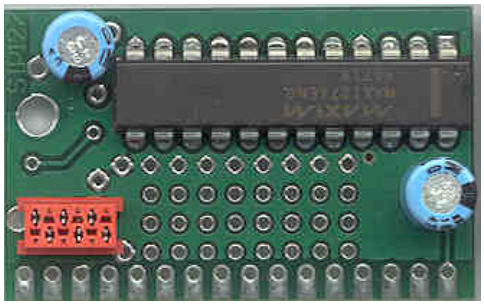
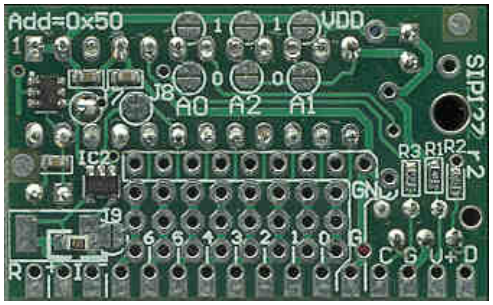
12 Bit ADC Module with +/-10V Range

December 13, 2012

Introduction

The SIP127 module is an 8 channel, 12 bit ADC module based on the Maxim MAX127 or MAX128 ADC chip.





The MAX127/8 have several unique features that are not available in other ADC chips and make them ideal for instrumentation and test systems.

- 0-5V, ±5V, 0-10V, ±10V Input ranges from a 5V supply.
- ±16.5V Overvoltage-Tolerant Input Multiplexer
- DIP package for easy field replacement
- precision internal reference, or external reference
- 8 ADC channels

The SIP127 module is a small easy to use module:

- MAX127 (standard) or MAX128 (optional) can be fitted
- Small Prototype area to fit resistor dividers, RC input filter etc
- High-side current sensor with on-board or external shunt for measuring power supply currents and voltages
- Optional high precision external reference chip
- Up to 8 boards per I2C bus

Contents

1 MAX127 vs Max128 **3**
- 1.1 Input Multiplexor . . . 4
- 1.2 Unselected Channels . . . 5
- 1.3 3.3V Operation . . . 5

2 I2C Communications **5**
- 2.1 Control Register Tables . . . 6

3 Current Sensor Max4372 **7**
- 3.1 On-board Sense Resistor . . . 7
- 3.2 Measuring the ISENSE Voltage . . . 7
- 3.3 MAX4372 Versions . . . 7

4 Prototyping Area: Dividers and Filters **8**

5 Voltage Reference **8**
- 5.1 Using Internal Reference Output . . . 8
- 5.2 Using External Reference Input . . . 8
- 5.3 Using VDD as reference . . . 9

6 MAX6033 Optional Precision Reference **9**
- 6.1 Fitting the MAX6033 . . . 9

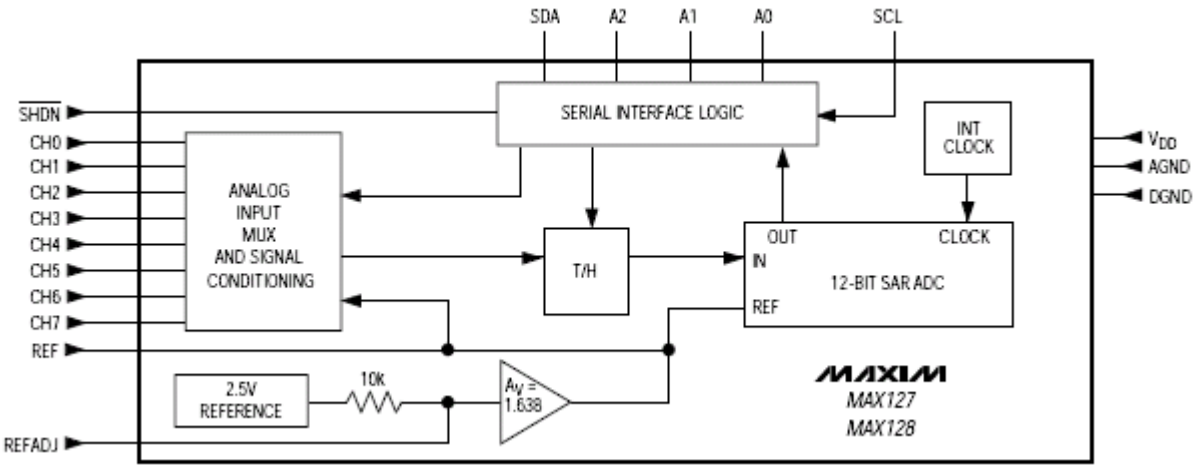
7 Jumpers **10**

8 Edge Connector **10**

9 Drawings **10**
- 9.1 Circuit Diagram . . . 11
- 9.2 PCB Drawings . . . 12

10 Revision History **13**

1 MAX127 vs Max128

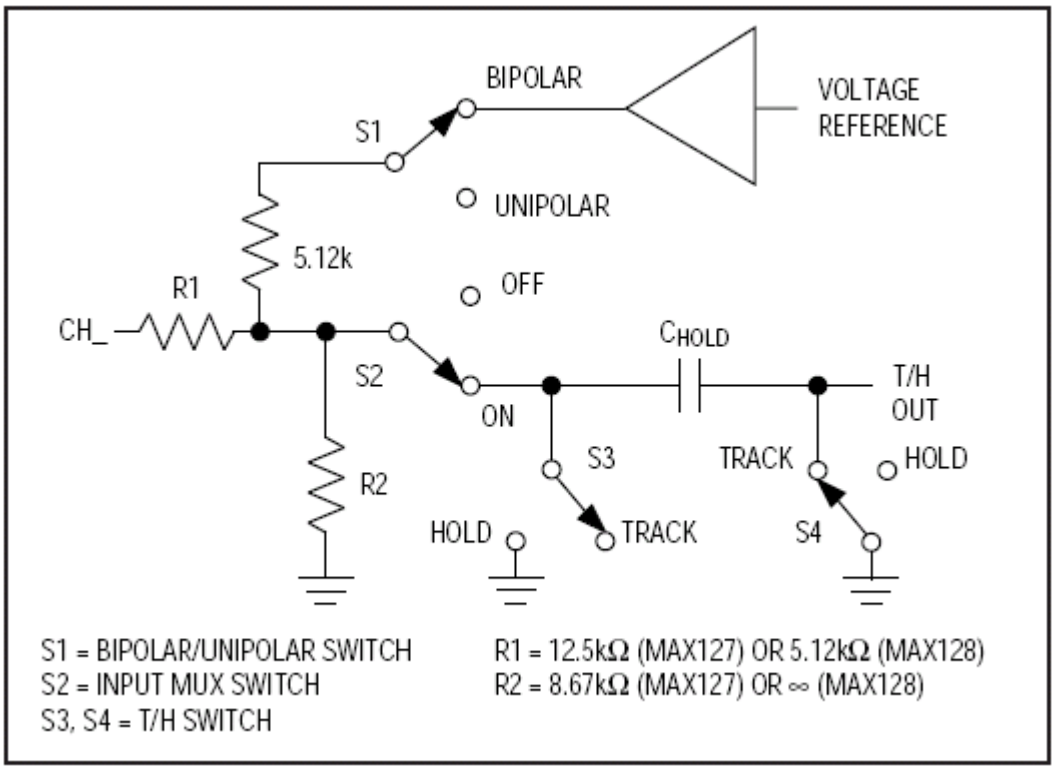


These two IC's are almost identical. They differ only in the input voltage range and divider arrangement. They both have the same effective VRef to the ADC of 4.096V.

The MAX127 has scaled input divide ratios at the input that gives exact 0-5,+/-5,0-10,+-10V input ranges. When using an external reference, full scale is (5/4.096)*VRef, ie VREF x 1.2207. Note that the MAX127 will measure 0-5V, even when its supply voltage is 4.75V. MAX127 is ideal for measuring voltage sources.

The MAX128 is for low input voltages. has simple x1 input to give 0-VRef/2, +/-VRef/2, 0-VRef, +/-VRef ranges. (Internal VRef is 4.096V). A consequence of this is that the 0-5V range has a high input impedance on the MAX128, but not on the MAX127. MAX128 is ideal for measuring ratiometric sources such as potentiometers.

1.1 Input Multiplexor



If you want to measure lower voltages with the external 2.5V reference, then the MAX128 is a better choice.

	VRef	RB=00	RB=10	RB=01	RB=11	
MAX127	Int	0-5	0-10	+/-5	+/-10	
MAX127	Ext 2.5V	0-3.052	0-6.104	+/-3.052	+/-6.104	
MAX128	Int	0-2.048	0-4.096	+/-2.048	+/-4.096	
MAX128	Ext 2.5V	0-1.25	0-2.5	+/-1.25	+/-2.5	

If you are using input dividers or high impedance sources then study the input circuit carefully. The input resistance is different in unipolar or bipolar mode

	Unipolar	Bipolar	
MAX127	21.17k	15.72k	
MAX128	open	10.24k	

In bipolar input mode, the input current is not flowing to ground, but to a +ve reference depending on range.

	VRef	Range=0	Range=1
MAX127	Int 4.096	1.25V	2.5V
MAX127	Ext	VRef/2.44	VRef/1.2207
MAX128	Int 4.096	2.048	4.096
MAX128	Ext	VRef/2	VRef

1.2 Unselected Channels

The multiplexor arrangement does not appear to be specified by Maxim.

Current continues to flow input unselected inputs, they appear to have similar input resistance to selected channels, connected to some +ve voltage.

1.3 3.3V Operation

While rated for 5V operation, the ADC appears to run correctly on 3.3V. However the internal reference shuts down, and an external VREF must be supplied.

2 I2C Communications

Make sure you are using a 5V supply. On 3.3V, the internal reference shuts down, and you will get invalid data. The ADC appears to operate normally on 3.3V with external reference.

The base address is 0x50. 8 sub-addresses are available through J1-6. Note that the order of A0,A2,A1 is correct.

Realterm (V2.0.0.65+) has controls for reading the MAX127/8 on the I2C-2 tab. (Be sure to set the address on the I2C tab)

The MAX127/8 is very easy to use. The control register is written to select the channel,range,power, and initiate a read cycle, then the 2 byte result is read. To read Channel 0, 0-5V range:

```
S5080PR02P
```

Data is Big Endian. In unipolar input mode, the output is straight binary. For bipolar input mode, the output is two's complement. To select a different range change "80" in the string above.

No separate initialisation command is required.

To convert ADC counts to actual voltage:

	VRef	RB=00	RB=10	RB=01	RB=11
MAX127	4.096	0-5	0-10	+/-5	+/-10
V=ADC*		5/65536	10/65536	+/- 5/32768	+/- 10/32768
MAX128	4.096	0-2.048	0-4.096	+/-2.048	+/-4.096
V=ADC*		2.048/65536	4.096/65536	+/- 2.048/32768	+/- 4.096/32768

,

2.1 Control Register Tables

Multirange, +5V, 12-Bit DAS with 2-Wire Serial Interface

Table 1. Control-Byte Format

BIT 7 (MSB)	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0 (LSB)
START	SEL2	SEL1	SEL0	RNG	BIP	PD1	PD0

BIT	NAME	DESCRIPTION
7 (MSB)	START	The logic "1" received after acknowledge of a write bit (R/$\overline{W}$ = 0) defines the beginning of the control byte.
6, 5, 4	SEL2, SEL1, SEL0	These three bits select the desired "ON" channel **(Table 2)**.
3	RNG	Selects the full-scale input voltage range **(Table 3)**.
2	BIP	Selects unipolar or bipolar conversion mode **(Table 3)**.
1, 0 (LSB)	PD1, PD0	These two bits select the power-down modes **(Table 4)**.

Table 2. Channel Selection

SEL2	SEL1	SEL0	CHANNEL
0	0	0	CH0
0	0	1	CH1
0	1	0	CH2
0	1	1	CH3
1	0	0	CH4
1	0	1	CH5
1	1	0	CH6
1	1	1	CH7

Table 4. Power-Down and Clock Selection

PD1	PD0	MODE
0	X	Normal Operation (always on)
1	0	Standby Power-Down Mode (STBYPD)
1	1	Full Power-Down Mode (FULLPD)

Table 3. Range and Polarity Selection

INPUT RANGE (V)	RNG	BIP	NEGATIVE FULL SCALE (V)	ZERO SCALE (V)	FULL SCALE (V)
MAX127					
0 to 5	0	0	–	0	V_{REF} x 1.2207
0 to 10	1	0	–	0	V_{REF} x 2.4414
±5	0	1	-V_{REF} x 1.2207	0	V_{REF} x 1.2207
±10	1	1	-V_{REF} x 2.4414	0	V_{REF} x 2.4414
MAX128					
0 to V_{REF}/2	0	0	–	0	V_{REF}/2
0 to V_{REF}	1	0	–	0	V_{REF}
±V_{REF}/2	0	1	-V_{REF}/2	0	V_{REF}/2
±V_{REF}	1	1	-V_{REF}	0	V_{REF}

3 Current Sensor Max4372

The MAX4372T high side current sensor is connected to *ADC6*. If you want to use this as an ADC input, then cut J8. ADC6 is the current measurement channel

- 0-28V common mode range
- Maximum Vout = VSense-0.25V
- Standard is 0.1ohm shunt and MAX4372T

3.1 On-board Sense Resistor

From the factory the SIP127 comes with an 0805, 0.1ohm current sense resistor and the 20V/V MAX4372T.

This gives 2V/A sensitivity at the ADC, or 610uA per count resolution.

Max continuous current is 1A.

The small 0805 sense resistor can be replaced with a larger 3210 resistor on the PCB. For very high currents, the internal sense resistor can be removed, and an external shunt used instead.

3.2 Measuring the ISENSE Voltage

J9 connects ADC7 to ISENSE_OUT. The sensed voltage must be within the 0-10V working range of the MAX127. J9 is normally open and must be connected. ADC7 is to measure the supply voltage to the device connected to ISenseOut. ADC6 is measuring the current drawn by that device.

If the sensed voltage is greater than 10V, then you can fit a resistor divider in the prototype area.

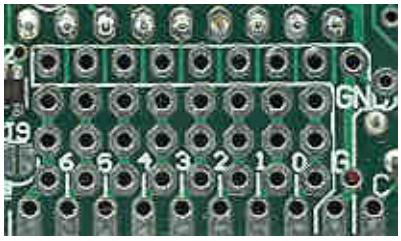
3.3 MAX4372 Versions

There are 3 gain variants of the MAX4372 available

Version	Gain	Marking	V@0.1ohm	
MAX4372T	20V/V	ADIU	2V/A	
MAX4372F	50V/V	ADIV	5V/A	
MAX4372H	100V/V	ADIW	10V/A	

4 Prototyping Area: Dividers and Filters

There is small prototyping area. You can use this for input dividers or RC or LC filters. The pads closest to IC1 are ground pads.



When using resistor dividers or series resistors on the input, pay careful attention to the input resistance of the MAX127/8. It is not a high impedance input (except MAX128 on 0-Vref range). The input resistance changes with the range selected.

As the internal resistors are precise, they can form part of a voltage divider, so only a series resistor is needed in many cases. The voltage at the input must remain within the +/-16.5V multiplexor limits on unselected channels, so see the input circuit notes above.

Optional Zener

You can fit Z1 the optional 6.2V protection zener where there is a chance of reversed or over voltage supply to the I2C bus, or where destructive voltages might get applied to the ADC inputs. In some cases it will prevent or limit damage spreading through the system

5 Voltage Reference

The MAX127/128 has an internal precision 4.096V reference, with low drift (<30ppm/ºC). The reference connection can be an input to the MAX127/8 or an output from it. *Make sure you are using a 5V supply. On 3.3V, the internal reference shuts down, and you will get invalid data. The ADC appears to operate normally on 3.3V with an External Reference.*

5.1 Using Internal Reference Output

The internal reference is available. C7 may be fitted if you need a lower dynamic output impedance. The DC load is specified as a minimum 10kΩ / 400µA

5.2 Using External Reference Input

Link J7 to disable the internal reference.

To use it as an input, J7 is closed. By default it is an output of 4.096V

At REF and REFADJ, the input impedance is a minimum of 10k for DC currents. During conversions, an external reference at REF must be able to drive a 400µA DC load, and must have an output

impedance of 10kΩ or less. If the reference has higher input impedance or is noisy, bypass REF with a 4.7µF capacitor to AGND as close to the chip as possible. With an external reference voltage of less than 4.096V at REF or less than 2.5V at REFADJ, the increase in RMS noise to the LSB value (full-scale voltage/4096) results in performance degradation and loss of effective bits.

5.3 Using VDD as reference

- Link J7 (disable internal reference)
- Join VDD to Vref: Link IC4 pin 4 to pin 5. (IC4 is adjacent to J77)

6 MAX6033 Optional Precision Reference

The module has provision for an optional MAX6033 precision reference. Compared to the built in reference it offers:

- Superior calibration accuracy of 0.04%
- better temperature stability of 7ppm/°C

With a 5V supply you can use the following variants:

	Suffix	Vout
	-25	2.5V
	-30	3.0V
	-41	4.096

6.1 Fitting the MAX6033

To use the external reference, fit IC4 (note the dot for pin 1), and link J7 to disable the internal reference of the MAX127/8

Note that J7 must be linked if IC4 is fitted. If you need to revert to the internal reference when IC4 is fitted, you will have to cut the pcb track connecting IC4,5 to IC1,23

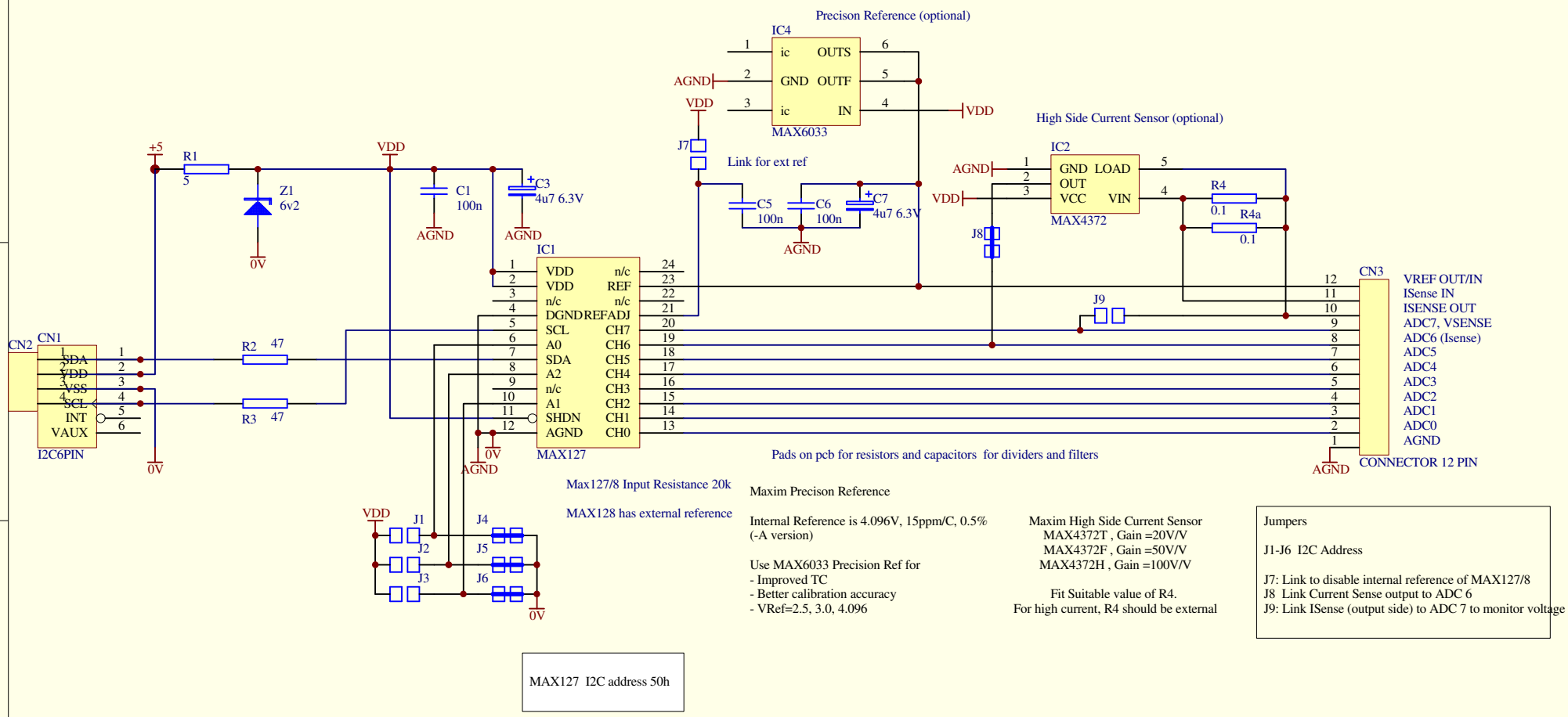
7 Jumpers

J#	Function	default	
J1-6	I2C Sub Address	joined to 0	
J7	Disable Internal Ref	open	
J8	Current sense to ADC6	closed	
J9	ISENSE_OUT to ADC7	open	

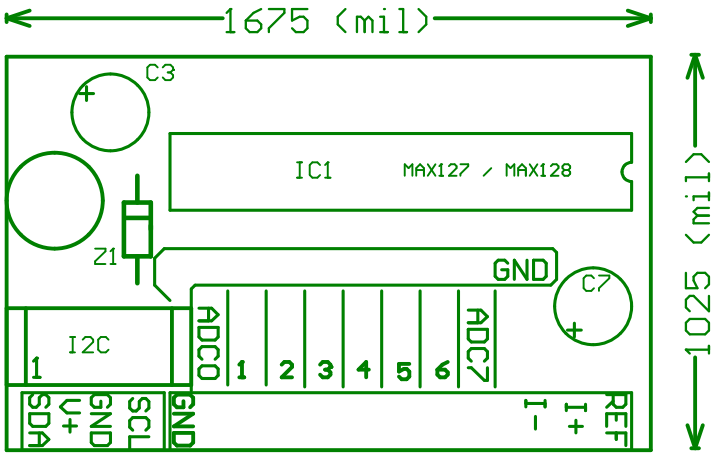
8 Edge Connector

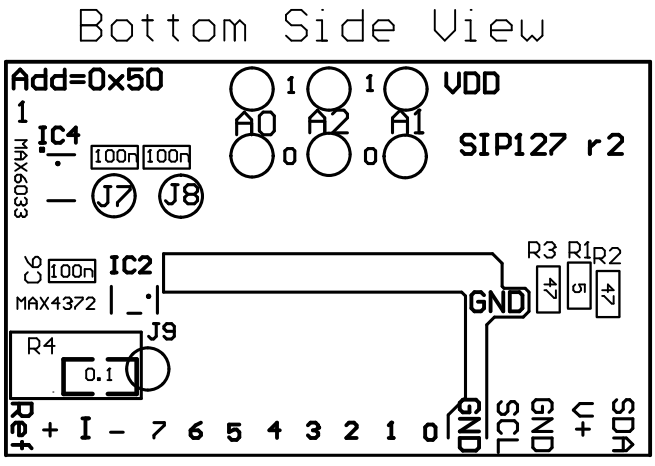
Pin	Function	
1	SDA	
2	+5	
3	GND	
4	SCL	
5	AGND	
6	ADC0	
7	ADC1	
8	ADC2	
9	ADC3	
10	ADC4	
11	ADC5	
12	ADC6	Current Sense
13	ADC7	J9 links to 14
14	ISENSE_OUT	
15	ISENSE_IN	
16	VREF (in/out)	J7 disables internal ref.

9 Drawings


Precison Reference (optional)
IC4
ic
GND
ic
OUTS
OUTF
IN
MAX6033
AGND
VDD
J7
Link for ext ref
High Side Current Sensor (optional)
IC2
GND
OUT
VCC
LOAD
VIN
MAX4372
R4
0.1
R4a
0.1
J8
J9
+5
R1
5
Z1
6v2
0V
VDD
C1
100n
C3
4u7 6.3V
C5
100n
C6
100n
C7
4u7 6.3V
IC1
VDD
VDD
n/c
n/c
DGND
SCL
A0
SDA
A2
n/c
A1
SHDN
AGND
n/c
REF
REFADJ
CH7
CH6
CH5
CH4
CH3
CH2
CH1
CH0
MAX127
CN1
CN2
SDA
VDD
VSS
SCL
INT
VAUX
I2C6PIN
R2
47
R3
47
CN3
VREF OUT/IN
ISense IN
ISENSE OUT
ADC7, VSENSE
ADC6 (Isense)
ADC5
ADC4
ADC3
ADC2
ADC1
ADC0
AGND
CONNECTOR 12 PIN
Pads on pcb for resistors and capacitors for dividers and filters
Max127/8 Input Resistance 20k
MAX128 has external reference
J1
J2
J3
J4
J5
J6
Maxim Precison Reference
Internal Reference is 4.096V, 15ppm/C, 0.5%
(-A version)
Use MAX6033 Precision Ref for
- Improved TC
- Better calibration accuracy
- VRef=2.5, 3.0, 4.096
Maxim High Side Current Sensor
MAX4372T , Gain =20V/V
MAX4372F , Gain =50V/V
MAX4372H , Gain =100V/V
Fit Suitable value of R4.
For high current, R4 should be external
Jumpers
J1-J6 I2C Address
J7: Link to disable internal reference of MAX127/8
J8 Link Current Sense output to ADC 6
J9: Link ISense (output side) to ADC 7 to monitor voltage
MAX127 I2C address 50h
MP1
PCB-SIP127D
FID1
FIDUCIAL-BOT
FID2
FIDUCIAL-BOT
H1
AGND
HOLE-M3
Designed and Manufactured by
Broadcast Equipment Ltd
www.i2cchip.com
Title
Max127 12 Bit ADC 0-5V +/-5V, 0-10V
Size
A4
Number
Revision
Date: 25-Nov-2008
Sheet of
File: C:\cad\a\I2CAd\I2CAd.ddb
Drawn By: sjb

9.2 PCB Drawings





J7: Link to disable internal reference of MAX127/8

J8 Link Current Sense output to ADC 6

J9: Link ISense (output side) to ADC 7 to monitor voltage

10 Revision History

Date	Rev#	Changes
2 Dec 2008	2	Add detail to MAX127/8 of ranges and input resistance
30 Oct 2012	3	Added Control register page from data sheet.
	4	Add 5V VDD note. Extend Voltage Reference section
13 Dec 12	5	Add 3.3V operation note. Add VDD for VRef