# Edge4707
# Quad Channel Per-Pin Precision Measurement Unit



## Description

The Edge4707 is a precision measurement unit designed for automatic test equipment and instrumentation. Manufactured in a wide voltage CMOS process, it is a monolithic solution for a quad channel per pin PMU.

Each channel of the Edge4707 features a PMU that can force or measure voltage over a 15V I/O range, and supports 4 current ranges: 2 µA, 200 µA, 20 µA, and 2 mA.

Each channel of the Edge4707 features an on-board window comparator that provides two bits of information — DUT too high and DUT too low. There is also a monitor function which provides a real time analog signal proportional to either the measured voltage or current.

The Edge4707 is designed to be a low power, low cost, small footprint solution to allow high pin count testers to support a PMU per pin.

In addition, two independent switches per channel (for a central PMU force and sense) plus two wide voltage analog muxes per channel are included.

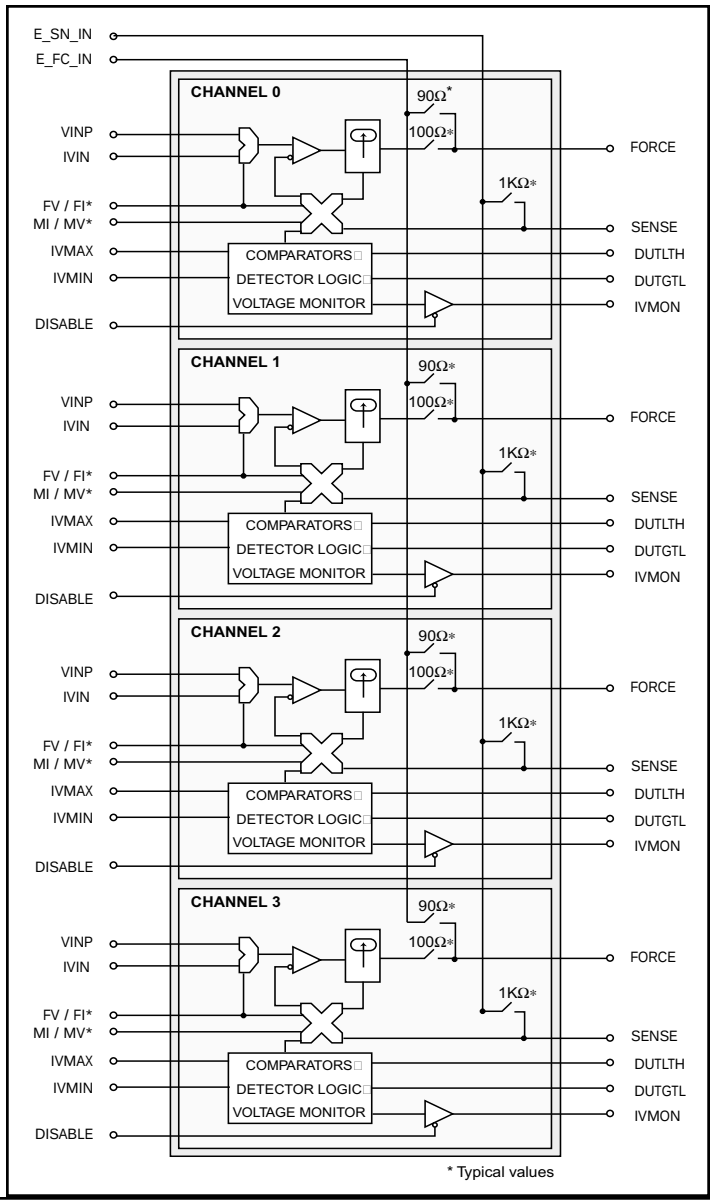
## Applications

- Automatic Test Equipment
  - Memory Testers
  - VLSI Testers
  - Mixed Signal Tester

## Features

- FV / MI Capability
- FI / MV Capability
- FV / MV Capability
- FI / MI Capability
- 4 Current Ranges (2 µA, 20 µA, 200 µA, 2mA)
- –2V to +13V Output Range (Zero Current)
- 0V to 11V Output Range (Full Scale Current)
- FV Linearity to ± .025% FSR
- Central PMU Switches
- Per Pin Super Voltage Switches

## Functional Block Diagram



## PIN Description

| Pin Name | Pin # | Description |
|---|---|---|
| VINP[0:3] | C2, F5, H3, L2 | Analog voltage input which forces the output voltage (FV/MI mode) (one per channel). |
| IVIN[0:3] | C1, F2, H4, J5 | Analog voltage input which forces the output current (FI/MV mode) (one per channel). |
| FORCE[0:3] | C14, F12, H13, L12 | Analog output pin which forces current or voltage. |
| SENSE[0:3] | C13, G10, H14, K11 | Analog input pin which senses voltage. |
| FV/FI*[0:3] | D10, B8, A6, E6 | TTL compatible input which determines whether the PMU is forcing voltage or forcing current. |
| MI/MV*[0:3] | B10, A8, C6, D5 | TTL compatible input which determines whether the PMU is measuring current or measuring voltage. |
| RS0[0:3]<br>RS1[0:3] | B11, A9, C7, C5<br>A12, C10, D8, A5 | TTL compatible current range select inputs. |
| IVMIN[0:3]<br>IVMAX[0:3] | G5, E1, H2, K3<br>C3, E3, H1, L1 | Analog input voltages which establish the lower and upper threshold level for the measurement comparator. |
| DUTLTH[0:3]<br>DUTGTL[0:3] | P11, N9, N7, N5<br>N11, P9, P7, P5 | Digital comparator output that indicates the DUT measurement is less than the upper threshold and greater than the lower threshold. |
| DISABLE[0:3] | A11, C9, D7, A4 | TTL compatible input which places the IVMON outputs in high impedance. |
| E_SNSEL[0:3] | D11, E9, B7, B5 | TTL switch select for the external SENSE switch for Channels 0–3. |
| E_SN_IN | L4 | Analog output for external SENSE. |
| E_FC_IN | K5 | Analog input for external FORCE signal. |
| E_FCSEL[0:3] | E10, B9, A7, D6 | TTL switch select for the external FORCE switch for Channels 0–3. |
| I_FCSEL[0:3] | C11, D9, B6, B4 | TTL switch select for internal FORCE switch for Channels 0–3. |
| RA[0:3], RB[0:3]<br>RC[0:3], RD[0:3] | D13, G11, J14, K10<br>D14, G12, J13, L11<br>E12, G14, J10, M14<br>F11, G13, K12, M13 | External resistor input corresponding to Ranges A through D. |
| RES_IN[0:3] | F10, F13, J12, L13 | External resistor input. One side of the external resistors connect to RA[0:3], RB[0:3], RC[0:3], RD[0:3]. The other side of all resistors connect to RES_IN. |

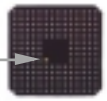
## PIN Description *(continued)*

| Pin Name | Pin # | Description |
|---|---|---|
| IVMON[0:3] | B1, E2, G4, J4 | Analog voltage output that provides a real time monitor of either the measured voltage or measured current level. |
| COMP1[0:3]<br>COMP2[0:3] | D4, F1, J2, K4<br>E5, F3, J1, M1 | Internal compensation pins that require an external capacitor connected between the two pins. |
| COMP3[0:3] | D2, F4, J3, M2 | Internal compensation pin that requires an external capacitor connected between the pin and ground. |
| COMP4[0:3] | D1, G2, H5, L3 | Internal compensation pin that requires an external capacitor connected between the pin and the RES_IN pin. |
| ***Analog MUX Switches*** | | |
| $V_{IH[0:3]}$ | K9, M9, M7, M5 | Driver High input. |
| $V_{IHH[0:3]}$ | L10, K8, L7, K6 | Super voltage input High. |
| $V_{IL[0:3]}$ | L9, M8, M6, M4 | Driver Low input. |
| $V_{ILH[0:3]}$ | M10, L8, L6, L5 | Super voltage input Low. |
| SVSEL[0:3] | A10, C8, E7, A3 | Select for MUX. |
| DVH[0:3] | P10, N8, N6, N4 | Output High. |
| DVL[0:3] | N10, P8, P6, P4 | Output Low. |
| ***Power Pins*** | | |
| VCC[1:4] | A1, D12, E4, E14, G3, H12, K2, K13 | Positive analog power supply. |
| VDD | P3 | Positive digital supply. |
| VEE[1:4] | D3, E13, G1, H11, K1, K14, M12, N1 | Negative analog power supply. |
| GND[1:4] | E11, F14, J11, L14 | Ground. |

## PIN Description *(continued)*

**Bottom View**

A1 Ball Pad Indicator



12 mm X 12 mm 180 FLEXBGA

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | P1 | P2 | P3 VDD | P4 DVL3 | P5 DUTGTL3 | P6 DVL2 | P7 DUTGTL2 | P8 DVL1 | P9 DUTGTL1 | P10 DVH0 | P11 DUTLTH0 | P12 | P13 | P14 |
| N | N1 VEE4 | N2 | N3 | N4 DVH3 | N5 DUTLTH3 | N6 DVH2 | N7 DUTLTH2 | N8 DVH1 | N9 DUTLTH1 | N10 DVL0 | N11 DUTGTL0 | N12 | N13 | N14 |
| M | M1 COMP2_3 | M2 COMP3_3 | M3 | M4 VIL3 | M5 VIH3 | M6 VIL2 | M7 VIH2 | M8 VIL1 | M9 VIH1 | M10 VILH0 | M11 | M12 VEE4 | M13 RD3 | M14 RC3 |
| L | L1 IVMAX3 | L2 VINP3 | L3 COMP4_3 | L4 E_SN_IN | L5 VILH3 | L6 VILH2 | L7 VIHH2 | L8 VILH1 | L9 VIL0 | L10 VIHH0 | L11 RB3 | L12 FORCE3 | L13 RESIN3 | L14 GND4 |
| K | K1 VEE3 | K2 VCC4 | K3 IVMIN3 | K4 COMP1_3 | K5 E_FC_IN | K6 VIHH3 | K7 | K8 VIHH1 | K9 VIH0 | K10 RA3 | K11 SENSE3 | K12 RD2 | K13 VCC4 | K14 VEE3 |
| J | J1 COMP2_2 | J2 COMP1_2 | J3 COMP3_2 | J4 IVMON3 | J5 IVIN3 | J6 | J7 | J8 | J9 | J10 RC2 | J11 GND3 | J12 RESIN2 | J13 RB2 | J14 RA2 |
| H | H1 IVMAX2 | H2 IVMIN2 | H3 VINP2 | H4 IVIN2 | H5 COMP4_2 | H6 | H7 | H8 | H9 | H10 | H11 VEE2 | H12 VCC3 | H13 FORCE2 | H14 SENSE2 |
| G | G1 VEE2 | G2 COMP4_1 | G3 VCC3 | G4 IVMON2 | G5 IVMIN0 | G6 | G7 | G8 | G9 | G10 SENSE1 | G11 RA1 | G12 RB1 | G13 RD1 | G14 RC1 |
| F | F1 COMP1_1 | F2 IVIN1 | F3 COMP2_1 | F4 COMP3_1 | F5 VINP1 | F6 | F7 | F8 | F9 | F10 RESIN0 | F11 RD0 | F12 FORCE1 | F13 RESIN1 | F14 GND2 |
| E | E1 IVMIN1 | E2 IVMON1 | E3 IVMAX1 | E4 VCC2 | E5 COMP2_0 | E6 FV/FI*3 | E7 SVSEL2 | E8 | E9 E_SNSEL1 | E10 E_FCSEL0 | E11 GND1 | E12 RC0 | E13 VEE1 | E14 VCC2 |
| D | D1 COMP4_0 | D2 COMP3_0 | D3 VEE1 | D4 COMP1_0 | D5 MI/MV*3 | D6 E_FCSEL3 | D7 DISABLE2 | D8 RS1_2 | D9 I_FCSEL1 | D10 FV/FI*0 | D11 E_SNSEL0 | D12 VCC1 | D13 RA0 | D14 RB0 |
| C | C1 IVIN0 | C2 VINP0 | C3 IVMAX0 | C4 | C5 RS0_3 | C6 MI/MV*2 | C7 RS0_2 | C8 SVSEL1 | C9 DISABLE1 | C10 RS1_1 | C11 I_FCSEL0 | C12 | C13 SENSE0 | C14 FORCE0 |
| B | B1 IVMON0 | B2 | B3 | B4 I_FCSEL3 | B5 E_SNSEL3 | B6 I_FCSEL2 | B7 E_SNSEL2 | B8 FV/FI*1 | B9 E_FCSEL1 | B10 MI/MV*0 | B11 RS0_0 | B12 | B13 | B14 |
| A | A1 VCC1 | A2 | A3 SVSEL3 | A4 DISABLE3 | A5 RS1_3 | A6 FV/FI*2 | A7 E_FCSEL2 | A8 MI/MV*1 | A9 RS0_1 | A10 SVSEL0 | A11 DISABLE0 | A12 RS1_0 | A13 | A14 |

A1 Ball Pad Corner Indicator (No Solder Ball)

## PIN Description *(continued)*

A1 Ball Pad Indicator

### Top View

12 mm X 12 mm 180 FLEXBGA

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | A1 VCC1 | A2 | A3 SVSEL3 | A4 DISABLE3 | A5 RS1_3 | A6 FV/FI*2 | A7 E_FCSEL2 | A8 MI/MV*1 | A9 RS0_1 | A10 SVSEL0 | A11 DISABLE0 | A12 RS1_0 | A13 | A14 |
| B | B1 IVMON0 | B2 | B3 | B4 I_FCSEL3 | B5 E_SNSEL3 | B6 I_FCSEL2 | B7 E_SNSEL2 | B8 FV/FI*1 | B9 E_FCSEL1 | B10 MI/MV*0 | B11 RS0_0 | B12 | B13 | B14 |
| C | C1 IVIN0 | C2 VINP0 | C3 IVMAX0 | C4 | C5 RS0_3 | C6 MI/MV*2 | C7 RS0_2 | C8 SVSEL1 | C9 DISABLE1 | C10 RS1_1 | C11 I_FCSEL0 | C12 | C13 SENSE0 | C14 FORCE0 |
| D | D1 COMP4_0 | D2 COMP3_0 | D3 VEE1 | D4 COMP1_0 | D5 MI/MV*3 | D6 E_FCSEL3 | D7 DISABLE2 | D8 RS1_2 | D9 I_FCSEL1 | D10 FV/FI*0 | D11 E_SNSEL0 | D12 VCC1 | D13 RA0 | D14 RB0 |
| E | E1 IVMIN1 | E2 IVMON1 | E3 IVMAX1 | E4 VCC2 | E5 COMP2_0 | E6 FV/FI*3 | E7 SVSEL2 | E8 | E9 E_SNSEL1 | E10 E_FCSEL0 | E11 GND1 | E12 RC0 | E13 VEE1 | E14 VCC2 |
| F | F1 COMP1_1 | F2 IVIN1 | F3 COMP2_1 | F4 COMP3_1 | F5 VINP1 | F6 | F7 | F8 | F9 | F10 RESIN0 | F11 RD0 | F12 FORCE1 | F13 RESIN1 | F14 GND2 |
| G | G1 VEE2 | G2 COMP4_1 | G3 VCC3 | G4 IVMON2 | G5 IVMIN0 | G6 | G7 | G8 | G9 | G10 SENSE1 | G11 RA1 | G12 RB1 | G13 RD1 | G14 RC1 |
| H | H1 IVMAX2 | H2 IVMIN2 | H3 VINP2 | H4 IVIN2 | H5 COMP4_2 | H6 | H7 | H8 | H9 | H10 | H11 VEE2 | H12 VCC3 | H13 FORCE2 | H14 SENSE2 |
| J | J1 COMP2_2 | J2 COMP1_2 | J3 COMP3_2 | J4 IVMON3 | J5 IVIN3 | J6 | J7 | J8 | J9 | J10 RC2 | J11 GND3 | J12 RESIN2 | J13 RB2 | J14 RA2 |
| K | K1 VEE3 | K2 VCC4 | K3 IVMIN3 | K4 COMP1_3 | K5 E_FC_IN | K6 VIHH3 | K7 | K8 VIHH1 | K9 VIH0 | K10 RA3 | K11 SENSE3 | K12 RD2 | K13 VCC4 | K14 VEE3 |
| L | L1 IVMAX3 | L2 VINP3 | L3 COMP4_3 | L4 E_SN_IN | L5 VILH3 | L6 VILH2 | L7 VIHH2 | L8 VILH1 | L9 VIL0 | L10 VIHH0 | L11 RB3 | L12 FORCE3 | L13 RESIN3 | L14 GND4 |
| M | M1 COMP2_3 | M2 COMP3_3 | M3 | M4 VIL3 | M5 VIH3 | M6 VIL2 | M7 VIH2 | M8 VIL1 | M9 VIH1 | M10 VILH0 | M11 | M12 VEE4 | M13 RD3 | M14 RC3 |
| N | N1 VEE4 | N2 | N3 | N4 DVH3 | N5 DUTLTH3 | N6 DVH2 | N7 DUTLTH2 | N8 DVH1 | N9 DUTLTH1 | N10 DVL0 | N11 DUTGTL0 | N12 | N13 | N14 |
| P | P1 | P2 | P3 VDD | P4 DVL3 | P5 DUTGTL3 | P6 DVL2 | P7 DUTGTL2 | P8 DVL1 | P9 DUTGTL1 | P10 DVH0 | P11 DUTLTH0 | P12 | P13 | P14 |

A1 Ball Pad Corner Indicator (No Solder Ball)

## Circuit Description

### Circuit Overview

The Edge4707 is a quad channel parametric test and measurement unit that can :

- Force Voltage / Measure Current
- Force Current / Measure Voltage
- Force Voltage / Measure Voltage
- Force Current / Measure Current

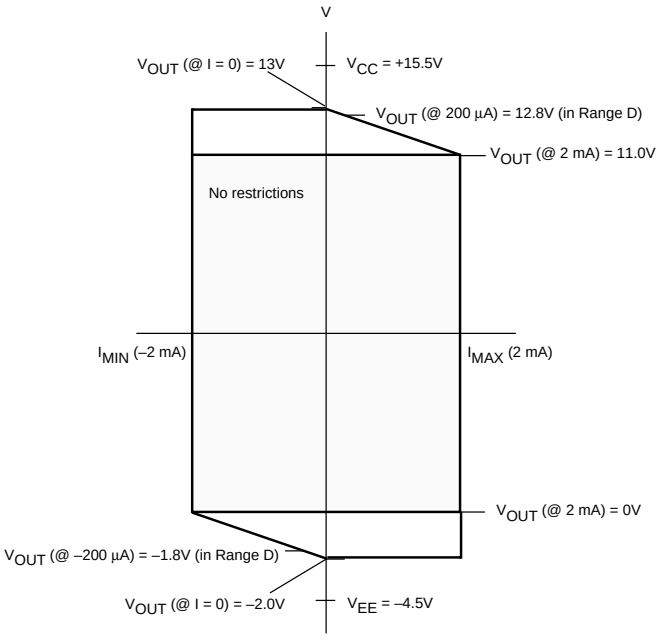
Each PMU channel can force or measure voltage over a 15V range and force or measure current over four distinct ranges:

- ± 2 µA
- ± 20 µA
- ± 200 µA
- ± 2 mA.

An on-board window comparator provides two bit output range classification. Also, a monitor passes a real time analog voltage which tracks either the measured current or voltage.

### PPMU Functionality

The trapezoid in Figure 1 describes the current-voltage functionality of the PMU with VCC = 15.5V and VEE = –4.5V, *in Range D.*




NOTE: Negative current implies current is flowing into the 4707 from DUT.

***Figure 1. PMU Functionality***

### Control Inputs

FV/FI* is a TTL compatible input which determines whether the PMU forces voltage or current, and MI/MV* is a TTL compatible input which determines whether the PMU measures current or voltage. FV/FI* and MI/MV* are independent for each PMU. Table 1 describes the modes of operation controlled by these pins.

| FV / FI* | MI/MV* | Mode of Operation |
|---|---|---|
| 0 | 0 | Force Current, Measure Voltage |
| 0 | 1 | Force Current, Measure Current |
| 1 | 0 | Force Voltage, Measure Voltage |
| 1 | 1 | Force Voltage, Measure Current |

***Table 1.***

RS0 and RS1 are TTL compatible inputs to an internal analog mux which selects an external resistor corresponding to a desired current range. The truth table for RS0 to RS1, along with the associated external resistor values and current ranges, is shown in Table 2. RS0 and RS1 are independent for each channel of the 4707.

| RS1 | RS0 | Range | Current Range | "Nominal" Ext. R |
|---|---|---|---|---|
| 0 | 0 | A | ± 2 µA | RA = 1MΩ |
| 0 | 1 | B | ± 20 µA | RB = 100KΩ |
| 1 | 0 | C | ± 200 µA | RC = 10KΩ |
| 1 | 1 | D | ± 2 mA | RD = 1KΩ |

***Table 2.***

### FORCE/SENSE

FORCE is an analog output which either forces a current or forces a voltage, depending on which operating mode is selected.

SENSE is a high impedance analog input which measures the DUT voltage input in the MV operating mode.

FORCE and SENSE are brought out to separate pins to allow remote sensing.

## Circuit Description *(continued)*

### IVMON

IVMON is a real time analog voltage output which tracks the sensed parameter.

In the MV mode, the output voltage displayed at IVMON is a 1:1 mapping of the SENSE voltage. In the MI mode, IVMON follows the equation:

$$IVMON = I(measured) * REXT$$

Using nominal values for the external resistors (RA, RB, RC, and RD), a voltage at IVMON of +2V corresponds to Imax and –2V corresponds to Imin of the selected current range.

The IVMON pin can also be placed into a high impedance state by using the DISABLE input (see Table 3).

| Disable | MI / MV* | Sensed Parameter |
|---|---|---|
| 1 | X | High Impedance |
| 0 | 0 | Measured Voltage |
| 0 | 1 | Measured Current |

***Table 3.***

### *Force Voltage Mode*

In the FV mode (FV/FI* = 1), VINP is a high impedance analog voltage input that maps directly to the voltage forced at the FORCE pin.

### *Measure Current Mode*

In the MI mode (MI/MV* = 1), a current monitor is connected in series with the PMU forcing amplifier. This monitor generates a voltage that is proportional to the current passing through it, and is brought out to IVMON. This voltage (corresponding to the measured current) is also tested by the on-board window comparator.

### *Force Current Mode (see page 15)*

In the FI mode (FV/FI* = 0), IVIN is a high impedance analog voltage input that is converted into a current at the FORCE pin using the following relationship:

$$Forced\ Current = IVIN / REXT$$

(Positive current is defined as current flowing out of the FORCE pin.) The IVIN input voltage range and forced current (at FORCE) can be seen in Table 4.

| IVIN | Corresponding Forced Current |
|---|---|
| +2V | Imax (full scale) |
| 0V | 0 |
| –2V | Imin (full scale) |

***Table 4.***

### *Measure Voltage Mode*

In the MV mode (MI/MV* = 0), DUT voltage is measured via the SENSE input pin. Note that EXT_SENSE_SEL = 0 when the Edge4707 SENSE is used. This measured voltage is also tested with the on-board window comparator.

### *Comparator*

The Edge4707 features an on-board window comparator which provides two-bit measurement range classification. IVMAX and IVMIN are high impedance analog inputs that establish the upper and lower thresholds for the window comparator.

In the MI mode, an I/V MAX input of +2V will set the upper threshold of the window comparator to a voltage corresponding to +FSC (full-scale current), and an I/V MIN input of –2V will set the lower threshold to a voltage corresponding to –FSC (positive current is defined as current flowing out of the PMU).

DUTGTL the DUTLTH are LVTTL compatible outputs which indicate the range of the measured parameter in relation to IVMIN and IVMAX. Comparator functionality is summarized in Table 5 for MI Mode and Table 6 for MV mode.

## Circuit Description *(continued)*

| TEST CONDITION | DUT LTH | DUT GTL |
|---|---|---|
| IVMON > IVMAX<br>IVMON < IVMAX | 0<br>1 | N/A |
| IVMON > IVMIN<br>IVMON < IVMIN | N/A | 1<br>0 |
| IVMON < IVMAX<br>and<br>IVMON > IVMIN | 1 | 1 |

***Table 5. MI Comparator Truth Table***

| TEST CONDITION | DUT LTH | DUT GTL |
|---|---|---|
| SENSE > IVMAX<br>SENSE < IVMAX | 0<br>1 | N/A |
| SENSE > IVMIN<br>SENSE < IVMIN | N/A | 1<br>0 |
| SENSE < IVMAX<br>and<br>SENSE >IVMIN | 1 | 1 |

***Table 6. MV Comparator Truth Table***

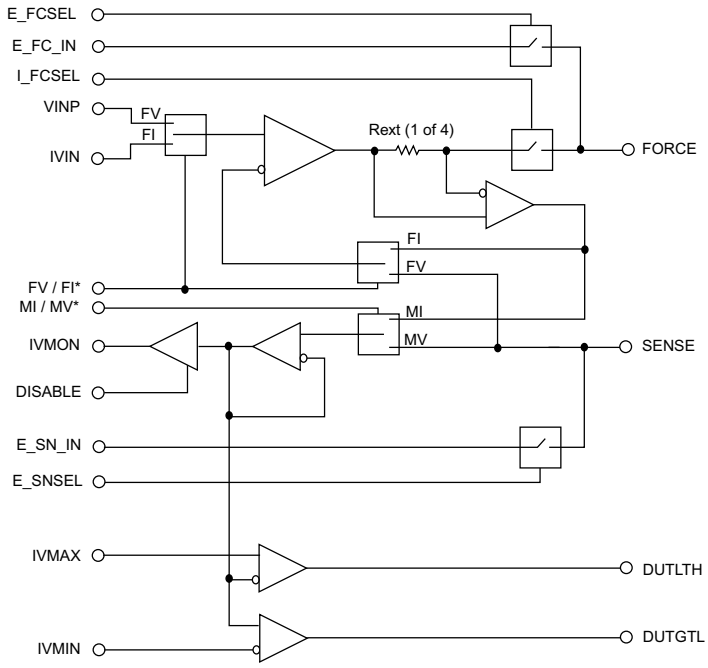



***Figure 2. Block Diagram of the PMU Section of One Channel***

## Circuit Description *(continued)*

### REXT Selection

The Edge 4707 is designed for the voltage drop across RA, RB, RC, and RD to be ≤ 2V with the maximum current passing through them. However, these resistor values can be changed to support different applications.

Increasing the maximum current beyond the nominal range is not recommended. However, decreasing the maximum current is allowed by increasing the external resistor using the equation IMAX = 2V / REXT.

### Switch Operation on Force and Sense Lines

Each channel of the Edge4707 features two 100Ω switches connected to the FORCE output pin and one 1KΩ switch connected to the SENSE input pin. These switches are controlled by the TTL compatible inputs I_FCSEL, E_FCSEL, and E_SNSEL. Switch operation is described in Table 7.

| Switch | Switch Select Name | Open/Close State on Switch |
|---|---|---|
| 100Ω, to internal force circuitry | I_FCSEL | 0 = Open<br>1 = Closed |
| 100Ω, to external force circuitry | E_FCSEL | 0 = Open<br>1 = Closed |
| 1KΩ, to external sense circuitry | E_SNSEL | 0 = Open<br>1 = Closed |

***Table 7.***

These switches can be configured to route the Edge4707 for external forcing or sensing operations (see Figure 2). For external forcing operation, the switch controlled by I_FCSEL can be used to internally isolate the PMU from the FORCE output. This enables the user to connect the FORCE pin to an external source connected to the E_FC_IN pin using the switch controlled by the E_FC_SEL input. When operating with an external source such as the Edge720, it is recommended that FV/FI* be set to 0 in order to reduce the amount of capacitance added to the FORCE pin by the Edge4707. I_FCSEL and E_FCSEL functionality is described in Table 8.

| I_FCSEL | E_FCSEL | FORCE |
|---|---|---|
| 0 | 0 | HiZ |
| 1 | 1 | Illegal Condition |
| 1 | 0 | VINP |
| 0 | 1 | E_FC_IN |

***Table 8.***

For external sense operation, the switch controlled by E_SNSEL can be used to internally connect the SENSE input pin to the E_SN_IN output pin (see Figure 2). This allows the user to use the E_SN_IN pin for remote sensing.

### Analog MUX

The Edge4707 has a separate analog mux section which is intended for 12V flash programming signal muxing with lower, more standard voltages. There are five inputs for this section, all of which are brought out to external pins (see Figure 3). The two outputs, DVH and DVL, connect to driver reference voltages of the Edge720 (or other pin electronics drivers).

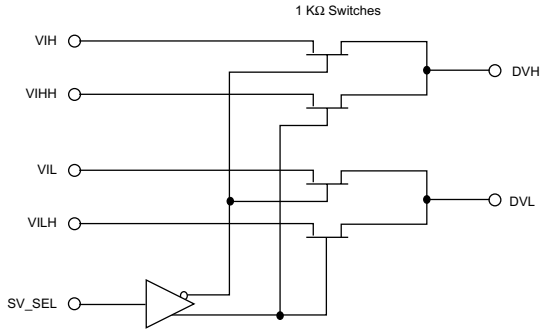



***Figure 3. Analog MUX Section***
*(Typically used to provide flash programming and standard voltages to driver pin electronic references.)*

The truth table for SV-SEL is shown in Table 9.

| SV_SEL | |
|---|---|
| 0 | DVH = VIH<br>DVL = VIL |
| 1 | DVH = VIHH<br>DVL = VILH<br>(supervoltage) |

***Table 9. SV-SEL Truth Table***

## Circuit Description *(continued)*

### Short Circuit Protection

The Edge 4707 is designed to survive a direct short circuit to any legal voltage at the FORCE and SENSE pins, by virtue of a limited current, which results from the presence of an external current sense resistor (normally 1 KΩ to 1MΩ) in the FORCE path.

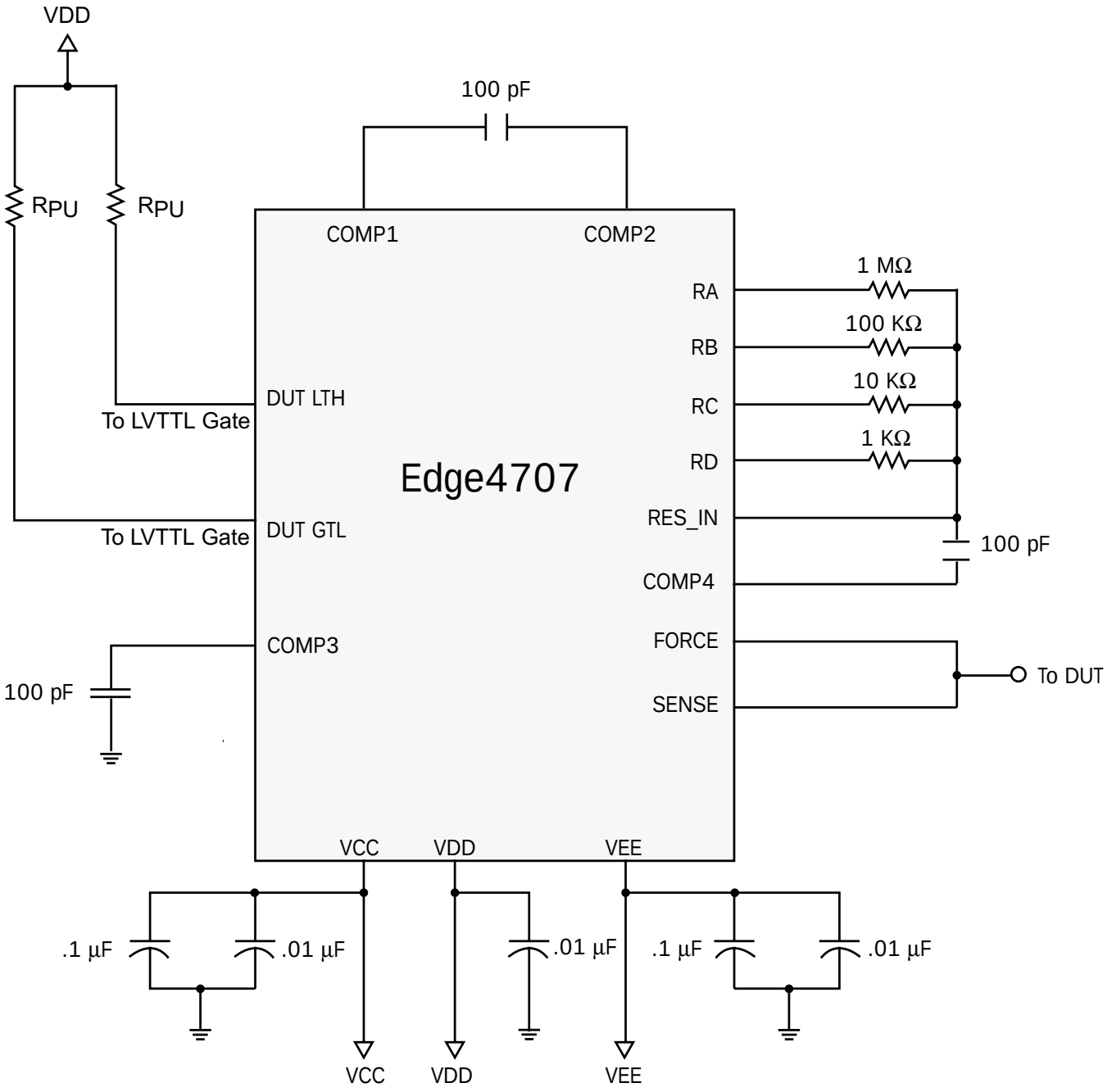
### Transient Clamps

The Edge 4707 has on-board clamps to limit the voltage and current spikes that might result from either changing the current range or changing the operating mode.

## Application Information

### Required External Components (Per Channel)

Choose $R_{PU}$ such that $\frac{VDD}{R_{PU}} < 1$ mA



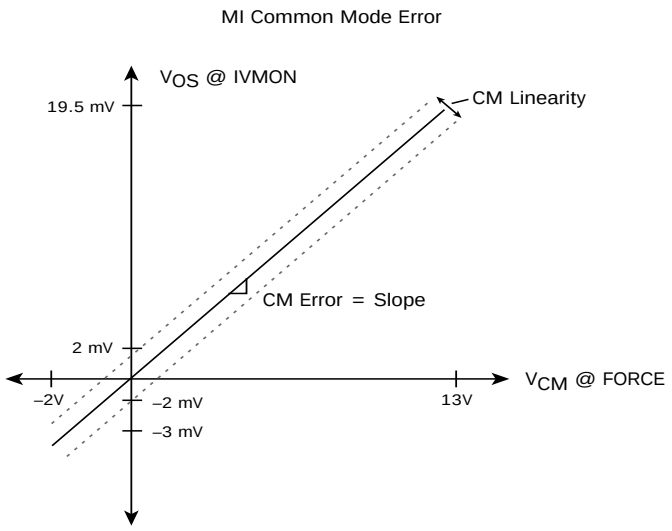

Actual decoupling capacitor values depend on the system environment.

## Application Information *(continued)*

### Calibration

In order to attain a high degree of accuracy in a typical ATE application, offset and gain errors are accounted for through software calibration. When operating the Edge4707 in the Measure Current (MI) or Force Current (FI) modes, an additional source of error, common mode error, should be accounted for. Common mode error is a measure of how the common mode voltage, $V_{CM}$, at the input of the current sense amplifier affects the forced or measured current values (see Figure 4). Since this error is created by internal resistors in the current sense amplifier, it is very linear in nature.

Using the common mode error and common mode linearity specifications, one can see that with a small number of calibration steps (see Applications note E4707-A1), the effect of this error can be significantly reduced.




NOTE: In some cases, slope may be negative.

***Figure 4. Graphical Representation of Common Mode Error***

### Maximum Input Voltage Range for FV Mode

In order to ensure that the full-scale output voltage range (FSV) can be achieved by the 4707, errors such as gain, linearity, and offset must be taken into account when determining the input voltage range required at VINP. The equations in Table 10 can be used to determine the input voltage range required at VINP to achieve full scale voltage (FSV) at the FORCE pin.

| VINP (Worst Case) | FORCE |
|---|---|
| $\frac{FSV}{Gain}$ + $V_{OS}$ + LInearity Error | + FSV |
| $\frac{-FSV}{Gain}$ + $V_{OS}$ + LInearity Error | – FSV |

***Table 10.***

Example: If it is desired to operate the 4707 with a FV range of –2V to 13V, the VINP input voltages in Table 11 may be required.

| VINP | FORCE |
|---|---|
| 13.3V | +13V |
| –2.13V | –2V |

***Table 11.***

## Application Information *(continued)*

### Maximum Input Voltage Range for FI Mode

In order to ensure that the full-scale output current range (FSC) can be achieved by the 4707, errors such as gain, linearity, common mode, and offset must be taken into account when determining the input voltage range required at IVIN. The equations in Table 12 can be used to determine the input voltage range required at IVIN to achieve full scale current (FSC) at the FORCE pin.

| IVIN (Worst Case) | Corresponding Forced Current |
|---|---|
| $\frac{2V}{Gain}$ + $V_{OS}$ + Common Mode Error + Linearity Error | + FSC |
| $\frac{-2V}{Gain}$ + $V_{OS}$ + Common Mode Error + Linearity Error | – FSC |

***Table 12.***

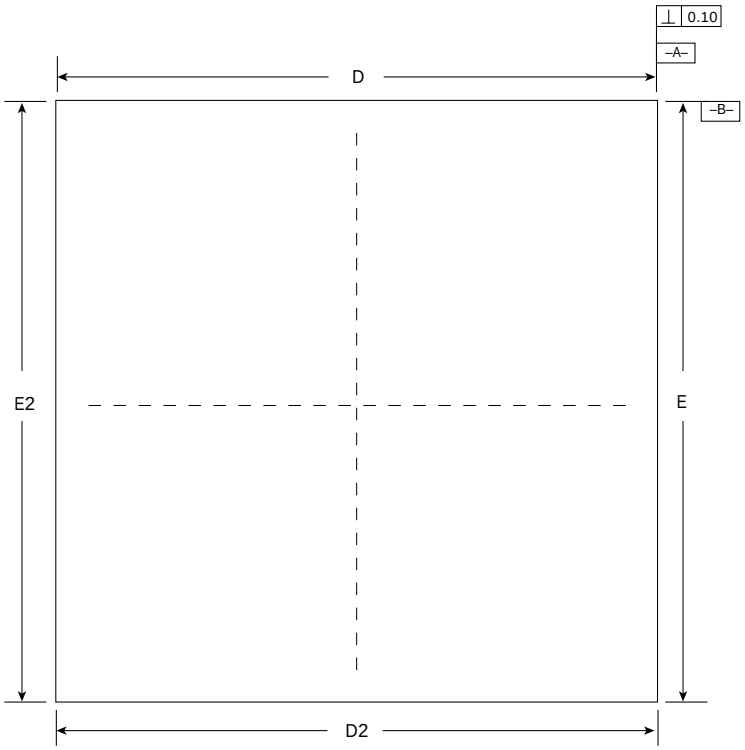
Example: To guarantee that the 4707 is capable of forcing ± 2 mA with REXT = 1KΩ (Range D), the input voltages in Table 13 may be required.

| IVIN | Corresponding Forced Current |
|---|---|
| 2.15V | 2 mA |
| –2.15V | – 2 mA |

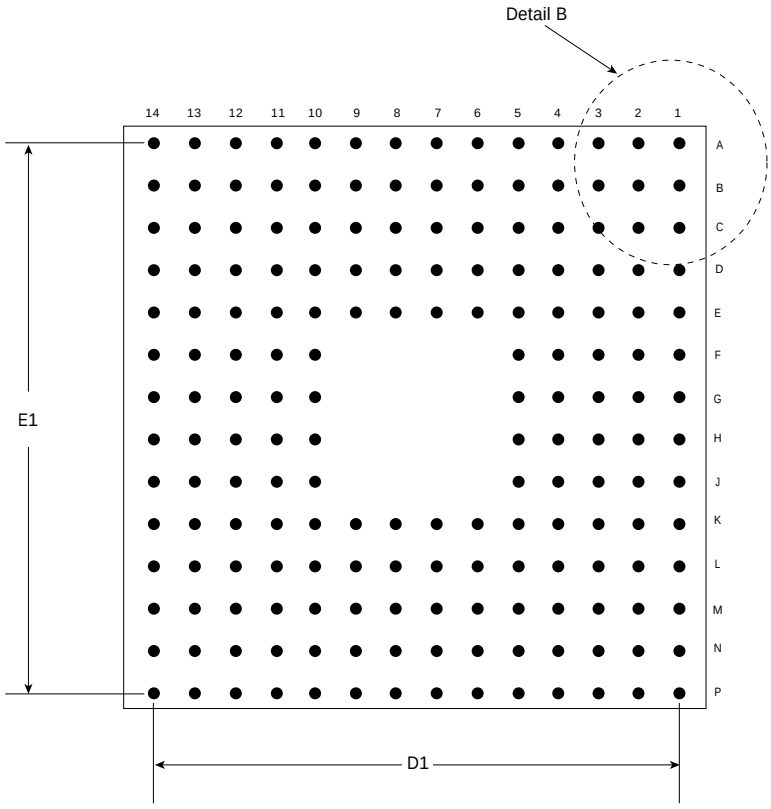
***Table 13.***

## Package Information

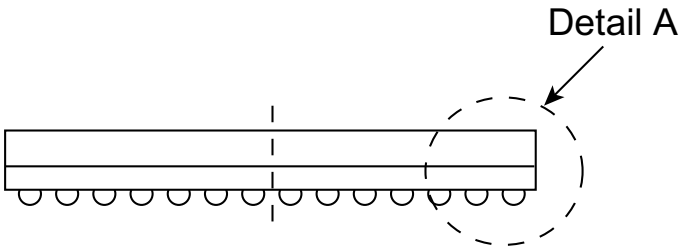
**Top View**



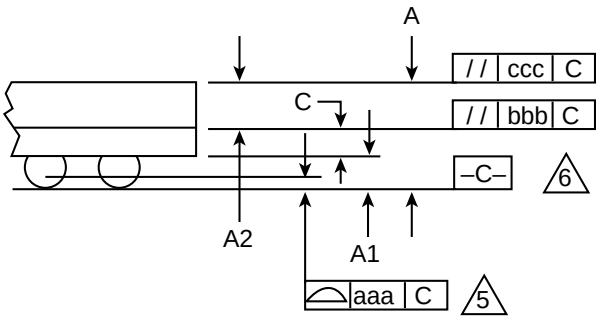

**Bottom View**



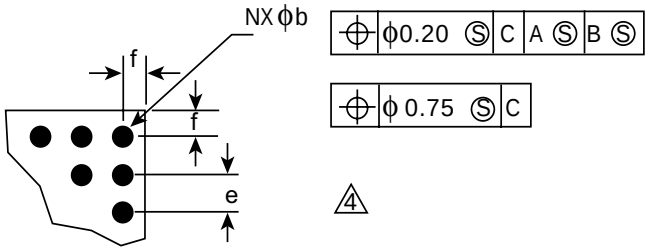
## Package Information *(continued)*




**Side View**




**Detail A**




**Detail B**

NOTES:

1. All dimensions are in millimeters.
2. 'e' represents the basic solder ball grid pitch.
3. 'M' represents the basic solder ball matrix size, and symbol 'N' is the maximum allowable number of balls after depopulating.
4. 'b' is measurable at the maximum solder ball diameter parallel to primary datum –C–.
5. Dimension 'ccc' is measured parallel to primary datum –C–.
6. Primary datum –C– and seating plane are defined by the spherical crowns of the solder balls.
7. Package surface shall be matte finish charmilles 24 to 27.
8. Package warp shall be 0.050 mm maximum.
9. Substrate material base is BT resin.
10. The overall package thickness 'A' already considers collapse balls.

| Dimensional References | | | |
|---|---|---|---|
| **REF.** | **MIN.** | **NOM.** | **MAX.** |
| A | 1.30 | 1.45 | 1.55 |
| A1 | 0.30 | 0.40 | 0.45 |
| A2 | 0.65 | 0.70 | 0.75 |
| D | 11.80 | 12.00 | 12.20 |
| D1 | | 10.40 BSC. | |
| D2 | 11.80 | 12.00 | 12.20 |
| E | 11.80 | 12.00 | 12.20 |
| E1 | | 10.40 BSC. | |
| E2 | 11.80 | 12.00 | 12.20 |
| b | 0.50 | 0.55 | 0.60 |
| c | | 0.35 | |
| aaa | | | 0.15 |
| bbb | | | 0.20 |
| ccc | | | 0.25 |
| e | 0.725 | 0.80 | 0.875 |
| f | 0.70 | 0.80 | 0.90 |
| M | | 14 | |
| N | | 180 | |

## Recommended Operating Conditions

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Positive Analog Power Supply (relative to GND) | VCC | 15.25 | 15.5 | 15.75 | V |
| Negative Analog Power Supply (relative to GND) | VEE | –4.75 | –4.5 | –4.25 | V |
| Total Analog Power Supply | VCC – VEE | 19.5 | 20 | 20.5 | V |
| Digital Power Supply (relative to GND) | VDD | 3.15 | 3.3 | 3.45 | V |
| Case Temperature | TC | 25 | | 65 | ˚C |

## Absolute Maximum Ratings

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Positive Power Supply | VCC | | | 20 | V |
| Negative Power Supply | VEE | –10 | | | V |
| Total Power Supply | VCC – VEE | 0 | | 21 | V |
| Digital Power Supply | VDD | GND – .5 | | VCC | V |
| Digital Inputs | | –.5 | | 7.0 | V |
| Analog Inputs | | VEE – .5 | | VCC + .5 | V |
| Analog MUX Breakdown Voltage | VI[H, L, HH, LH] – DV[L, H] | | | VCC – VEE | V |
| Current Capability of MUX | $I_{MUX}$ | –4.8 | | 4.8 | mA |
| External Force and Sense Switch Breakdown Voltage | E_FC_IN – FORCE<br>E_SN_IN – FORCE | | | VCC – VEE | V |
| Storage Temperature | | –55 | | +150 | ˚C |
| Junction Temperature | | –65 | | +150 | ˚C |
| Soldering Temperature | | | | 260 | ˚C |

Stresses above listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC Characteristics

### Power Supplies

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Power Supply Consumption (Note 1) | | | | | |
| Positive Supply | ICC | | | 30 | mA |
| Negative Supply | IEE | | | 30 | mA |
| Digital Supply (Quiescent) | IDD | | $I_{LOAD}$ | 1 | mA |
| Power Supply Rejection Ratio (Notes 2, 3) | PSRR | | | | |
| 1 MHz | | | –8.5 | | dB |
| 500 kHz | | | –14.5 | | dB |
| 100 kHz | | | –29 | | dB |

### Force Voltage

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Input Voltage Range @ VINP | VINP | VEE + 2 | | VCC – 1.75 | V |
| Input Bias Current | Ibias | –1 | 0 | 1 | µA |
| Output Forcing Voltage (positive full scale current through REXT) | FORCE | VEE + 2.25 | | VCC – 4.25 | V |
| Output Forcing Voltage (0 current through REXT) | FORCE | VEE + 2.25 | | VCC – 2.25 | V |
| Output Forcing Voltage (negative full scale current through REXT) | FORCE | VEE + 4.25 | | VCC – 2.25 | V |
| Voltage Accuracy | | | | | |
| Offset | Vos | –100 | | 100 | mV |
| Gain | | .985 | | 1.015 | |
| Linearity | | –0.025 | ±.01 | +0.025 | %FSR |

### Measure Current

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Current Measurement | | | | | |
| Measure Current Offset | $V_{OS}$ | –150 | | +150 | mV |
| Gain | | .985 | | 1.015 | |
| Linearity (measured at IVMON) | | | | | |
| FORCE = VEE + 4.25 to VCC – 5.25V | | –.05 | ±.01 | .05 | % FSR |
| FORCE = VCC – 5.25 to VCC – 4.25V | | –.08 | | .08 | % FSR |
| Common Mode Error (Note 5) | | | | 1.5 | mV/V |
| Common Mode Linearity | | –.05 | | .05 | %FSR |

## DC Characteristics *(continued)*

### Force Current

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Input Voltage Range @ IVIN | IVIN | VEE + 2 | | VCC – 13 | V |
| Input Bias Current | Ibias | –1 | 0 | 1 | µA |
| Output Forcing Current | FORCE | | | | |
| Range A | | –2 | | 2 | µA |
| Range B | | –20 | | 20 | µA |
| Range C | | –200 | | 200 | µA |
| Range D | | –2 | | 2 | mA |
| Current Accuracy (Note 4) | | | | | |
| Offset | $V_{OS}$ | –2.5 | | 2.5 | % FSR |
| Gain | | .985 | | 1.015 | |
| Linearity (measured at IVMON) | | | | | |
| FORCE = VEE + 4.25 to VCC – 5.25V | | –.05 | ±.01 | .05 | % FSR |
| FORCE = VCC – 5.25 to VCC – 4.25V | | –.08 | | .08 | % FSR |
| Common Mode Error (Note 5) | | | | 1.5 | mV/V |
| Common Mode Linearity | | –.05 | | .05 | %FSR |

### Measure Voltage

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Voltage Measurement | | | | | |
| Measure Voltage Offset | | –100 | | 100 | mV |
| Gain | | .985 | | 1.015 | |
| Linearity | | –.025 | ±.01 | .025 | %FSR |

### Digital Inputs (FV/FI*, MI/MV*, RS0, RS1, DISABLE, I_FCSEL, E_FCSEL, E_SNSEL, SV_SEL)

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Input Low Level | VIL | | | 0.8 | V |
| Input High Level | VIH | 2.0 | | | V |
| Input Bias Current @ 0V to VDD | IIN | –1 | 0 | 1 | µA |

## DC Characteristics *(continued)*

### External Force & Sense Switches

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| On-resistance – External Force Switches | $R_{ON\_FRC}$ | | 90 | 135 | Ω |
| On-resistance – External Sense Switches | $R_{ON\_SNS}$ | | 1000 | 1200 | Ω |
| HiZ (Switch Open) Leakage Current (Note 6) @ FORCE = –3 to +13V, FI Mode | ILEAK | –10 | | +10 | nA |
| Leakage Current at External Force Switch Input (Switch Open) | ILEAK | –10 | | +10 | nA |
| Usable Input Voltage Range | | VEE | | VCC | V |
| Capacitance of Force and Sense (Combined) (Note 6) | $C_{RFC\_SNS}$ | | | 8 | pF |
| Maximum Current for E_FC_IN | IFRC | –6 | | 6 | mA |

### Analog MUX

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Usable Input Voltage Range | | VEE | | VCC | V |
| On-resistance (Force) @ 500 µA | $R_{ON\_MUX}$ | | 600 | 1000 | Ω |
| Leakage Current | $I_{LEAK\_MUX}$ | | | 200 | nA |

### IVMON

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Leakage in DISABLED Mode @ IVMON = –2.2V to +13V | $I_{LEAK\_IVMON}$ | –100 | | +100 | nA |

## DC Characteristics *(continued)*

### Comparator

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| IVMAX Voltage Range | | VEE + 1.75 | | VCC – 1.75 | V |
| IVMIN Voltage Range | | VEE + 1.75 | | VCC – 1.75 | V |
| Comparator Offset (IVMIN, IVMAX) | | –100 | | +100 | mV |
| Input Bias Current at IVMIN, IVMAX | | –1 | | +1 | µA |

### Digital Outputs (DUTLTH, DUTGTL)

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Output Low Level @ $I_{OL}$ = 200 µA | VOL | | | 400 | mV |
| Output High Level @ $I_{OH}$ = 10 µA (Note 7) | VOH | 2.4 | | VDD | V |

Above DC Characteristic specifications are guaranteed under Recommended Operating Conditions unless otherwise noted.

Note 1: Under no load conditions.
Note 2: Guaranteed by design and characterization. Not production tested.
Note 3: PSRR is tested from VCC/VEE supplies to FORCE and IVMON outputs. Characterized in FV/MI and FI/MV modes.
Note 4: Includes effect of 1% resistor tolerance.
Note 5: The mV/V units shown are derived as follows: (Δoffset current * range resistance) / Δoutput force voltage.
Note 6: Test Conditions: E_FC_SEL = I_FC_SEL = 0; FV/FI* = 0, FORCE and SENSE tied together.
Note 7: Measured with 50 KΩ pull-up to VDD.

## AC Characteristics

### Force Voltage/Measure Current

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| FORCE Output Voltage Settling Time (Notes 1, 2) (To 0.1% of final value) for Cap. between COMP1 and COMP2 = 100 pF | | | | | |
| Range A | | | | 530 | µs |
| Ranges B, C, D | | | | 110 | µs |
| Measured Current Settling Time (Notes 1, 5) (To 0.1% of final value) for Cap. between COMP1 and COMP2 = 100 pF | | | | | |
| Range A | | | | 1.4 | ms |
| Ranges B, C, D | | | | 150 | µs |
| I/V Monitor | | | | | |
| DISABLE True to HiZ Propagation Delay | | | | 250 | ns |
| DISABLE False to Active Propagation Delay | | | | 200 | ns |

### Force Current/Measure Voltage

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| FORCE Output Current Settling Time (Notes 1, 6) (To 0.1% of final value) for Cap. between COMP1 and COMP2 = 100 pF | | | | | |
| Range A | | | | 2 | ms |
| Ranges B, C, D | | | | 250 | µs |
| SENSE (Measure) Voltage Settling Time (Notes 1, 7) (To 0.1% of final value) for Cap. between COMP1 and COMP2 = 100 pF | | | | | |
| Range A | | | | 1.75 | ms |
| Ranges B, C, D | | | | 225 | µs |
| I/V Monitor | | | | | |
| DISABLE True to HiZ Propagation Delay | | | | 250 | ns |
| DISABLE False to Active Propagation Delay | | | | 200 | ns |

## AC Characteristics *(continued)*

### Analog MUX

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Switch Propagation Delay (Note 4) | | | | 250 | ns |

### Comparator

| Parameter | Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Propagation Delay (Note 3) | | | | 25 | µs |

AC Test Conditions: COMP3 = 100 pF to Ground, COMP4 = 100 pF to RES_IN, Load at FORCE/SENSE combined output = 100 pF.

Note 1: Settling times are not production tested. Guaranteed by characterization.
Note 2: Measured from 2V step at VINP to FORCE output.
Note 3: Test Conditions: 50kΩ to +3.3V pullup used.
Note 4: Not production tested. Guaranteed by characterization. Test Conditions: $V_{IHH}$ = 13.5V, $V_{IH}$ = 7.5V, measured when SV_SEL is switched from low to high; measured at 90% of voltage difference of $V_{IHH} - V_{IH}$.
Note 5: Measured from 2V step at VINP to IVMON output.
Note 6: Measured from 2V step at IVIN to FORCE output.
Note 7: Measured from 2V step at IVIN to IVMON output.

## Ordering Information

| Model Number | Package |
|---|---|
| E4707ABG | 180 Lead 12 mm x 12 mm FlexBGA |
| EVM4707ABG | Edge4707 Evaluation Module |

## Contact Information

Semtech Corporation
High-Performance Division
10021 Willow Creek Rd., San Diego, CA 92131
Phone: (858)695-1808 FAX (858)695-2633

## Revision History

**Current Revision Date:** September 24, 2001
**Previous Revision Date:** July 16, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| all | | | *Change from "Target" to "Preliminary"*<br><br>*add:* Figure & table #'s |
| 1 | Features | –2V/+13V Output Range<br>(0V / +11V (at full scale current) | –2V to 13V Output Range (zero current)<br><br>*add:* 0V to 11V Output Range (Full Scale Current)<br><br>Update Functional Block Diagram |
| 6 | Control Inputs | | *Add:* para 1: new sentence at end<br><br>New 2nd paragraph<br><br>Combine tables |
| 7 | Circuit Description | | Sections: IVMON, Force Voltage Mode, Measure Current Mode, Force Current Mode - completely rewritten, tables revised<br><br>*Add:* Comparator Section |
| 9 | Circuit Description | Analog MUX, 1st para, last sentence:<br>... voltages of the Edge710 ... | Switch Operation on Force and Sense Lines - Whole section rewritten<br><br>Analog MUX, 1st para, last sentence:<br>... voltages of the Edge720 ... |
| 11, 12 | Application Information | | Updated Figure<br><br>*Add:* Application Information Sections |
| 16 | Recommended Operating Conditions | Total Analog Power Supply, Min: 18 | Total Analog Power Supply, Min: 19.5 |
| 17 | Force Voltage | | *Delete:* Input Voltage Range to Achieve Full Scale Voltage<br><br>*Add:* Input Voltage Range @ VINP |
| 17 | Measure Current | VEE + 4.25 to VCC – 5.25V<br>VCC – 5.24 to VCC – 4.25V<br><br>Common Mode Error, Max: 1.8 | FORCE = VEE + 4.25 to VCC – 5.25V<br>FORCE = VCC – 5.24 to VCC – 4.25V<br><br>Common Mode Error, Max: 1.5<br><br>*Add:* Common Mode Linearity |
| 18 | Force Current | | *Add: Add:* Input Voltage Range @ IVIN |
| 19 | Force Current | Offset, Min: –5, Max: 5<br><br>VEE + 4.25 to VCC – 5.25V<br>VCC – 5.24 to VCC – 4.25V<br><br>Common Mode Error, Max: +1.8 | *Delete:* Input Voltage Range to Achieve Full Scale Current<br><br>Offset, Min: –2.5, Max: 2.5<br><br>FORCE = VEE + 4.25 to VCC – 5.25V<br>FORCE = VCC – 5.24 to VCC – 4.25V<br><br>Common Mode Error, Max: 1.5<br><br>*Add:* Common Mode Linearity |
| 21 | Comparator | IVMAX Voltage Range & IVMIN Voltage Range,<br>Min: –2.5, Max: +13.5 | IVMAX Voltage Range & IVMIN Voltage Range,<br>Min: VEE + 1.75, VCC – 1.75<br><br>*Delete:* Minimum Overdrive Requirement<br><br>New Note 3.<br><br>*Delete:* Note 8 |
| 22 | Force Current/Measure Voltage *and* Force Voltage/Measure Current | | *Delete:* for Cap. between COMP1 and COMP2 = 600 pF lines under FORCE and SENSE |
| 22 | AC Test Conditions | ... 100 pF to Ground ... | ... 100 pF to RES_IN ... |
| 23 | Ordering Information | | *Delete:* Die information |

## Revision History

**Current Revision Date:** July 16, 2001
**Previous Revision Date:** June 27, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 14 | Force Voltage | Input Voltage Range to Achieve Full Scale Voltage Min: –2.3, Max: 13.3<br><br>Output Forcing Voltage (positive full scale current through REXT), Min: VEE + 2.5, Max: VCC – 4.5<br><br>Output Forcing Voltage (0 current through REXT) Min: VEE + 2.5, Max: VCC – 2.5<br><br>Output Forcing Voltage (negative full scale current through REXT), Min: VEE + 4.5, Max: VCC – 2.5 | Input Voltage Range to Achieve Full Scale Voltage Min: VEE + 1.95, VCC – 1.95<br><br>Output Forcing Voltage (positive full scale current through REXT), Min: VEE + 2.25, Max: VCC – 4.25<br><br>Output Forcing Voltage (0 current through REXT) Min: VEE + 2.25, Max: VCC – 2.25<br><br>Output Forcing Voltage (negative full scale current through REXT), Min: VEE + 4.25 Max: VCC – 2.25 |
| 14 | Measure Current | Linearity<br><br>Common Mode Error, Max: 1.5 | Break into 2 separate lines<br><br>Common Mode Error, Max: +2.2 |
| 15 | Force Current | Linearity<br><br>Common Mode Error, Max: 1.5 | Break into 2 separate lines<br><br>Common Mode Error, Max: +2.2 |
| 16 | External Force & Sense Switches | On-resistance - External Force Switches, Max: 120 | On-resistance - External Force Switches, Max: 135 |

**Current Revision Date:** June 27
**Previous Revision Date:** May 9, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 9 | Short Circuit Protection | … the presence of a large external resistor (normally 1 KΩ to 1 MΩ) in the FORCE and SENSE path. | .. the presence of an external current sense resistor (normally 1 KΩ to 1 MΩ) in the FORCE path. |
| 13 | Ab Max Ratings | | *Add:* Current Capability of MUX (moved from DC Char section) |
| 16 | Analog MUX | On-resistance (Force) @ 50 µA | On-resistance (Force) @ 500 µA<br><br>*Move:* Current Capability of MUX to Ab Max Ratings Table |

**Current Revision Date:** May 9, 2001
**Previous Revision Date:** May 4, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 17 | Comparator | | *Add:* Comparator Offset (IVMIN, IVMAX) |
| 17 | DC Char Notes | Note 8: Actually production tested … | Note 8: Production tested … |

## Revision History

**Current Revision Date:** May 4, 2001
**Previous Revision Date:** April 27, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 7 | I/V Monitor Table | Forced Voltage | Measured Voltage |
| 14 | Power Supplies | "Digital" Supply, Sym: IDDQ, Max 1 (no load) | Digital Supply (Quiescent), Sym: IDD, remove (no load) |
| 14 | Force Voltage | Iput Voltage Range, Min: –2.31, Max: 13.31 | Input Voltage Range, Min: –2.3, Max: 13.3 |
| 16 | External Force & Sense Switches | | *Add:* Leakage Current at External Force Switch Input (Switch Open) |
| 17 | DC Char Notes | Note 5: ... Δoutput voltage | Note 5: ... Δoutput force voltage |

**Current Revision Date:** April 27, 2001
**Previous Revision Date:** April 24, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 14 | Force Voltage | Input Forcing Voltage, Min: –2.2, Max: 13.2<br><br>Output Forcing Voltage (2 mA current...)<br>Output Forcing Voltage (–2 mA current ...) | Input Forcing Voltage, Min: –2.31, Max: 13.31<br><br>Output Forcing Voltage (positive full scale current...)<br>Output Forcing Voltage (negative full scale current ...)<br><br>*Remove:* Maximum Current for E_FC_IN (move to External Force & Senses Switches table) |
| 14 | Measure Current | Common Mode Error | Common Mode Error (Note 5) |
| 17 | Comparator | | *Add:* Input Bias Current at IVMIN, IVMAX |

**Current Revision Date:** April 24, 2001
**Previous Revision Date:** April 16, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 1 | Features | FV/FI Capability | FV/MI Capability |
| 11, 12 | Package Information | | New Figures and Notes |
| 18 | Force/Voltage Measure Current | | *New:* FORCE and SENSE Outputs information |
| 18 | Force Current/Measure Voltage | | *New:* FORCE Output Information |
| 19 | AC Characteristics | AC Test Conditions: COMP4 = OPEN | COMP4 = 100 pF to Ground |

## Revision History

**Current Revision Date:** April 16, 2001
**Previous Revision Date:** April 11, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 1 | Features | | *Remove:* 16 Bit Voltage Resolution<br>*Add:* FV linearity to ±.025% FSR |
| 13 | Recommended Operating Conditions | Positive Analog Power Supply<br>Negative Analog Power Supply<br>Digital Power Supply<br><br>Case Temperature, Min: TBD, Max: TBD | Positive Analog Power Supply (relative to Ground)<br>Negative Analog Power Supply (relative to Ground)<br>Digital Power Supply (relative to Ground)<br><br>Case Temperature, Min: 25, Max: 65<br><br>*Remove:* Junction Temperature |
| 13 | Absolute Max Ratings | Digital Power Supply, Min: TBD, Max: 20<br>Analog Inputs, Min: TBD, Max: TBD | Digital Power Supply, Min: GND – .5, Max: VCC<br>Analog Inputs, Min: VEE – .5, VCC + .5 |
| 14 | Power Supplies | Positive Supply, Max: 50<br>Negative Supply, Max: 50<br>Digital Supply, Sym: IDD, Max: TBD | Positive Supply, Max: 30<br>Negative Supply, Max: 30<br>Digital Supply, Sym: IDDQ, Max: 1 (no load) |
| 16 | Force & Sense Switches | On-resistance (Force), Max: no value<br>On-resistance (Sense), Max: no value | On-resistance - External Force Switches, Max: 120<br>On-resistance - External Sense Switches, Max: 1200 |
| 16 | Analog MUX | On-resistance (Force) @ 500 µA | On-resistance (Force) @ 50 µA |
| 17 | DC Characteristics Notes | | New DC Test Conditions note.<br><br>Note 6: add "FORCE and SENSE tied together". |
| 18 | Force/Voltage Measure Current | | *New:* FORCE and SENSE Outputs information<br><br>Delete: Comparators |
| 18 | Force Current/Measure Voltage | | *New:* FORCE Output Information<br><br>*Add:* Sense Measure Voltage information |
| 19 | AC Characteristics Notes | … load at FORCE/SENSE combined output = 10 pF. | *Remove:* Capacitor between COMP1 and COMP2 = 100 pF<br><br>… load to FORCE/SENSE combined output = 100 pF.<br><br>*Remove:* Note 2, renumber<br><br>*Add:* Notes 5, 6, 7 |

**Current Revision Date:** April 1, 2001
**Previous Revision Date:** April 4, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 14 | DC Characteristics Measure Current | Linearity, Min: –.025, Typ: ±.01, Max: +.025 | Linearity, Min: –.05, Typ: , Max: .05 |
| 15 | DC Characteristics Force Current | Linearity, Min: –.025, Max: +.025 | Linearity, Min: –.05, Max: .05 |
| 16 | DC Characteristics Analog MUX | | *Add:* Output Voltage @ ±50 µA Loafd |
| 17 | DC Characteristics Comparator | Minimum Overdrive Requirement, Max: 10 | Minimum Overdrive Requirement, Max: 2<br><br>*Add:* Note 8 |

## Revision History

**Current Revision Date:** April 4, 2001
**Previous Revision Date:** March 21, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 14 | DC Characteristics Power Supplies | | Add new Note 1 - renumber all notes. |
| 14 | DC Characteristics Force Voltage | Input Voltage Range, Min: 2.0, Max: 13 | Input Voltage Range to Achieve Full Scale Voltage, Min: –2.2, Max: 13.2 |
| 15 | DC Characteristics Force Current | Input Voltage Range | Input Voltage Range to Achieve Full Scale Current |
| 15 | DC Characteristics Measure Voltage | | *delete:* Minimum Overdrive Requirement |
| 15 | DC Characteristics Digital Inptus | Input High Level, Min: 2.4 | Input High Level, Min: 2.0 |
| 16 | DC Characteristics Force & Sense Switches | | *Add:* Usable Input Voltage Range |
| 16 | DC Characteristics Analog MUX | On resistance (Force), Max: no value | On resistance (Force) @ 500 µA, Max: 1000<br>*Add:* Current Capability of MUX |
| 17 | DC Characteristics Digital Outputs | Output High Level, Max: 3.3 | Output High Level, Max: VDD<br>New Notes 1, 3, renumber all other notes |
| 19 | AC Char Notes | | Delete: Notes 4, 5 |

**Current Revision Date:** March 21, 2001
**Previous Revision Date:** March 16, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 14 | Force Voltage | Input Voltage Range, Min: –1.5 | Input Voltage Range, Min: –2.0 |

# Revision History

**Current Revision Date:** March 16, 2001
**Previous Revision Date:** March 9, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 1 | Description | 2nd para: ... measure voltage over a 16V I/O ... | 2nd para: ... measure voltage over a 15V I/O ... |
| 1 | Features | –1.5V/+13V Output Range | –2.0V/+13V Output Range |
| 6 | Circuit Overview | 2nd para: ... measure voltage over a 14.5V range ... | 2nd para: ... measure voltage over a 15V range ... |
| 6 | PPMU Functionality | | New diagram |
| 14 | Force Voltage | Output Forcing Voltage (2 mA), Min: VEE + 3<br>Output Forcing Voltage (0 current), Min: VEE + 3 | Output Forcing Voltage (2 mA), Min: VEE + 2.5<br>Output Forcing Voltage (0 current), Min: VEE + 2.5 |
| 15 | Force Current | Current Accuracy<br>Offset, MIn: –0.05, Max: +0.05 | Current Accuracy (Note 5)<br>Offset, MIn: –5, Max: +5 |
| 16 | Force & Sense Switches | HiZ (Switch Open) Leakage Current (Note 3)<br>@ FORCE = –3 to +13V<br>Min: –15, Max: +15 | HiZ (Switch Open) Leakage Current (Note 3)<br>@ FORCE = –3 to +13V, FI Mode<br>Min: –10, Max: +10 |
| 17 | Digital Outputs | Output High Level @ IOH = 20 µA | Output High Level @ IOH = 10 µA |
| 17 | DC Char Notes | | Add Note 5 |
| 18 | Force/Voltage Measurement Current | Output Voltage Settling Time (Note 2)<br><br>DISABLE True to HiZ, Max: 40<br>DISABLE False to Active, Max: 40 | Output Voltage Settling Time (Notes 1, 2)<br><br>DISABLE True to HiZ, Max: 250<br>DISABLE False to Active, Max: 200 |
| 18 | Force Current/Measure Voltage | DISABLE True to HiZ, Max: 40<br>DISABLE False to Active, Max: 40 | DISABLE True to HiZ, Max: 250<br>DISABLE False to Active, Max: 200 |
| 18 | Analog MUX | | Add Analog MUX Table |
| 19 | AC Char Notes | | Add Note 6. |

# Revision History

**Current Revision Date:** March 9, 2001
**Previous Revision Date:** March 1, 2001

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 1 | Features | MI/MV Capability<br>+13V/–3V I/O Range<br>16 Bit Voltage | FI/MV Capability<br>–1.5V/+13V Output Range<br>16 Bit Voltage Resolution |
| 2 | Pin Description | E_SN_IN: Analog input for external SENSE | E_SN_IN: Analog Output for external SENSE |
| 3 | Pin Description | COMP1, COMP2<br>... capacitor connector between ...<br><br>COMP3[0:3]<br>COMP4[0:3] | COMP1, COMP2<br>... capacitor connected between ...<br><br>separate COMP3 and COMP4 (add description for 4)<br>change description for COMP3 to<br>... external capacitor connected between ... |
| 4, 5 | Pin Description | 12 x 12 180 FLEXBGA | 12 mm x 12 mm 180 FLEXBGA |
| 6 | Circuit Description | Circuit Overview<br>2nd para: ... over an 16V range ...<br><br>3rd para: ... two bit error resolution.<br><br>PPMU Functionality<br><br>Control Inputs | Circuit Overview<br>2nd para: ... over an 14.5V range ...<br><br>3rd para: ... two bit output range classification.<br><br>New Figure<br><br>New paragraph 1. |
| 7 | Circuit Description | Force Voltage<br>... FV mode, VINP ...<br><br>Measure Current<br><br><br>Force Current<br><br>Table: VINP<br>Threshold: > Imax (full scale) <Imin (full scale) | Force Voltage<br>... FV mode (FV/FI* = 1), VINP ...<br><br>Move 3rd paragraph before current 2nd paragraph.<br><br>*Add:* ... to the DUT to last sentence of new para 3.<br><br>*Add:* ... to the DUT to last sentence of 1st para.<br><br>Table: IVIN<br>Threshold: Imax (full scale, Imin (full scale) |
| 9 | Circuit Description | Short Circuit Protection<br>... (normally 1 MΩ) ... | Short Circuit Protection<br>... (normally 1 KΩ to 1 MΩ) ... |
| 10 | Application Information | | Revised figure. |
| 13 | Ab Max Ratings | | *Add:* Analog Inputs |
| 14 | Force Voltage | Input Voltage Range, Min: VEE + 4.5, Max: VCC – 4.5<br><br>Output Forcing Voltage (2 mA current...)<br>Min: VEE + 4.5<br><br><br>Gain, Units: %<br><br>Linearity, Min: –0.25, Max: +.025<br><br>Maximum Current for E_FC_IN, MIn: no value | Input Voltage Range, Min: –1.5, Max: 13<br><br>Output Forcing Voltage (2 mA current...)<br>Min: VEE + 3<br><br>*Add:* Output Forcing Voltage (–2 mA current ...)<br><br>Gain, Units: remove %<br><br>Linearity, Min: –0.025, Max: +0.025<br><br>Maximum Current for E_FC_IN, Min: –6 |
| 14 | Measure Current | Gain, Units: % | Gain, Units: remove % |
| 15 | Force Current | Input Voltage Range, Min: VEE + 1.5, Max: VCC – 3.5<br><br>Gain, Units: % | Input Voltage Range, Min: –2.2, Max: +2.2<br><br>Gain, Units: remove % |
| 15 | Digital Inputs | Input Bias Current | Input Bias Current @ 0V to VDD |
| 16 | Analog MUX | On-resistance, Typ: TBD<br><br>Leakage Current, Max: TBD | On-resistance, Typ: 600<br><br>Leakage Current, Max: 200 |
| 17 | Digital Outputs | Output High Level<br>@ IOH = TBD | Output High Level<br>@ IOH = 20 µA (Note 4) |
| 17 | DC Characteristics | | *Add:* DC Test Conditions and Note 4 |
| 18 | Force Voltage/<br>Measurement Current | Output Voltage Settling Time<br><br>Propagation Delay, Max: 20 | Output Voltage Settling Time (Note 2)<br><br>Propagation Delay, Max: 25 |

# Revision History

**Current Revision Date:** March 1, 2001
**Previous Revision Date:** August 16, 2000

| Page # | Section Name | Previous Revision | Current Revision |
|---|---|---|---|
| 6 | Circuit Description | | Revised PPMU Functionality drawing |
| 13 | Recommended Operating Conditions | Positive Analog Power Supply<br>Min: 14.5, Max: 16.5<br><br>Negative Analog Power Supply<br>Min: –4, Max: –5.5<br><br>Total Analog Power Supply<br>Max: 22<br><br>Digital Power Supply<br>Min: , Max: | Positive Analog Power Supply<br>Min: 15.25, Max: 15.75<br><br>Negative Analog Power Supply<br>Min: –4.75, Max: –4.25<br><br>Total Analog Power Supply<br>Max: 20.5<br><br>Digital Power Supply<br>Min: 3.15 , Max: 3.45<br><br>*Add:* Case Temperature |
| 13 | Absolute Max Ratings | Total Power Supply, Max: 27.5 | Total Power Supply, Max: 21<br><br>*Add:* Analog MUX Breakdown Voltage<br><br>*Add:* External Force & Sense Switch Breakdown Voltage |
| 14 | Force Voltage Table | Gain: Min: TBD, Max: TBD | Gain: Min: .985, Max: 1.015<br><br>*Delete:* HiZ (Switch Open) Leakage Current |
| 14 | Measure Current Table | | *Add:* Gain |
| 15 | Force Current Table | Gain: Min: –2.5, Max: +2.5 | Gain: Min: .985, Max: 1.015<br><br>*Add:* Offset |
| 15 | Measure Voltage Table | Gain: Min: TBD, Max: TBD | Gain: Min: .985, Max: 1.015 |
| 16 | Force & Sense Switches Table | | *Delete:* Breakdown Voltage |
| 16 | Analog MUX Table | | *Add:* Usable Input Voltage Range<br><br>*Add:* HiZ (Switch Open) Leakage Current<br><br>*Delete:* Breakdown Voltage |
| 16 | IVMON | | *Add:* IVMON Table |
| 17 | Digital Outputs Table<br><br><br><br><br><br>Comparator Table | Table previously in AC Characteristics Section<br><br>Output Low Level (no load)<br><br>Output High Level (no load) | <br><br>Output Low Level @ $I_{OL}$ = 200 µA<br><br>Output High Level @ $I_{OH}$ = TBD<br><br>*Add:* Comparator Table<br><br>Relocate all DC Char notes to this page. |
| 18 | Force Voltage/ Measurement Current Table | Propagation Delay | Propagation Delay (Note 3)<br><br>*Add:* Note 3<br><br>Combine all AC Char notes. |