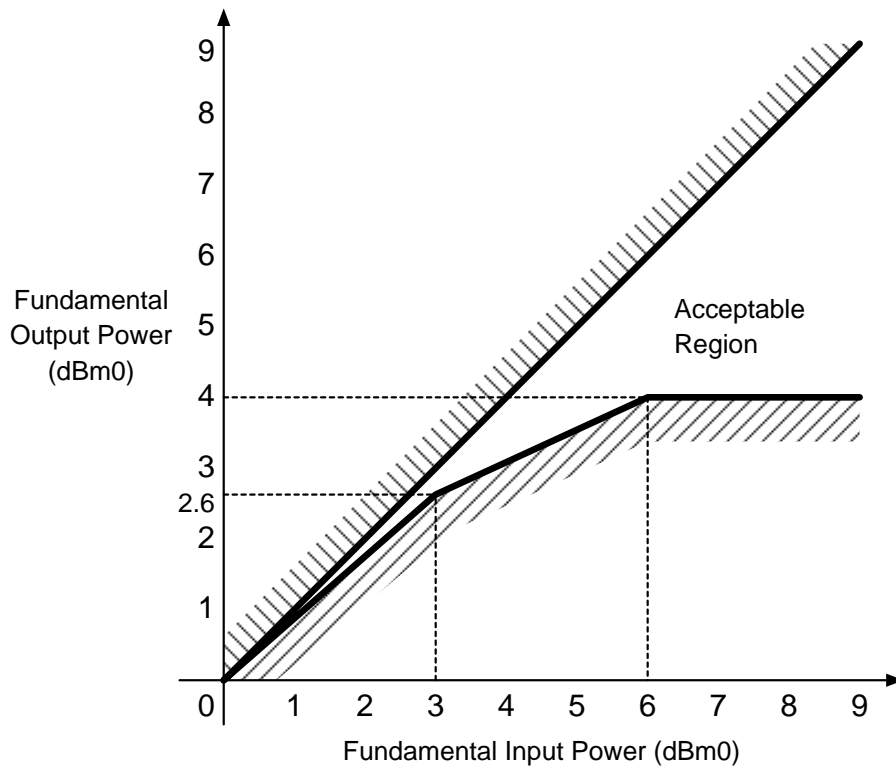


Figure 6. Overload Compression Performance

2. Typical Application Circuits

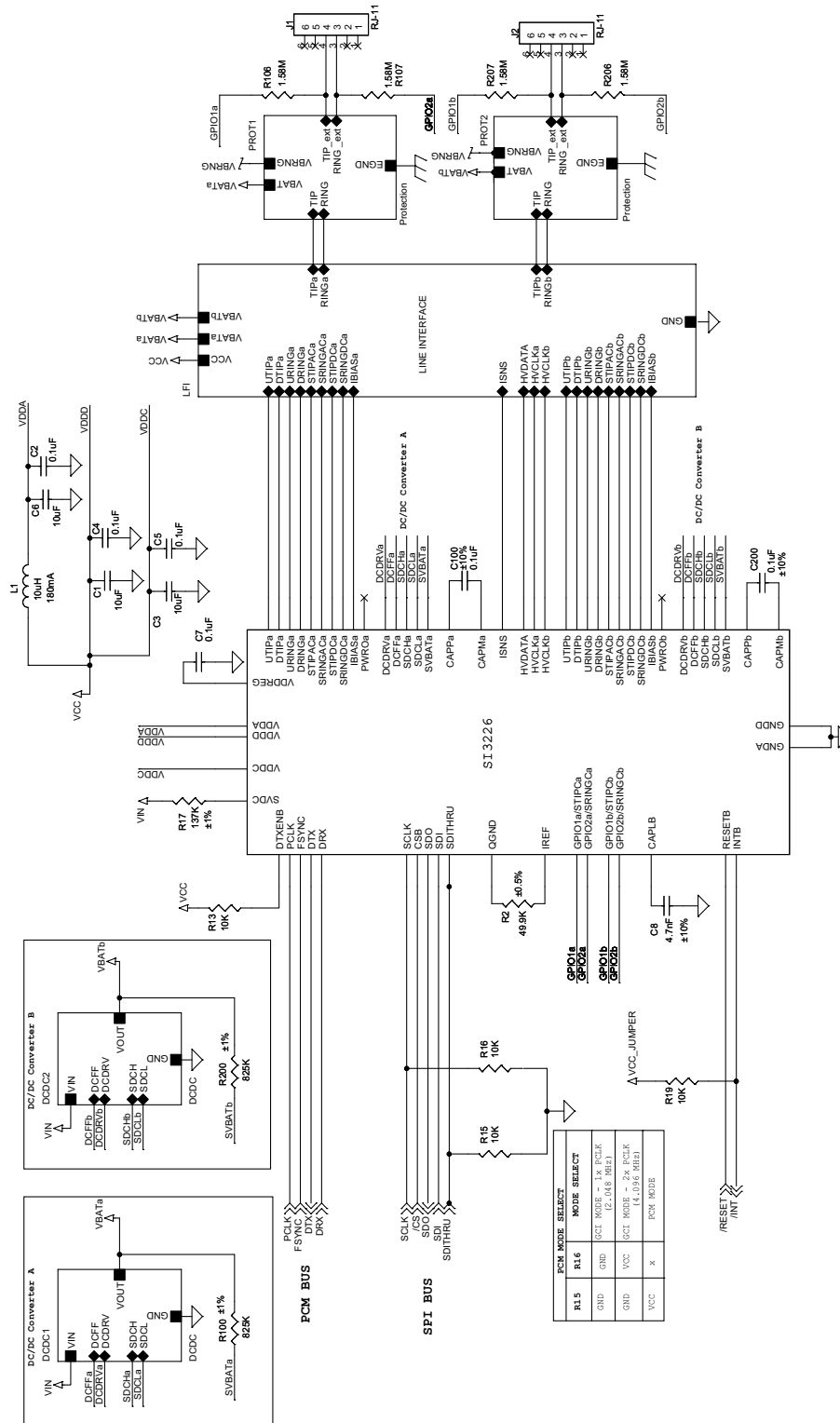
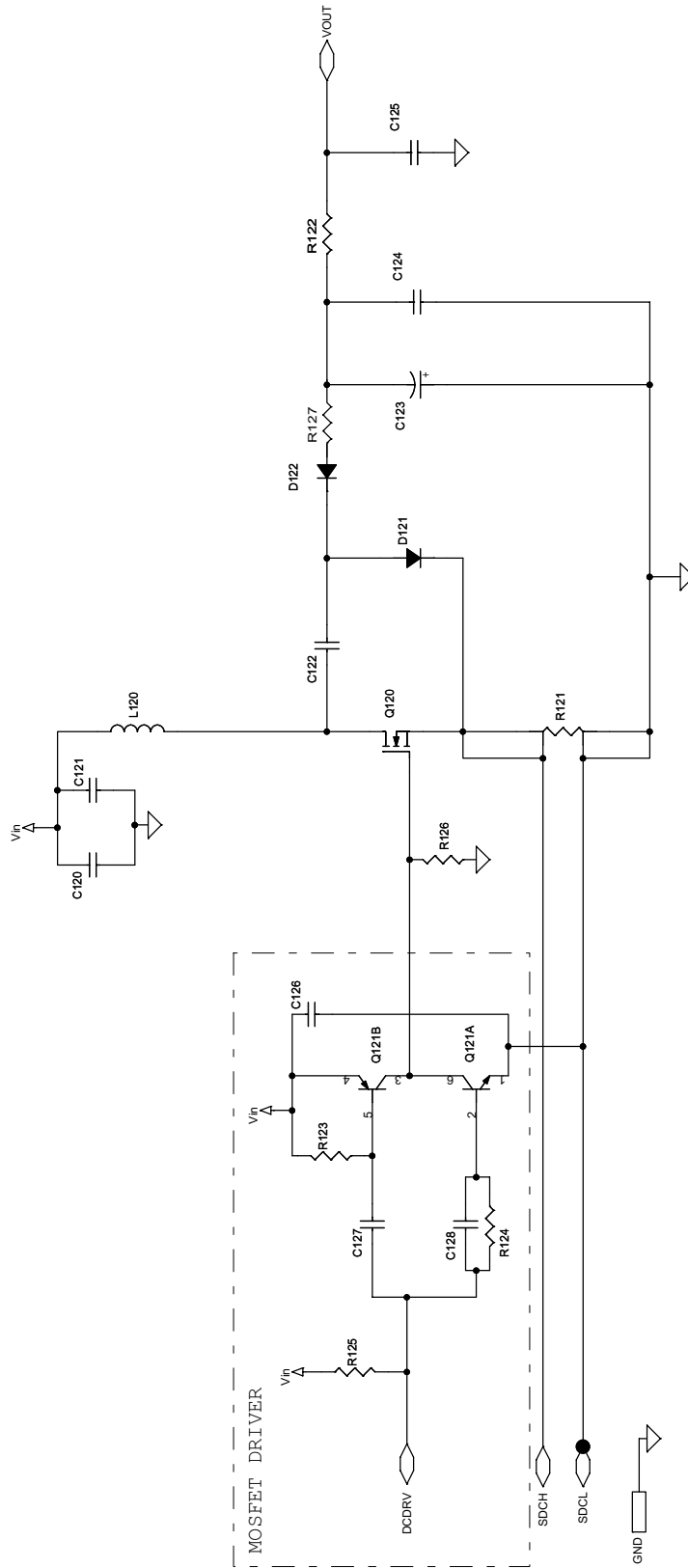
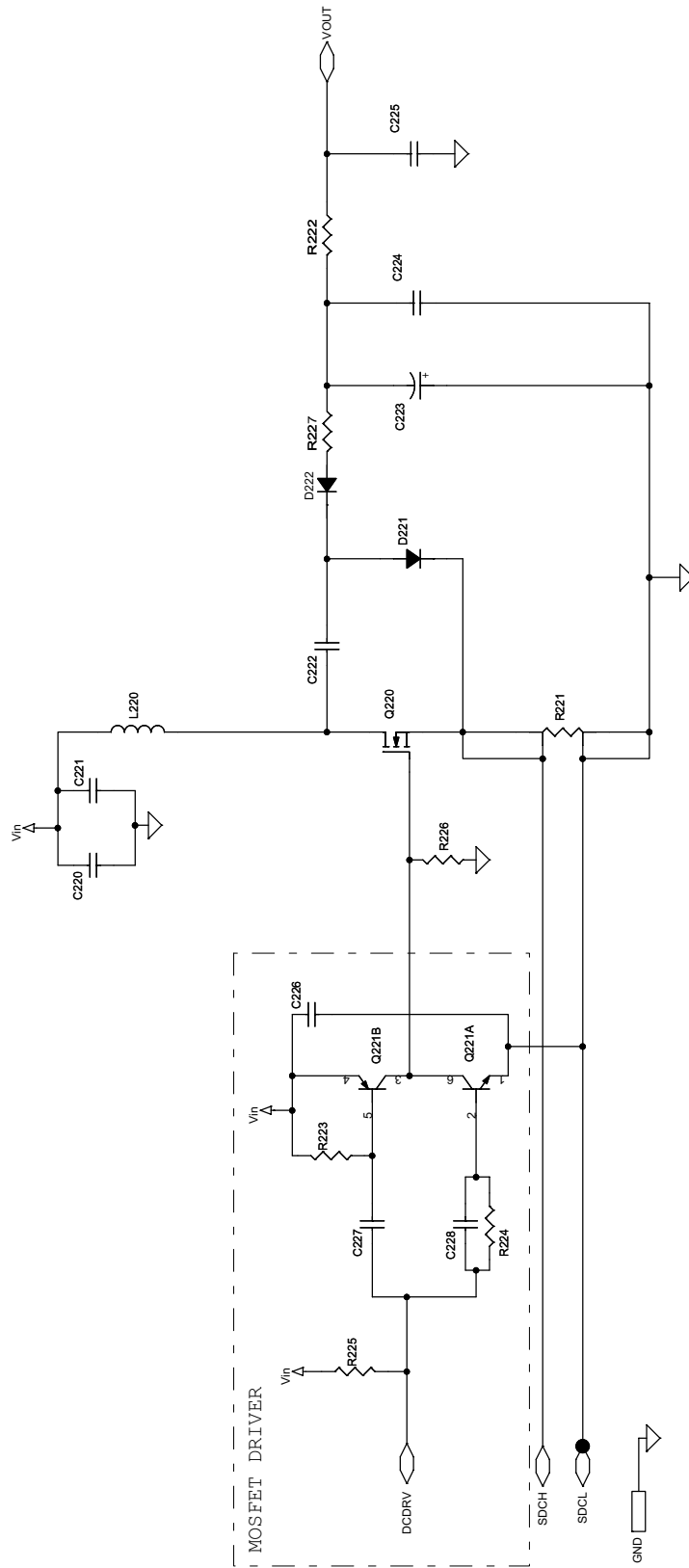


Figure 7. Si3226/7 (2 Lines)



Notes:
1) Component values and ratings are shown in the bill of materials.
2) V_{in} and V_{out} are defined in the bill of materials.

Figure 8. DC-DC Converter (A)



Notes:
1) Component values and ratings are shown in the bill of materials.
2) V_{in} and V_{out} are defined in the bill of materials.

Figure 9. DC-DC Converter (B)

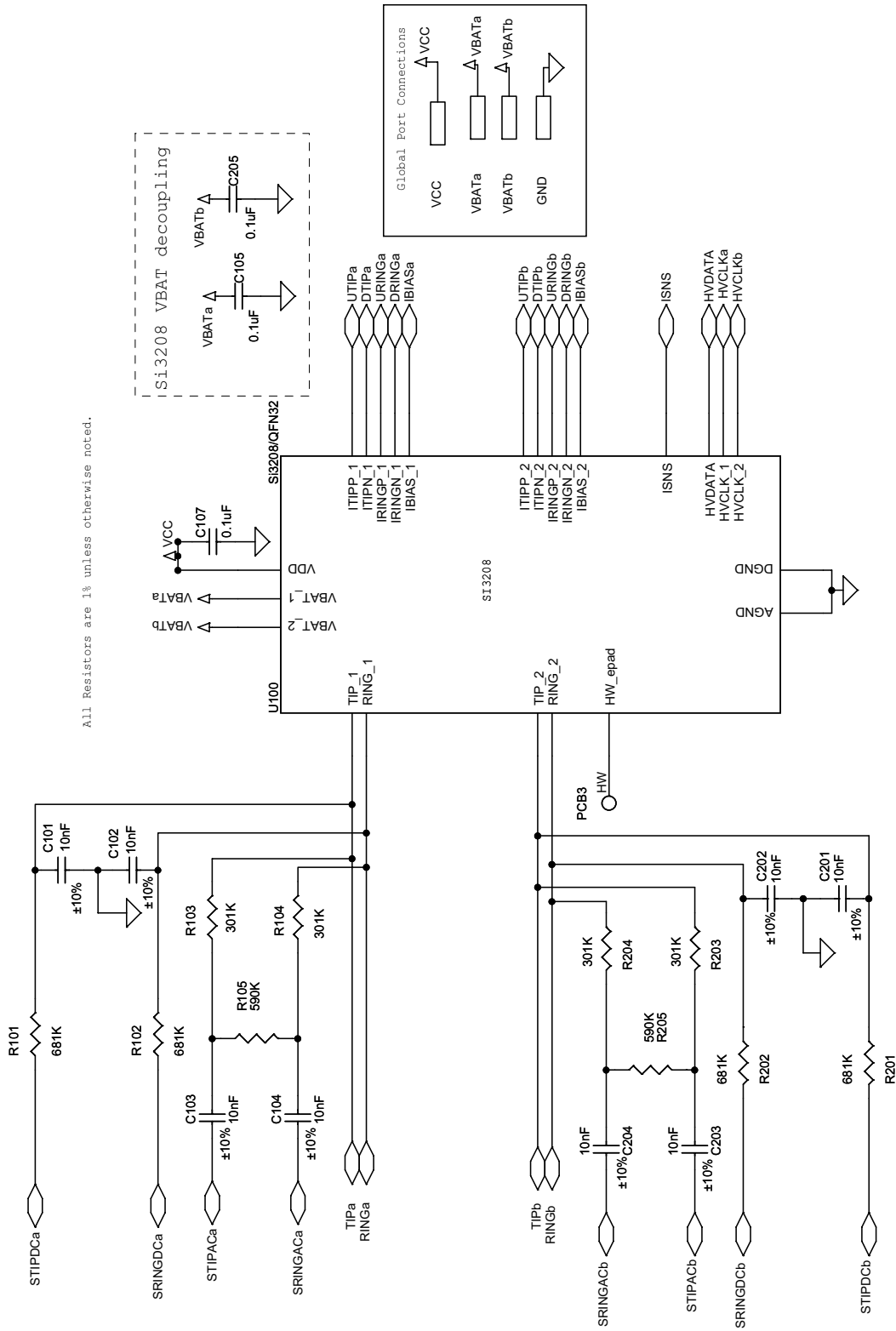


Figure 10. Linefeed (2 Lines)

3. Bill of Materials

Table 13. Bill of Materials for Si3226/7 (2 Lines)

| Quantity | Reference | Value | Rating | Tolerance | Dielectric | PCB Footprint | Manufacturer |
|----------|----------------------------|-----------------|---------------|------------|------------|---------------|--------------|
| 2 | C1, C6 | 10 μ F | 6.3 V | \pm 20% | Y5V | CC1210 | Venkel |
| 2 | C100, C200 | 0.1 μ F | 6.3 V | \pm 10% | X7R | CC0603 | Venkel |
| 4 | C2, C4, C5, C7 | 0.1 μ F | 6.3 V | \pm 20% | X7R | CC0603 | Venkel |
| 1 | C3* | 10 μ F | 6.3 V | \pm 20% | Y5V | CC1210 | Venkel |
| 1 | C8 | 4.7 nF | 6.3 V | \pm 10% | X7R | CC0603 | Venkel |
| 1 | L1* | 10 μ H | 180 mA | \pm 10% | | IND-NLC3225 | TDK |
| 1 | R2 | 49.9 k Ω | 1/16 W | \pm 0.5% | | RC0603 | Venkel |
| 4 | R13, R15, R16, R19 | 10 k Ω | 1/10 W | \pm 5% | | RC0603 | Venkel |
| 1 | R17 | 137 k Ω | 1/16 W | \pm 1% | | RC0603 | Venkel |
| 2 | R100, R200 | 825 k Ω | 1/10 W, 100 V | \pm 1% | | RC0805 | Venkel |
| 4 | R106*, R107*, R206*, R207* | 1.58 M Ω | 1/10 W, 100 V | \pm 5% | | RC0805 | Venkel |
| 1 | U1 | Si3226 | | | | TQFP64 | SiLabs |

*Note: Denotes optional component.

Table 14. Bill of Materials for Linefeed and DC-DC Converters with $|V_{OUT}| < 90\text{ V}$ (2 Lines)

$V_{IN} = +12\text{ V}$ nominal, $|V_{OUT}| < 90\text{ V}$

| Quantity | Reference | Value | Rating | Tolerance | Dielectric | PCB Footprint | Manufacturer |
|----------|------------------------|--------------------|---------------|------------|------------|----------------|--------------|
| 1 | C120 | 10 μF | 25 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 1 | C220* | 10 μF | 25 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 2 | C121, C221 | 0.1 μF | 25 V | $\pm 10\%$ | X7R | CC0603 | Venkel |
| 2 | C126, C226 | 0.1 μF | 25 V | $\pm 20\%$ | X7R | CC0603 | Venkel |
| 2 | C124, C224 | 0.1 μF | 100 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 2 | C125*, C225* | 0.1 μF | 100 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 2 | C122, C222 | 0.22 μF | 100 V | $\pm 20\%$ | X7R | CC1812 | Venkel |
| 2 | C123, C223 | 3.3 μF | 100 V | $\pm 20\%$ | Al | C2.5X6.3MM-RAD | Panasonic |
| 4 | C127, C128, C227, C228 | 470 pF | 25 V | $\pm 10\%$ | X7R | CC0402 | Venkel |
| 2 | D122, D222 | BAS21HT1 | 250 V, 200 mA | | | SOD-323 | ON SEMI |
| 2 | D121, D221 | STPS2150A | 150 V, 2.0 A | | | DO-214AC | STMicro |
| 2 | L120, L220 | 15 μH | | | | CDR74 | SUMIDA |
| 2 | Q120, Q220 | FQT7N10 | 100 V, 2 W | | | SOT-223 | Fairchild |
| 2 | Q121, Q221 | MMDT3946 | | | | SOT-363 | Diodes Inc. |
| 2 | R121, R221 | 0.1 Ω | 1/4 W | $\pm 1\%$ | | RC1210 | Venkel |
| 2 | R122, R222 | 15 Ω | 1/4 W | $\pm 5\%$ | | RC1206 | Venkel |
| 2 | R123, R223 | 220 Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R124, R224 | 1 k Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R125, R225 | 150 k Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R126, R226 | 100 k Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R127, R227 | 2 Ω | 1/8 W | $\pm 5\%$ | | RC0402 | Venkel |
| 1 | C107 | 0.1 μF | 25 V | $\pm 10\%$ | X7R | CC0603 | Venkel |

*Note: Denotes optional component.

Table 14. Bill of Materials for Linefeed and DC-DC Converters with $|V_{OUT}| < 90\text{ V}$ (2 Lines) (Continued)

$V_{IN} = +12\text{ V}$ nominal, $|V_{out}| < 90\text{ V}$

| Quantity | Reference | Value | Rating | Tolerance | Dielectric | PCB Footprint | Manufacturer |
|----------|------------------------|------------------|---------------|-----------|------------|---------------|----------------------|
| 4 | C101, C102, C201, C202 | 10 nF | 100 V | ±10% | X7R | CC0805 | Venkel |
| 4 | C103, C104, C203, C204 | 10 nF | 100 V | ±10% | X7R | CC0805 | Venkel |
| 2 | C105, C205 | 0.1 µF | 100 V | ±20% | X7R | CC1210 | Venkel |
| 4 | R101, R102, R201, R202 | 681 kΩ | 1/10 W, 150 V | ±1% | | RC0805 | Venkel |
| 4 | R103, R104, R203, R204 | 301 kΩ | 1/16 W, 75 V | ±1% | | RC0603 | Venkel |
| 2 | R105, R205 | 590 kΩ | 1/10 W, 150 V | ±1% | | RC0805 | Venkel |
| 1 | U100 | Si3208 or Si3209 | | | | QFN-40 | Silicon Laboratories |

*Note: Denotes optional component.

Table 15. Bill of Materials for Linefeed and DC-DC Converters with $|V_{OUT}| < 135\text{ V}$ (2 Lines) $V_{IN} = +12\text{ V}$ nominal, $|V_{out}| < 135\text{ V}$

| Quantity | Reference | Value | Rating | Tolerance | Dielectric | PCB Footprint | Manufacturer |
|----------|------------------------|--------------------|---------------|------------|------------|----------------|--------------|
| 1 | C120 | 10 μF | 25 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 1 | C220* | 10 μF | 25 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 2 | C121, C221 | 0.1 μF | 25 V | $\pm 10\%$ | X7R | CC0603 | Venkel |
| 2 | C126, C226 | 0.1 μF | 25 V | $\pm 20\%$ | X7R | CC0603 | Venkel |
| 2 | C124, C224 | 0.1 μF | 200 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 2 | C125*, C225* | 0.1 μF | 200 V | $\pm 20\%$ | X7R | CC1210 | Venkel |
| 2 | C122, C222 | 0.22 μF | 200 V | $\pm 20\%$ | X7R | CC1812 | Venkel |
| 2 | C123, C223 | 3.3 μF | 160 V | $\pm 20\%$ | Al | C2.5X6.3MM-RAD | Panasonic |
| 4 | C127, C128, C227, C228 | 470 pF | 25 V | $\pm 10\%$ | X7R | CC0402 | Venkel |
| 2 | D122, D222 | BAS21HT1 | 250 V, 200 mA | | | SOD-323 | ON SEMI |
| 2 | D121, D221 | STPS2150A | 150 V, 2.0 A | | | DO-214AC | STMicro |
| 2 | L120, L220 | 15 μH | | | | CDRH125 | SUMIDA |
| 2 | Q120, Q220 | FQD7N20L | 200 V, 2.5 W | | | D-PAK | Fairchild |
| 2 | Q121, Q221 | MMDT3946 | | | | SOT-363 | Diodes Inc. |
| 2 | R121, R221 | 0.1 Ω | 1/4 W | $\pm 1\%$ | | RC1210 | Venkel |
| 2 | R122, R222 | 15 Ω | 1/4 W | $\pm 5\%$ | | RC1206 | Venkel |
| 2 | R123, R223 | 220 Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R124, R224 | 1 k Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R125, R225 | 150 k Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R126, R226 | 100 k Ω | 1/16 W | $\pm 5\%$ | | RC0402 | Venkel |
| 2 | R127, R227 | 2 Ω | 1/8 W | $\pm 5\%$ | | RC0402 | Venkel |
| 1 | C107 | 0.1 μF | 25 V | $\pm 10\%$ | X7R | CC0603 | Venkel |

*Note: Denotes optional component.

Table 15. Bill of Materials for Linefeed and DC-DC Converters with $|V_{out}| < 135\text{ V}$ (2 Lines) (Continued)

$V_{IN} = +12\text{ V}$ nominal, $|V_{out}| < 135\text{ V}$

| Quantity | Reference | Value | Rating | Tolerance | Dielectric | PCB Footprint | Manufacturer |
|----------|------------------------|--------|---------------|-----------|------------|---------------|----------------------|
| 4 | C101, C102, C201, C202 | 10 nF | 200 V | ±10% | X7R | CC0805 | Venkel |
| 4 | C103, C104, C203, C204 | 10 nF | 100 V | ±10% | X7R | CC0805 | Venkel |
| 2 | C105, C205 | 0.1 µF | 200 V | ±20% | X7R | CC1210 | Venkel |
| 4 | R101, R102, R201, R202 | 681 kΩ | 1/10 W, 150 V | ±1% | | RC0805 | Venkel |
| 4 | R103, R104, R203, R204 | 301 kΩ | 1/16 W, 75 V | ±1% | | RC0603 | Venkel |
| 2 | R105, R205 | 590 kΩ | 1/10 W, 150 V | ±1% | | RC0805 | Venkel |
| 1 | U100 | Si3209 | | | | QFN-40 | Silicon Laboratories |

*Note: Denotes optional component.

4. Functional Description

The Dual ProSLIC® chipset includes the Si3226/7 low-voltage IC and the Si3208/9 high-voltage linefeed IC. The Dual ProSLIC provides all SLIC, codec, DTMF detection, and signal generation functions needed for two complete analog telephone interfaces. The Dual ProSLIC performs all battery, over-voltage, ringing, supervision, codec, hybrid, and test (BORSCHT) functions; it also supports extensive metallic loop testing capabilities.

The Si3226 provides a standard voice-band (200 Hz–3.4 kHz) audio codec. The Si3227 provides an audio CODEC with both wideband (50 Hz–7 kHz) and standard voice-band (200 Hz– 3.4 kHz) modes. The wideband mode provides an expanded audio band with a 16 kHz sample rate for enhanced audio quality while the standard voice-band mode provides standard telephony audio compatibility. The Si3226/7 provides two independent, programmable, dc-dc converter controllers, each of which reacts to line conditions to provide the optimal battery voltage required for each line-state.

The linefeed chips (Si3208/9) provide programmable on-hook voltage, programmable off-hook loop current, reverse battery operation, loop or ground start operation, and on-hook transmission. Loop current and voltage are continuously monitored using an A/D converter in the Si3226/7. The Si3208 supports battery voltages up to 110 V, sufficient for most ringing signals. The Si3209 supports battery voltages up to 130 V for higher-voltage ringing applications.

The Dual ProSLIC supports balanced 5 REN ringing with or without a programmable dc offset. The available offset, frequency, waveshape, and cadence options are designed to ring the widest variety of terminal devices and to reduce external controller requirements.

A complete audio transmit and receive path is integrated, including ac impedance and hybrid gain. These features are software-programmable, allowing a single hardware design to meet global requirements. Digital voice data transfer occurs over a standard PCM bus. Control data is transferred using a standard SPI.

The Si3226/7 is available in a 64-pin TQFP; the Si3208 is available in a 32-pin QFN, and the Si3209 is available in a 40-pin QFN or a 48-pin eTQFP.

4.1. DC Feed Characteristics

Dual ProSLIC internal linefeed circuitry provides completely programmable dc feed characteristics. Linefeed characteristics for each channel are independently configurable.

When in the active state, each ProSLIC channel operates in one of three dc linefeed operating regions: a constant-voltage region, a constant-current region, or a resistive region, as shown in Figure 11. The constant-voltage region has a low resistance, typically 160 Ω. The constant-current region approximates infinite resistance.

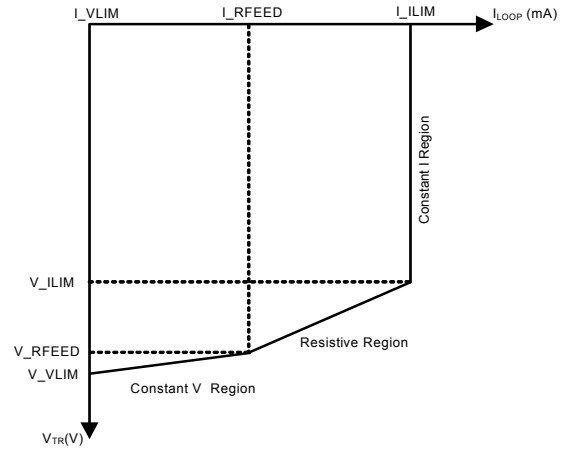


Figure 11. Dual ProSLIC DC Feed Characteristics

4.2. Linefeed Operating States

The linefeed interface includes eight different register-programmable operating states as listed in Table 16. The Open state is the default condition in the absence of any preloaded register settings. The device may also automatically enter the open state in the event of a linefeed fault condition.

4.3. Line Voltage and Current Monitoring

The Dual ProSLIC continuously monitors the TIP, RING, and battery voltages and currents via an on-chip ADC and stores the resulting values in individual register addresses. Additionally, the loop voltage ($V_{TIP} - V_{RING}$), loop current, and longitudinal current values are calculated based on the TIP and RING measurements and are stored in unique register locations for further processing. The ADC updates all registers at a rate of 2 kHz or greater.

4.4. Power Monitoring and Power Fault Detection

The Dual ProSLIC's line monitoring functions are used to continuously protect the linefeed IC (LFIC) against excessive power conditions. The LFIC contains an on-chip, analog sensing diode that provides real-time temperature data to the Si3226/7 and turns off the LFIC when a preset threshold is exceeded. The LFIC status is reflected in a Si3226/7 register bit.

If the Si3226/7 detects a fault condition or overpower condition on any channel, it automatically sets that channel to the open state and generates a "power alarm" interrupt. The interrupt can be masked, but the automatic transition to open cannot be masked. The various power alarms and linefeed faults supporting automatic intervention are described below.

1. LFIC total power exceeded.
2. Power exceeded in one or more transistors of a LFIC internal transistor group (if capable of measuring individual power consumption).
3. Excessive foreign current or voltage on TIP and/or RING.
4. LFIC thermal shutdown event; this event is automatically performed, and no intervention by the Si3226/7 is required.

4.5. Thermal Overload Shutdown

If the LFIC die temperature exceeds the maximum junction temperature threshold, T_{Jmax} , of 145 °C or 200 °C or other programmed temperature threshold range, the LFIC has the ability to shut itself down to a low-power state without any assistance from the Si3226/7. The thermal shutdown circuit contains a sufficient amount of hysteresis and/or turn-on delay time so as to remain shut down during a power cross event, where 50 Hz or 60 Hz, 600 V, is connected to TIP and/or RING.

Table 16. Linefeed Operating States

| Linefeed State | Description |
|----------------------------------|---|
| Open | Output is high-impedance, and all line supervision functions are powered down. Audio is powered down. This is the default state after powerup or following a hardware reset. This state can also be used in the presence of line fault conditions and to generate open switch intervals (OSIs). This state is used in line diagnostics mode as a high-Z state during linefeed testing. A power fault condition may also force the device into the open state. |
| Forward Active Reverse Active | Linefeed circuitry and audio are active. In Forward Active state, the TIP lead is more positive than the RING lead; in Reverse Active state, the RING lead is more positive than the TIP lead. Loop closure and ground key detect circuitry are active. |
| Forward OHT Reverse OHT | Provides data transmission during an on-hook loop condition (e.g., transmitting caller ID data between ringing bursts). Linefeed circuitry and audio are active. In Forward OHT state, the TIP lead is more positive than the RING lead; in Reverse OHT state, the RING lead is more positive than the TIP lead. |
| TIP Open | Provides an active linefeed on the RING lead and sets the TIP lead to high impedance (>400 kΩ) for ground start operation in forward polarity. Loop closure and ground key detect circuitry are active. |
| RING Open | Provides an active linefeed on the TIP lead and sets the RING lead to high impedance (>400 kΩ) for ground start operation in reverse polarity. Loop closure and ground key detect circuitry are active. |
| Ringing | Drives programmable ringing signal onto TIP and RING leads with or without dc offset. |
| Line Diagnostics | The channel selected is put into diagnostic mode. In this mode, the selected channel has special diagnostic resources available. |

4.6. Power Dissipation Considerations

The Dual ProSLIC is designed to source loops up to 20 kft as well as short loop applications. The LFIC provides all battery sourcing functions and is, therefore, the determining factor regarding power dissipation in a specific application. The Dual ProSLIC provides an on-chip dc-dc controller that can dynamically reduce the battery supply to ideally match the required line feed voltage.

4.7. Loop Closure Detection

The Dual ProSLIC provides a completely programmable loop closure detection mechanism. The loop closure detection scheme provides two unique thresholds to allow hysteresis, and also includes a programmable debounce filter to eliminate false detection. A loop closure detect status bit provides continuous status, and a maskable interrupt bit is also provided.

4.8. Ground Key Detection

The Dual ProSLIC provides a ground key detect mechanism using a programmable architecture similar to the loop closure scheme. The ground key detect scheme provides two unique thresholds to allow hysteresis and also includes a programmable debounce filter to eliminate false detection. A ground key detect status bit provides continuous status, and a maskable interrupt bit is also provided.

4.9. Ringing Generation

The Dual ProSLIC provides the ability to generate a programmable sinusoidal or trapezoidal ringing waveform, with or without dc offset. The ringing frequency, wave shape, cadence, and offset are all register-programmable. Using a balanced ringing scheme, the ringing signal is applied to both the TIP and RING leads using dual ringing waveforms that are 180° out of phase with each other. The resulting ringing signal seen across TIP-RING is twice the amplitude of the ringing waveform on either the TIP or RING lead, which allows the ringing circuitry to be forced to withstand only half the total ringing amplitude seen across TIP-RING.

4.10. Polarity Reversal

The Dual ProSLIC supports polarity reversal for message waiting and various other signaling modes. The ramp rate can be programmed for a smooth or abrupt transition to accommodate different application requirements.

4.11. Two-Wire Impedance Synthesis

The ac two-wire impedance synthesis is generated on-chip using a DSP-based scheme to optimally match the output impedance of the Dual ProSLIC to the impedance of the subscriber loop and minimize the receive path signal reflected back onto the transmit path. Most real or complex two-wire impedances can be generated by using the coefficient generator software to simulate the desired line conditions and generate the required register coefficients.

4.12. Transhybrid Balance Filter

The trans-hybrid balance function is implemented on-chip using a DSP-based scheme to effectively cancel the reflected receive path signal from the transmit path. The coefficient generator software is used to optimize the filter coefficients.

4.13. Tone Generators

The Dual ProSLIC includes two digital tone generators that allow a wide variety of single- or dual-tone frequency and amplitude combinations. Each tone generator has its own set of registers that hold the desired frequency, amplitude, and cadence to allow generation of DTMF and call progress tones for different requirements. The tones can be directed to either receive or transmit paths.

4.14. DTMF Detection

In DTMF, two tones generate a DTMF digit. One tone is chosen from the four possible row tones, and one tone is chosen from the four possible column tones. The sum of these tones constitutes one of 16 possible DTMF digits. The Dual ProSLIC performs DTMF detection using an algorithm to compute the DFT for each of the eight DTMF frequencies and their second harmonics. At the end of the DFT computation, the squared magnitudes of the DFT results for the 8 DTMF fundamental tones are computed. The row and column results are sorted to determine the strongest tones, and checks are made to determine if the strongest row and column tones constitute a DTMF digit.

4.15. DC-DC Controller

The controller converts a single positive dc input voltage into an independent negative battery voltage for each channel. The controller operates a dc-dc converter circuit that converts a single positive dc input voltage into an independent negative battery voltage for each channel. In addition to eliminating external high-voltage power supplies, the dc-dc controller allows the Dual ProSLIC to dynamically control the battery voltage to the minimum required for any given operating state according to the programmed linefeed parameters.

4.16. Wideband Audio

The Si3226 supports a narrowband (200 Hz–3.4 kHz) audio codec. The Si3227 supports a software-selectable wideband (50 Hz–7 kHz) and narrowband (200 Hz–3.4 kHz) audio codec. The Si3227 wideband mode provides an expanded audio band at a 16-bit, 16 kHz sample rate for enhanced audio quality while maintaining standard telephony audio compatibility. Wideband audio samples are transmitted and received on the PCM interface using two consecutive 8 kHz frames.

4.17. SPI Control Interface

The controller interface to the Dual ProSLIC is a 4-wire interface modeled after microcontroller and serial peripheral devices. The interface consists of a clock (SCLK), chip select (CS), serial data input (SDI), and serial data output (SDO). In addition, the Dual ProSLIC devices feature a serial data through output (SDITHRU) to support operation of up to eight devices (up to 16 channels) using a single chip select line. The device operates with both 8-bit and 16-bit SPI controllers.

4.18. PCM Interface and Companding

The Dual ProSLIC contains a flexible, programmable interface for the transmission and reception of digital PCM samples. PCM data transfer is controlled by the PCM clock (PCLK) and frame sync (FSYNC) inputs as well as the PCM Mode Select, PCM Transmit Start, and PCM Receive Start settings.

The interface can be configured to support from four to 128 8-bit time slots in each 125 μ s frame, corresponding to a PCM clock (PCLK) frequency range of 256 kHz to 8.192 MHz. 1.544 MHz is also supported.

The Dual ProSLIC supports both μ -255 Law (μ -Law) and A-law companding formats in addition to 16-bit linear data mode with no companding.

4.19. General Circuit Interface

The Dual ProSLIC supports an alternative communication interface to the SPI and PCM control and data interface. The General Circuit Interface (GCI) is used for transmission and reception of both control and data information onto a GCI bus. The PCM and GCI interfaces are both 4-wire interfaces and share the same pins. In GCI mode, the four-wire SPI control interface is used as hard-wired channel selector pins. The selection between PCM and GCI modes is performed when coming out of reset using the SDITHRU pin.

4.20. Metallic Loop Testing

The Dual ProSLIC includes the ability to detect multiple fault conditions within the line card as well as on the T/R pair.

1. Hazardous Potential Test—This test checks for ac voltage $>50 V_{\text{rms}}$ or dc voltage $>135 V$ on T-G or R-G. If a hazardous voltage is encountered, test access MUST release within two seconds of the time when it was initiated using a preset threshold.
2. Foreign ElectroMotive Force Test—Checks T-G or R-G for ac voltage $>10 V_{\text{rms}}$, dc voltage $>6 V$. Uses same threshold as for hazardous voltage test.
3. Resistive Faults Test—Checks for dc resistance from T-R, T-G or R-G. Any measurement $<150 k\Omega$ is considered a resistive fault.
4. Receiver-Off-Hook Test—Distinguishes between a T-R resistive fault and an off-hook condition.
5. Ringers Test—Checks for the presence of REN across T-R. Result are $>0.175\text{REN}$ and $<5\text{REN}$ for a valid load.
6. AC Line Impedance (line length)—T-R, T-G, and R-G. Generate a tone at several specific frequencies (audio band) and measure the reflected signal amplitude (complex spectrum) that comes back (with transhybrid balance filter disabled). The reflected signal is then used to calculate the line impedance based on certain assumptions of wire gauge, etc.
7. Line Capacitance—T-R, T-G, R-G. Generate a linear ramp function with polarity reversal, and measure the time constant.
8. Ringer Capacitance—This test uses the same procedure as the ringer test above but also measures the V/I phase relationship of the received signal (dc path) and then subtracts the delay to calculate the ringer capacitance.
9. Ringing Voltage Verification—Uses current voltage sensing capability.
10. Test-In Diagnostics—The Dual ProSLIC can switch in a preset load impedance to test the SLIC/codec functionality using a known set of conditions.

5. Pin Descriptions: Si3226/7

Table 17. Si3226/7 Pin Descriptions

| Pin Number | Symbol | I/O | Description |
|------------|--------------------------|-----|---|
| 1 | SRINGDCa | I | RING DC Sense Input. |
| 2 | SRINGACa | I | RING AC Sense Input. |
| 3 | STIPACa | I | TIP AC Sense Input. |
| 4 | STIPDCa | I | TIP DC Sense Input. |
| 5 | CAPPa | I/O | Metallic Loop Filter Capacitor-Positive Terminal. |
| 6 | CAPMa | I/O | Metallic Loop Filter Capacitor-Negative Terminal. |
| 7 | SVBATA | I | Battery Sensing Input. |
| 8 | SVDC | I | DC-DC Input Power Rail Sensor. |
| 9 | GPIO3a / PWROa | I/O | General Purpose I/O / Power Offloading Output. |
| 10 | GPIO2a / SRINGCa / TRD2a | I/O | General Purpose I/O / TIP Course Sense Input / Test Relay Driver. |
| 11 | GPIO1a / STIPCa / TRD1a | I/O | General Purpose I/O / TIP Course Sense Input / Test Relay Driver. |
| 12 | \overline{CS} | I | Chip Select Input. |
| 13 | FSYNC | I | Frame Sync Clock Input. |
| 14 | SDI | I | Serial Port Data Input. |
| 15 | HVCLKa | O | Line-Driver IC Clock Output. |
| 16 | SCLK | I | Serial Port Bit Clock Input. |
| 17 | HVDATA | O | Line-Driver IC Data Output |
| 18 | SDITHRU | O | Serial Data Daisy Chain Output. |
| 19 | SDO | O | Serial Port Data Output. |
| 20 | DCFFa | I/O | DC-DC BJT Drive Monitor. |
| 21 | SDCHa | I | DC-DC Current Monitor Input-High Terminal. |
| 22 | SDCLa | I | DC-DC Current Monitor Input-Low Terminal. |
| 23 | DCDRVa | I/O | DC-DC Drive Output. |
| 24 | VDDC | PWR | DC-DC Switch Driver Power Supply. |
| 25 | DCDRVb | O | DC-DC Drive Output. |
| 26 | SDCLb | I | DC-DC Current Monitor Input-Low Terminal. |
| 27 | SDCHb | I | DC-DC Current Monitor Input-High Terminal. |
| 28 | DCFFb | I/O | DC-DC BJT Drive Monitor. |
| 29 | GNDD | GND | Digital Ground. |
| 30 | VDDD | PWR | Digital Supply Voltage. |
| 31 | PCLK | I | PCM Bus Clock Input. |
| 32 | HVCLKb | O | Line-Driver IC Clock Output. |

Table 17. Si3226/7 Pin Descriptions (Continued)

| Pin Number | Symbol | I/O | Description |
|------------|---------------------------|-----|---|
| 33 | $\overline{\text{DTXEN}}$ | O | Transmit PCM Enable Output. |
| 34 | DTX | O | Transmit PCM Data Output. |
| 35 | DRX | I | Receive PCM Data Input. |
| 36 | $\overline{\text{INT}}$ | O | Interrupt Output. |
| 37 | $\overline{\text{RST}}$ | I | Reset Input. |
| 38 | VDDREG | I/O | Regulated Core Power Supply. |
| 39 | GPIO1b / STIPCb / TRD1b | I/O | General Purpose I/O / TIP Course Sense Input / Test Relay Driver. |
| 40 | GPIO2b / SRINGCb / TRD2b | I/O | General Purpose I/O / TIP Course Sense Input / Test Relay Driver. |
| 41 | GPIO3b / PWROb | I/O | General Purpose I/O / Power Offloading Output. |
| 42 | SVBATb | I | Battery Sensing Input. |
| 43 | CAPMb | I/O | Differential Loop Filter Capacitor-Negative Term. |
| 44 | CAPPb | I/O | Differential Loop Filter Capacitor-Positive Term. |
| 45 | STIPDCb | I | TIP DC Sense Input. |
| 46 | STIPACb | I | TIP AC Sense Input. |
| 47 | SRINGACb | I | RING AC Sense Input. |
| 48 | SRINGDCb | I | RING DC Sense Input. |
| 49 | DRINGb | O | RING Pull-Down Current Driver Output. |
| 50 | URINGb | O | RING Pull-Up Current Driver Output. |
| 51 | DTIPb | O | TIP Pull-Down Current Driver Output. |
| 52 | UTIPb | O | TIP Pull-Up Current Driver Output. |
| 53 | IBIASb | O | Line Driver IC Bias Current Output. |
| 54 | CAPLB | O | Longitudinal Balance Calibration Capacitor. |
| 55 | IREF | I | Current Reference Input. |
| 56 | QGND | I | Quiet Ground Reference Input. |
| 57 | GND A | GND | Analog Ground. |
| 58 | VDDA | PWR | Analog Supply Voltage. |
| 59 | ISNS | I/O | Line Current Sense Input. |
| 60 | IBIASa | O | Line Driver IC Bias Current Output. |
| 61 | UTIPa | O | TIP Pull-Up Current Driver Output. |
| 62 | DTIPa | O | TIP Pull-Down Current Driver Output. |
| 63 | URINGa | O | RING Pull-Up Current Driver Output. |
| 64 | DRINGa | O | RING Pull-Down Current Driver Output. |

6. Pin Descriptions: Si3208/9

Table 18. Si3208/9 Pin Descriptions

| QFN Pin # | Symbol | I/O | Description |
|-----------|----------|-----|--|
| 1 | IC | | Internal connection; leave to float. |
| 2 | NC | | No Connect. |
| 3 | RING_1 | I/O | Ring Channel 1 Input/Output. |
| 4 | NC | | No Connect. |
| 5 | TIP_1 | I/O | Tip Channel 1 Input/Output. |
| 6 | NC | | No Connect. |
| 7 | IC | | Internal connection; leave to float. |
| 8 | IRINGN_1 | I | Negative Ring Current Control Channel 1 Input. |
| 9 | IRINGP_1 | I | Positive Ring Current Control Channel 1 Input. |
| 10 | ITIPN_1 | I | Negative Tip Current Control Channel 1 Input. |
| 11 | ITIPP_1 | I | Positive Tip Current Control Channel 1 Input. |
| 12 | IBIAS_1 | I | Current Bias Channel 1 Input. |
| 13 | ISNS | O | Current Sense Output. |
| 14 | VDD | I | IC Supply Voltage Input. |
| 15 | HVCLK_1 | I | High-Voltage IC Clock Channel 1 Input. |
| 16 | HVDATA | I/O | High-Voltage IC Data Input/Output. |
| 17 | HVCLK_2 | I | High-Voltage IC Clock Channel 2 Input. |
| 18 | DGND | I | Digital Ground. |
| 19 | IBIAS_2 | I | Current Bias Channel 2 Input. |
| 20 | ITIPP_2 | I | Positive Tip Current Control Channel 1 Input. |
| 21 | ITIPN_2 | I | Negative Tip Current Control Channel 2 Input. |
| 22 | IRINGP_2 | I | Positive Ring Current Control Channel 2 Input. |
| 23 | IRINGN_2 | I | Negative Ring Current Control Channel 2 Input. |
| 24 | IC | | Internal connection; leave to float. |
| 25 | NC | | No Connect. |
| 26 | TIP_2 | I/O | Tip Channel 2 Input/Output. |
| 27 | NC | | No Connect. |
| 28 | RING_2 | I/O | Ring Channel 2 Input/Output. |
| 29 | NC | | No Connect. |
| 30 | IC | | Internal connection; leave to float. |
| 31 | IC | | Internal connection; leave to float. |
| 32 | VBAT_2 | I | Operating Battery Voltage Channel 2 Input. |
| 33 | NC | | No Connect. |
| 34 | IC | | Internal connection; leave to float. |

Table 18. Si3208/9 Pin Descriptions (Continued)

| QFN Pin # | Symbol | I/O | Description |
|------------------|---------------|------------|---|
| 35 | NC | | No Connect. |
| 36 | AGND | I | Analog Ground. |
| 37 | IC | | Internal connection; leave to float. |
| 38 | IC | | Internal connection; leave to float. |
| 39 | VBAT_1 | I | Operating Battery Voltage Channel 1 Input. |
| 40 | IC | | Internal connection; leave to float. |
| epad | | | Exposed Die Attach Paddle. For adequate thermal management, the exposed die paddle should be soldered to a printed circuit board pad that is connected to an electrically-isolated low-impedance inner layer and/or back-side thermal plane(s) using multiple thermal vias. Do not connect this pad to ground. |

7. Ordering Guide

| Device | Description | Wideband Audio | Package | Temp Range |
|-------------|-----------------|----------------|---------|--------------|
| Si3226-X-FQ | Dual ProSLIC | No | TQFP-64 | 0 to 70 °C |
| Si3226-X-GQ | Dual ProSLIC | No | TQFP-64 | -40 to 85 °C |
| Si3227-X-FQ | Dual ProSLIC | Yes | TQFP-64 | 0 to 70 °C |
| Si3227-X-GQ | Dual ProSLIC | Yes | TQFP-64 | -40 to 85 °C |
| Si3208-X-FM | 110 V Dual LFIC | — | QFN-40 | 0 to 70 °C |
| Si3208-X-GM | 110 V Dual LFIC | — | QFN-40 | -40 to 85 °C |
| Si3209-X-FM | 135 V Dual LFIC | — | QFN-40 | 0 to 70 °C |
| Si3209-X-GM | 135 V Dual LFIC | — | QFN-40 | -40 to 85 °C |

Notes:

1. All devices are lead-free and RoHS compliant.
2. "X" denotes product revision (A, B, C, etc.).
3. Add an R at the end of the device to denote tape and reel options.

8. Package Outline: 64-Pin TQFP

Figure 12 illustrates the package details for the Si3226/7. Table 19 lists the values for the dimensions shown in the illustration.

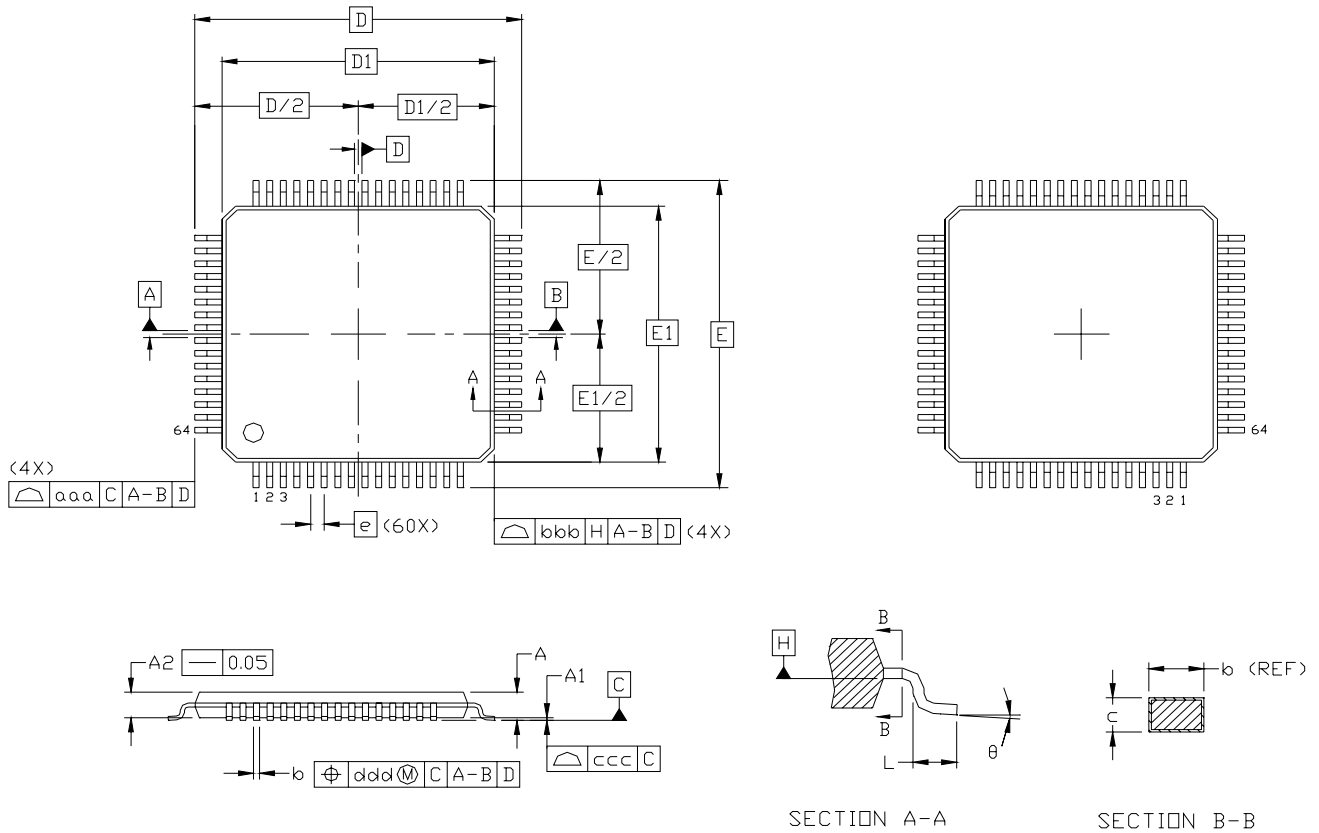


Figure 12. 64-Pin Thin Quad Flat Package (TQFP)

Table 19. 64-Pin TQFP Package Dimensions

| Dimension | Min | Nom | Max |
|---|------------|------|------|
| A | — | — | 1.20 |
| A1 | 0.05 | — | 0.15 |
| A2 | 0.95 | 1.00 | 1.05 |
| b | 0.17 | 0.22 | 0.27 |
| c | 0.09 | — | 0.20 |
| D | 12.00 BSC. | | |
| D1 | 10.00 BSC. | | |
| e | 0.50 BSC. | | |
| E | 12.00 BSC. | | |
| E1 | 10.00 BSC. | | |
| L | 0.45 | 0.60 | 0.75 |
| aaa | — | — | 0.20 |
| bbb | — | — | 0.20 |
| ccc | — | — | 0.08 |
| ddd | — | — | 0.08 |
| Q | 0° | 3.5° | 7° |
| Notes: | | | |
| 1. All dimensions shown are in millimeters (mm) unless otherwise noted. | | | |
| 2. Dimensioning and tolerancing per ANSI Y14.5M-1994. | | | |
| 3. This package outline conforms to JEDEC MS-026, variant ACD. | | | |
| 4. Recommended card reflow profile is per the JEDEC/IPC J-STD-020C specification for small body components. | | | |

9. Package Outline: 40-Pin QFN

Figure 13 illustrates the package details for the Si3208/9. Table 20 lists the values for the dimensions shown in the illustration.

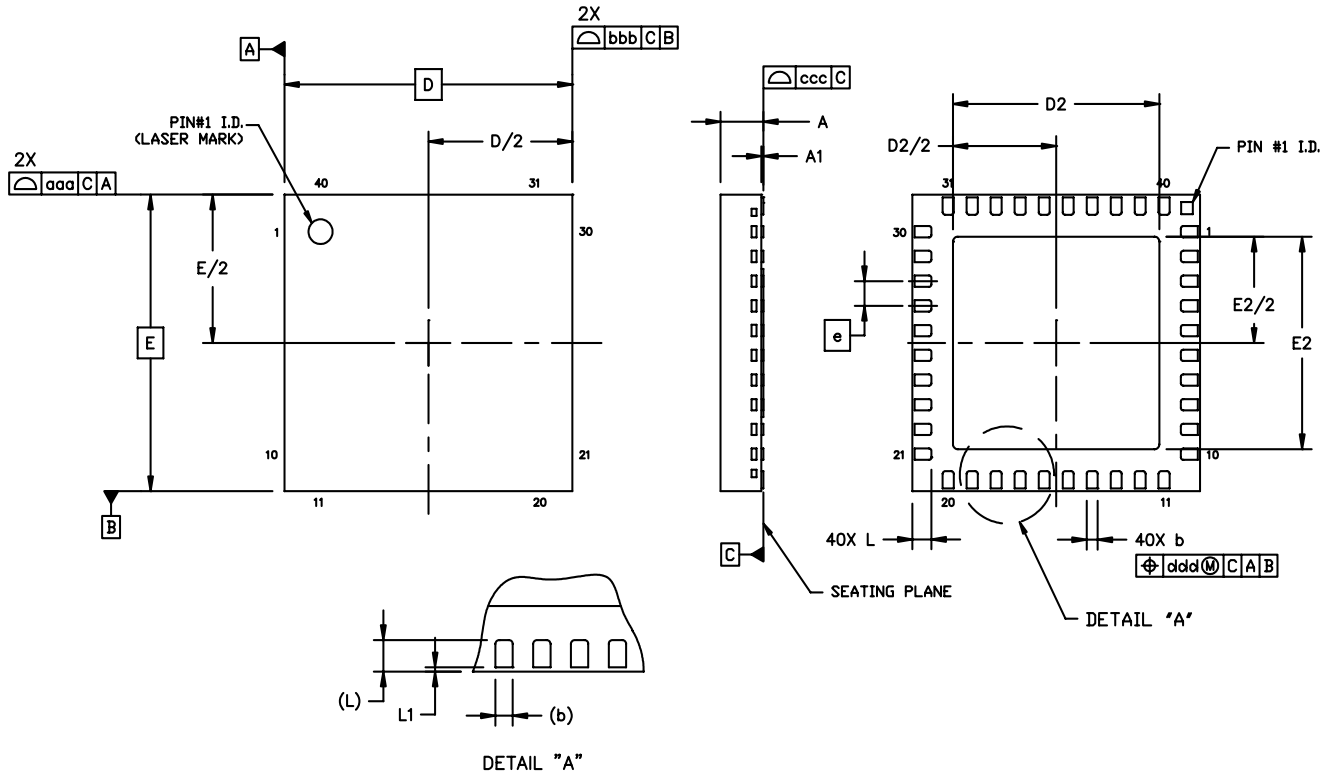


Figure 13. 40-Pin QFN Package

Table 20. 40-Pin QFN Package Dimensions

| Dimension | Min | Nom | Max | Dimension | Min | Nom | Max |
|-----------|-----------|------|------|-----------|------|------|------|
| A | 0.80 | 0.90 | 1.00 | E2 | 4.10 | 4.30 | 4.40 |
| A1 | 0.00 | 0.02 | 0.05 | L | 0.30 | 0.40 | 0.50 |
| b | 0.18 | 0.25 | 0.30 | L1 | 0.03 | 0.05 | 0.08 |
| D | 6.00 BSC. | | | aaa | — | — | 0.10 |
| D2 | 4.10 | 4.30 | 4.40 | bbb | — | — | 0.10 |
| e | 0.50 BSC. | | | ccc | — | — | 0.08 |
| E | 6.00 BSC. | | | ddd | — | — | 0.10 |

Notes:

1. All dimensions shown are in millimeters (mm) unless otherwise noted.
2. Dimensioning and tolerancing per ANSI Y14.5M-1994.
3. This drawing conforms to JEDEC outline MO-220, variation VJJD-2.
4. Recommended card reflow profile is per the JEDEC/IPC J-STD-020C specification for small body components.

DOCUMENT CHANGE LIST

Revision 0.2 to Revision 0.32

- Added Si3208 and Si3209.
- Removed Si3203, Si3205, and Si3206.
- Added pin-outs and package drawings for Si3208 and Si3209.
- Updated pin-out for Si3226.
- Updated bill of materials.
- Updated “2. Typical Application Circuits” and added dc-dc converter schematics.
- Updated tables.

Revision 0.32 to Revision 0.33

- Changed package type for Si3208.
- Deleted QFN-32 drawing.
- Updated dc-dc converter schematic.
- Updated bills of materials.
- Updated max V_{BAT} values.
- Updated thermal shutdown thresholds.
- Updated Si3208/9 pin descriptions.

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