Dual Matched Amplifiers with Digitally Programmable Gain in MSOP

FEATURES

- **3-Bit Digital Gain Control: (Inverting Gains of 0, 1, 2, 5, 10, 20, 50 and 100V/V) -1 Option (Inverting Gains of 0, 1, 2, 4, 8, 16, 32 and 64V/V) -2 Option**
- **Two Matched Programmable Gain Amplifiers**
- **Channel-to-Channel Gain Matching of 0.1dB (Max)**
- **Rail-to-Rail Input Range**
- **Rail-to-Rail Output Swing**
- **Single or Dual Supply: 2.7V to 10.5V Total**
- 11MHz Gain Bandwidth Product
- Input Noise: 10nV/√Hz
- Total System Dynamic Range to 120dB
- Input Offset Voltage: 2mV, Gain of 10
- Low Profile 10-Lead MSOP Package

DESCRIPTION

The LTC®6911 is a family of low noise digitally programmable gain amplifiers (PGAs) that are easy to use and occupy very little PC board space. The matched gain of both channels is adjustable using a 3-bit parallel interface to select voltage gains of 0, 1, 2, 5, 10, 20, 50 and 100V/V (LTC6911-1) and 0, 1, 2, 4, 8, 16, 32 and 64V/V (LTC6911-2). All gains are inverting.

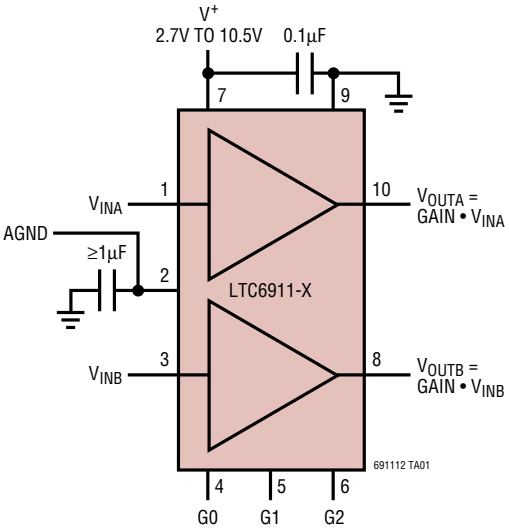
The LTC6911 family consists of two matched inverting amplifiers with rail-to-rail outputs. When operated with unity gain, they will also process rail-to-rail input signals. A half-supply reference generated internally at the AGND pin supports single power supply applications. Operating from single or split supplies from 2.7V to 10.5V, the LTC6911 family is offered in a 10-lead MSOP package.

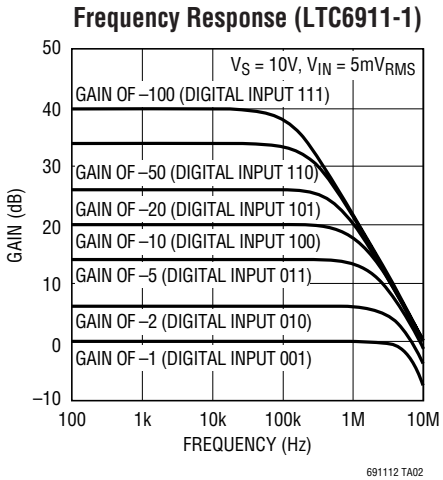
APPLICATIONS

- Data Acquisition Systems
- Dynamic Gain Changing
- Automatic Ranging Circuits
- Automatic Gain Control

TYPICAL APPLICATION

DIGITAL INPUT			GAIN IN V/V	
G2	G1	G0	LTC6911-1	LTC6911-2
0	0	0	0	0
0	0	1	–1	–1
0	1	0	–2	–2
0	1	1	–5	–4
1	0	0	–10	–8
1	0	1	–20	–16
1	1	0	–50	–32
1	1	1	–100	–64



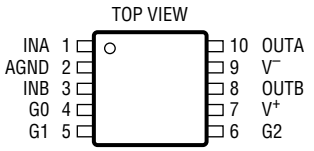


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Total Supply Voltage (V^+ to V^-) 11V
Input Current ..... ±10mA
Operating Temperature Range (Note 2)
LTC6911C-1/LTC6911C-2 ..... –40°C to 85°C
LTC6911I-1/LTC6911I-2 ..... –40°C to 85°C
LTC6911H-1/LTC6911H-2 ..... –40°C to 125°C
Specified Temperature Range (Note 3)
LTC6911C-1/LTC6911C-2 ..... –40°C to 85°C
LTC6911I-1/LTC6911I-2 ..... –40°C to 85°C
LTC6911H-1/LTC6911H-2 ..... –40°C to 125°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec)..... 300°C

PACKAGE/ORDER INFORMATION



MS PACKAGE
10-LEAD PLASTIC MSOP

T_{JMAX} = 150°C, θ_{JA} = 230°C/W

ORDER PART NUMBER	MS PART MARKING
LTC6911CMS-1	LTAHK
LTC6911IMS-1	LTAHM
LTC6911HMS-1	LTBCF
LTC6911CMS-2	LTAHH
LTC6911IMS-2	LTAHJ
LTC6911HMS-2	LTBCG

Consult LTC Marketing for parts specified with wider operating temperature ranges.

GAIN SETTINGS AND PROPERTIES

Table 1 (LTC6911-1)

DIGITAL INPUTS			NOMINAL VOLTAGE GAIN		MAXIMUM LINEAR INPUT RANGE (V_{P-P})			NOMINAL INPUT IMPEDANCE (kΩ)
G2	G1	G0	Volts/Volt	(dB)	Dual 5V Supply	Single 5V Supply	Single 3V Supply	
0	0	0	0	–120	10	5	3	(Open)
0	0	1	–1	0	10	5	3	10
0	1	0	–2	6	5	2.5	1.5	5
0	1	1	–5	14	2	1	0.6	2
1	0	0	–10	20	1	0.5	0.3	1
1	0	1	–20	26	0.5	0.25	0.15	1
1	1	0	–50	34	0.2	0.1	0.06	1
1	1	1	–100	40	0.1	0.05	0.03	1

Table 2 (LTC6911-2)

DIGITAL INPUTS			NOMINAL VOLTAGE GAIN		MAXIMUM LINEAR INPUT RANGE (V_{P-P})			NOMINAL INPUT IMPEDANCE (kΩ)
G2	G1	G0	Volts/Volt	(dB)	Dual 5V Supply	Single 5V Supply	Single 3V Supply	
0	0	0	0	–120	10	5	3	(Open)
0	0	1	–1	0	10	5	3	10
0	1	0	–2	6	5	2.5	1.5	5
0	1	1	–4	12	2.5	1.25	0.75	2.5
1	0	0	–8	18.1	1.25	0.625	0.375	1.25
1	0	1	–16	24.1	0.625	0.3125	0.188	1.25
1	1	0	–32	30.1	0.3125	0.156	0.094	1.25
1	1	1	–64	36.1	0.156	0.078	0.047	1.25

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications that apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, AGND = 2.5V, Gain = 1 (Digital Inputs 001), R_L = 10k to midsupply point, unless otherwise noted.

PARAMETER	CONDITIONS		C/I GRADES MIN	C/I GRADES TYP	C/I GRADES MAX	H GRADE MIN	H GRADE TYP	H GRADE MAX	UNITS
LTC6911-1/LTC6911-2									
Total Supply Voltage (V_S)		●	2.7		10.5	2.7		10.5	V
Supply Current per Channel	V_S = 2.7V, V_{INA} = V_{INB} = V_{AGND}	●		2.1	3.15		2.1	3.25	mA
	V_S = 5V, V_{INA} = V_{INB} = V_{AGND}	●		2.5	3.75		2.5	4.00	mA
	V_S = ±5V, V_{INA} = V_{INB} = 0V, Pins 4, 5, 6 = –4.5V or 5V	●		3.1	4.65		3.1	5.00	mA
	V_S = ±5V, V_{INA} = V_{INB} = 0V, Pin 4 = 4.5V, Pins 5, 6 = 0.5V	●		3.1	4.65		3.1	5.00	mA
Output Voltage Swing LOW (Note 4)	V_S = 2.7V, R_L = 10k Tied to Mid Supply	●		12	30		12	35	mV
	V_S = 2.7V, R_L = 500Ω Tied to Mid Supply	●		60	110		60	125	mV
	V_S = 5V, R_L = 10k Tied to Mid Supply	●		20	40		20	45	mV
	V_S = 5V, R_L = 500Ω Tied to Mid Supply	●		100	170		100	190	mV
	V_S = ±5V, R_L = 10k Tied to 0V	●		30	50		30	60	mV
	V_S = ±5V, R_L = 500Ω Tied to 0V	●		190	260		190	290	mV
Output Voltage Swing HIGH (Note 4)	V_S = 2.7V, R_L = 10k Tied to Mid Supply	●		10	20		10	25	mV
	V_S = 2.7V, R_L = 500Ω Tied to Mid Supply	●		50	80		50	90	mV
	V_S = 5V, R_L = 10k Tied to Mid Supply	●		10	30		10	35	mV
	V_S = 5V, R_L = 500Ω Tied to Mid Supply	●		90	160		90	175	mV
	V_S = ±5V, R_L = 10k Tied to 0V	●		20	40		20	45	mV
	V_S = ±5V, R_L = 500Ω Tied to 0V	●		180	250		180	270	mV
Output Short-Circuit Current (Note 5)	V_S = 2.7V	●		±27			±27		mA
	V_S = ±5V	●		±35			±35		mA
AGND Open-Circuit Voltage	V_S = 5V	●	2.45	2.5	2.55	2.45	2.5	2.55	V
AGND (Common Mode) Input Voltage Range	V_S = 2.7V	●	0.55		1.60	0.55		1.60	V
	V_S = 5V	●	0.75		3.65	0.75		3.65	V
	V_S = ±5V	●	–4.30		3.20	–4.30		3.20	V
AGND Rejection (i.e., Common Mode Rejection or CMRR)	V_S = 2.7V, V_{AGND} = 1.1V to 1.6V	●	55	80		50	80		dB
	V_S = ±5V, V_{AGND} = –2.5V to 2.5V	●	55	75		50	75		dB
Power Supply Rejection Ratio (PSRR)	V_S = 2.7V to ±5V	●	60	80		57	80		dB
Slew Rate	V_S = 5V, V_{OUTA} = V_{OUTB} = 1.1V to 3.9V			12			12		V/µs
	V_S = ±5V, V_{OUTA} = V_{OUTB} = ±1.4V			16			16		V/µs
Signal Attenuation at Gain = 0 Setting	Gain = 0 (Digital Inputs 000), f = 20kHz	●		–120			–120		dB
Digital Input "High" Voltage	V_S = 2.7V	●	2.43			2.43			V
	V_S = 5V	●	4.50			4.50			V
	V_S = ±5V	●	4.50			4.50			V
Digital Input "Low" Voltage	V_S = 2.7V	●			0.27			0.27	V
	V_S = 5V	●			0.50			0.50	V
	V_S = ±5V	●			0.50			0.50	V
Digital Input "High" Current	V_S = 2.7V, Pins 4, 5, 6 = 2.43V	●		1			1		µA
	V_S = 5V, Pins 4, 5, 6 = 4.5V	●		5			5		µA
	V_S = ±5V, Pins 4, 5, 6 = 4.5V	●		10			10		µA
Digital Input "Low" Current	V_S = 2.7V, Pins 4, 5, 6 = 0.27V	●		1			1		µA
	V_S = 5V, Pins 4, 5, 6 = 0.5V	●		5			5		µA
	V_S = ±5V, Pins 4, 5, 6 = 0.5V	●		10			10		µA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications that apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, AGND = 2.5V, Gain = 1 (Digital Inputs 001), R_L = 10k to midsupply point, unless otherwise noted.

PARAMETER	CONDITIONS		C/I GRADES MIN	C/I GRADES TYP	C/I GRADES MAX	H GRADE MIN	H GRADE TYP	H GRADE MAX	UNITS
LTC6911-1 Only									
Voltage Gain (Note 6)	V_S = 2.7V, Gain = 1, R_L = 10k	●	–0.07	0	0.07	–0.08	0	0.07	dB
	V_S = 2.7V, Gain = 1, R_L = 500Ω	●	–0.11	–0.02	0.07	–0.13	–0.02	0.07	dB
	V_S = 2.7V, Gain = 2, R_L = 10k	●	5.94	6.01	6.08	5.93	6.01	6.08	dB
	V_S = 2.7V, Gain = 5, R_L = 10k	●	13.85	13.95	14.05	13.8	13.95	14.05	dB
	V_S = 2.7V, Gain = 10, R_L = 10k	●	19.7	19.93	20.1	19.65	19.93	20.1	dB
	V_S = 2.7V, Gain = 10, R_L = 500Ω	●	19.6	19.85	20.1	19.45	19.85	20.1	dB
	V_S = 2.7V, Gain = 20, R_L = 10k	●	25.75	25.94	26.1	25.65	25.94	26.1	dB
	V_S = 2.7V, Gain = 50, R_L = 10k	●	33.5	33.8	34.1	33.4	33.8	34.1	dB
	V_S = 2.7V, Gain = 100, R_L = 10k	●	39.0	39.6	40.1	38.8	39.6	40.1	dB
	V_S = 2.7V, Gain = 100, R_L = 500Ω	●	37.4	38.9	40.1	36.5	38.9	40.1	dB
	V_S = 5V, Gain = 1, R_L = 10k	●	–0.08	0.01	0.08	–0.09	0.01	0.08	dB
	V_S = 5V, Gain = 1, R_L = 500Ω	●	–0.11	–0.01	0.07	–0.13	–0.01	0.07	dB
	V_S = 5V, Gain = 2, R_L = 10k	●	5.95	6.02	6.09	5.94	6.02	6.09	dB
	V_S = 5V, Gain = 5, R_L = 10k	●	13.8	13.96	14.1	13.78	13.96	14.1	dB
	V_S = 5V, Gain = 10, R_L = 10k	●	19.8	19.94	20.1	19.75	19.94	20.1	dB
	V_S = 5V, Gain = 10, R_L = 500Ω	●	19.6	19.87	20.1	19.45	19.87	20.1	dB
	V_S = 5V, Gain = 20, R_L = 10k	●	25.8	25.94	26.1	25.75	25.94	26.1	dB
	V_S = 5V, Gain = 50, R_L = 10k	●	33.5	33.84	34.1	33.4	33.84	34.1	dB
	V_S = 5V, Gain = 100, R_L = 10k	●	39.3	39.7	40.1	39.1	39.7	40.1	dB
	V_S = 5V, Gain = 100, R_L = 500Ω	●	38.0	39.2	40.1	37.0	39.2	40.1	dB
	V_S = ±5V, Gain = 1, R_L = 10k	●	–0.06	0.01	0.08	–0.07	0.01	0.08	dB
	V_S = ±5V, Gain = 1, R_L = 500Ω	●	–0.10	0.00	0.08	–0.11	0.00	0.08	dB
	V_S = ±5V, Gain = 2, R_L = 10k	●	5.95	6.02	6.09	5.94	6.02	6.09	dB
	V_S = ±5V, Gain = 5, R_L = 10k	●	13.8	13.96	14.1	13.79	13.96	14.1	dB
	V_S = ±5V, Gain = 10, R_L = 10k	●	19.8	19.94	20.1	19.75	19.94	20.1	dB
	V_S = ±5V, Gain = 10, R_L = 500Ω	●	19.7	19.91	20.1	19.60	19.91	20.1	dB
	V_S = ±5V, Gain = 20, R_L = 10k	●	25.8	25.95	26.1	25.75	25.95	26.1	dB
	V_S = ±5V, Gain = 50, R_L = 10k	●	33.7	33.87	34.1	33.60	33.87	34.1	dB
	V_S = ±5V, Gain = 100, R_L = 10k	●	39.4	39.8	40.2	39.25	39.8	40.2	dB
	V_S = ±5V, Gain = 100, R_L = 500Ω	●	38.8	39.5	40.1	38.00	39.5	40.1	dB
Channel-to-Channel Voltage Gain Match	V_S = 2.7V, Gain = 1, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 2.7V, Gain = 1, R_L = 500Ω	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 2.7V, Gain = 2, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 2.7V, Gain = 5, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 10, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 10, R_L = 500Ω	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 20, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 50, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 100, R_L = 10k	●	–0.20	0.02	0.20	–0.20	0.02	0.20	dB
	V_S = 2.7V, Gain = 100, R_L = 500Ω	●	–1.00	0.02	1.00	–1.50	0.02	1.50	dB

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications that apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, AGND = 2.5V, Gain = 1 (Digital Inputs 001), R_L = 10k to midsupply point, unless otherwise noted.

PARAMETER	CONDITIONS		C/I GRADES MIN	C/I GRADES TYP	C/I GRADES MAX	H GRADE MIN	H GRADE TYP	H GRADE MAX	UNITS
LTC6911-1 Only									
Channel-to-Channel Voltage Gain Match	V_S = 5V, Gain = 1, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 5V, Gain = 1, R_L = 500Ω	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 5V, Gain = 2, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 5V, Gain = 5, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 10, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 10, R_L = 500Ω	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 20, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 50, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 100, R_L = 10k	●	–0.2	0.02	0.2	–0.2	0.02	0.2	dB
	V_S = 5V, Gain = 100, R_L = 500Ω	●	–0.8	0.02	0.8	–1.2	0.02	1.2	dB
	V_S = ±5V, Gain = 1, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = ±5V, Gain = 1, R_L = 500Ω	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = ±5V, Gain = 2, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = ±5V, Gain = 5, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 10, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 10, R_L = 500Ω	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 20, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 50, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 100, R_L = 10k	●	–0.2	0.02	0.2	–0.2	0.02	0.2	dB
	V_S = ±5V, Gain = 100, R_L = 500Ω	●	–0.6	0.02	0.6	–0.9	0.02	0.9	dB
Gain Temperature Coefficient	V_S = 5V, Gain = 1, R_L = Open			2			2		ppm/°C
	V_S = 5V, Gain = 2, R_L = Open			–1.5			–1.5		ppm/°C-
	V_S = 5V, Gain = 5, R_L = Open			–11			–11		ppm/°C
	V_S = 5V, Gain = 10, R_L = Open			–30			–30		ppm/°C
	V_S = 5V, Gain = 20, R_L = Open			–38			–38		ppm/°C
	V_S = 5V, Gain = 50, R_L = Open			–70			–70		ppm/°C
	V_S = 5V, Gain = 100, R_L = Open			–140			–140		ppm/°C
Channel-to-Channel Gain Temperature Coefficient Match	V_S = 5V, Gain = 1, R_L = Open			1.0			1.0		ppm/°C
	V_S = 5V, Gain = 2, R_L = Open			1.0			1.0		ppm/°C
	V_S = 5V, Gain = 5, R_L = Open			0.2			0.2		ppm/°C
	V_S = 5V, Gain = 10, R_L = Open			1.0			1.0		ppm/°C
	V_S = 5V, Gain = 20, R_L = Open			0.4			0.4		ppm/°C
	V_S = 5V, Gain = 50, R_L = Open			3.0			3.0		ppm/°C
	V_S = 5V, Gain = 100, R_L = Open			3.0			3.0		ppm/°C
Channel-to-Channel Isolation (Note 7)	f = 200kHz								
	V_S = 5V, Gain = 1, R_L = 10k			108			108		dB
	V_S = 5V, Gain = 10, R_L = 10k			107			107		dB
	V_S = 5V, Gain = 100, R_L = 10k			93			93		dB
Offset Voltage Magnitude Referred to INA or INB Pins (Note 8)	Gain = 1	●		2.0	22		2.0	22	mV
	Gain = 10	●		1.1	12		1.1	14	mV
Offset Voltage Magnitude Drift Referred to INA or INB Pins (Note 8)	Gain = 1			12			20		µV/°C
	Gain = 10			6.6			11		µV/°C

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications that apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, AGND = 2.5V, Gain = 1 (Digital Inputs 001), R_L = 10k to midsupply point, unless otherwise noted.

PARAMETER	CONDITIONS		C/I GRADES MIN	C/I GRADES TYP	C/I GRADES MAX	H GRADE MIN	H GRADE TYP	H GRADE MAX	UNITS
LTC6911-1 Only									
DC Input Resistance at INA or INB Pins (Note 9)	DC V_{INA} or V_{INB} = 0V								
	Gain = 0	●		>100			>100		MΩ
	Gain = 1	●		10			10		kΩ
	Gain = 2	●		5			5		kΩ
	Gain = 5	●		2			2		kΩ
	Gain > 5	●		1			1		kΩ
DC Input Resistance Match $R_{INA} – R_{INB}$	Gain = 1	●		10			10		Ω
	Gain = 2	●		5			5		Ω
	Gain = 5	●		2			2		Ω
	Gain > 5	●		1			1		Ω
DC Small-Signal Output Resistance at OUTA or OUTB Pins	DC V_{INA} or V_{INB} = 0V								
	Gain = 0			0.4			0.4		Ω
	Gain = 1			0.7			0.7		Ω
	Gain = 2			1.0			1.0		Ω
	Gain = 5			1.9			1.9		Ω
	Gain = 10			3.4			3.4		Ω
	Gain = 20			6.4			6.4		Ω
	Gain = 50			15			15		Ω
	Gain = 100			30			30		Ω
Gain-Bandwidth Product	Gain = 100, f_{IN} = 200kHz	●	7	11	18	6	11	18	MHz
Wideband Noise (Referred to Input)	f = 1kHz to 200kHz								
	Gain = 0 (Output Noise Only)			7.5			7.5		μV_{RMS}
	Gain = 1			12.3			12.3		μV_{RMS}
	Gain = 2			8.5			8.5		μV_{RMS}
	Gain = 5			6.1			6.1		μV_{RMS}
	Gain = 10			5.2			5.2		μV_{RMS}
	Gain = 20			5.0			5.0		μV_{RMS}
	Gain = 50			4.5			4.5		μV_{RMS}
	Gain = 100			3.8			3.8		μV_{RMS}
Voltage Noise Density (Referred to Input)	f = 50kHz								
	Gain = 1			28			28		$nV/\sqrt{Hz}$
	Gain = 2			19			19		$nV/\sqrt{Hz}$
	Gain = 5			14			14		$nV/\sqrt{Hz}$
	Gain = 10			12			12		$nV/\sqrt{Hz}$
	Gain = 20			11.5			11.5		$nV/\sqrt{Hz}$
	Gain = 50			10.8			10.8		$nV/\sqrt{Hz}$
	Gain = 100			9.9			9.9		$nV/\sqrt{Hz}$
Total Harmonic Distortion	Gain = 10, f_{IN} = 10kHz, V_{OUT} = $1V_{RMS}$			–90 0.003			–90 0.003		dB %
	Gain = 10, f_{IN} = 100kHz, V_{OUT} = $1V_{RMS}$			–82 0.008			–82 0.008		dB %

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications that apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, AGND = 2.5V, Gain = 1 (Digital Inputs 001), R_L = 10k to midsupply point, unless otherwise noted.

PARAMETER	CONDITIONS		C/I GRADES MIN	C/I GRADES TYP	C/I GRADES MAX	H GRADE MIN	H GRADE TYP	H GRADE MAX	UNITS
LTC6911-2 Only									
Voltage Gain (Note 6)	V_S = 2.7V, Gain = 1, R_L = 10k	●	–0.07	0	0.07	–0.08	0	0.07	dB
	V_S = 2.7V, Gain = 1, R_L = 500Ω	●	–0.11	–0.02	0.07	–0.13	–0.02	0.07	dB
	V_S = 2.7V, Gain = 2, R_L = 10k	●	5.94	6.01	6.08	5.93	6.01	6.08	dB
	V_S = 2.7V, Gain = 4, R_L = 10k	●	11.9	12.02	12.12	11.88	12.02	12.12	dB
	V_S = 2.7V, Gain = 8, R_L = 10k	●	17.80	18.00	18.15	17.75	18.00	18.15	dB
	V_S = 2.7V, Gain = 8, R_L = 500Ω	●	17.65	17.94	18.15	17.55	17.94	18.15	dB
	V_S = 2.7V, Gain = 16, R_L = 10k	●	23.8	24.01	24.25	23.75	24.01	24.25	dB
	V_S = 2.7V, Gain = 32, R_L = 10k	●	29.7	30	30.2	29.65	30	30.2	dB
	V_S = 2.7V, Gain = 64, R_L = 10k	●	35.3	35.8	36.2	35.15	35.8	36.2	dB
	V_S = 2.7V, Gain = 64, R_L = 500Ω	●	34.2	35.3	36.2	33.65	35.3	36.2	dB
	V_S = 5V, Gain = 1, R_L = 10k	●	–0.08	0.00	0.08	–0.09	0.00	0.08	dB
	V_S = 5V, Gain = 1, R_L = 500Ω	●	–0.10	–0.01	0.08	–0.12	–0.01	0.08	dB
	V_S = 5V, Gain = 2, R_L = 10k	●	5.96	6.02	6.1	5.95	6.02	6.1	dB
	V_S = 5V, Gain = 4, R_L = 10k	●	11.85	12.02	12.15	11.83	12.02	12.15	dB
	V_S = 5V, Gain = 8, R_L = 10k	●	17.85	18.01	18.15	17.83	18.01	18.15	dB
	V_S = 5V, Gain = 8, R_L = 500Ω	●	17.65	17.96	18.15	17.50	17.96	18.15	dB
	V_S = 5V, Gain = 16, R_L = 10k	●	23.85	24.02	24.15	23.80	24.02	24.15	dB
	V_S = 5V, Gain = 32, R_L = 10k	●	29.70	30.02	30.2	29.65	30.02	30.2	dB
	V_S = 5V, Gain = 64, R_L = 10k	●	35.5	35.9	36.3	35.40	35.9	36.3	dB
	V_S = 5V, Gain = 64, R_L = 500Ω	●	34.7	35.6	36.1	34.20	35.6	36.1	dB
	V_S = ±5V, Gain = 1, R_L = 10k	●	–0.06	0.01	0.08	–0.07	0.01	0.08	dB
	V_S = ±5V, Gain = 1, R_L = 500Ω	●	–0.10	0.00	0.08	–0.11	0.00	0.08	dB
	V_S = ±5V, Gain = 2, R_L = 10k	●	5.96	6.02	6.1	5.95	6.02	6.1	dB
	V_S = ±5V, Gain = 4, R_L = 10k	●	11.9	12.03	12.15	11.88	12.03	12.15	dB
	V_S = ±5V, Gain = 8, R_L = 10k	●	17.85	18.02	18.15	17.83	18.02	18.15	dB
	V_S = ±5V, Gain = 8, R_L = 500Ω	●	17.80	17.99	18.15	17.73	17.99	18.15	dB
	V_S = ±5V, Gain = 16, R_L = 10k	●	23.85	24.03	24.15	23.82	24.03	24.15	dB
	V_S = ±5V, Gain = 32, R_L = 10k	●	29.85	30	30.2	29.8	30	30.2	dB
	V_S = ±5V, Gain = 64, R_L = 10k	●	35.65	36.0	36.20	35.55	36.0	36.20	dB
	V_S = ±5V, Gain = 64, R_L = 500Ω	●	35.20	35.8	36.20	34.80	35.8	36.20	dB
Channel-to-Channel Voltage Gain Match	V_S = 2.7V, Gain = 1, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 2.7V, Gain = 1, R_L = 500Ω	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 2.7V, Gain = 2, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 2.7V, Gain = 4, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 8, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 8, R_L = 500Ω	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 16, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 32, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 2.7V, Gain = 64, R_L = 10k	●	–0.2	0.02	0.2	–0.2	0.02	0.2	dB
	V_S = 2.7V, Gain = 64, R_L = 500Ω	●	–0.7	0.02	0.7	–1.0	0.02	1.0	dB

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications that apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, AGND = 2.5V, Gain = 1 (Digital Inputs 001), R_L = 10k to midsupply point, unless otherwise noted.

PARAMETER	CONDITIONS		C/I GRADES MIN	C/I GRADES TYP	C/I GRADES MAX	H GRADE MIN	H GRADE TYP	H GRADE MAX	UNITS
LTC6911-2 Only									
	V_S = 5V, Gain = 1, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 5V, Gain = 1, R_L = 500Ω	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 5V, Gain = 2, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = 5V, Gain = 4, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 8, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 8, R_L = 500Ω	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 16, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 32, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 64, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = 5V, Gain = 64, R_L = 500Ω	●	–0.60	0.02	0.60	–0.80	0.02	0.80	dB
	V_S = ±5V, Gain = 1, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = ±5V, Gain = 1, R_L = 500Ω	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = ±5V, Gain = 2, R_L = 10k	●	–0.1	0.02	0.1	–0.1	0.02	0.1	dB
	V_S = ±5V, Gain = 4, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 8, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 8, R_L = 500Ω	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 16, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 32, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 64, R_L = 10k	●	–0.15	0.02	0.15	–0.15	0.02	0.15	dB
	V_S = ±5V, Gain = 64, R_L = 500Ω	●	–0.40	0.02	0.40	–0.60	0.02	0.60	dB
Gain Temperature Coefficient	V_S = 5V, Gain = 1, R_L = Open			2			2		ppm/°C
	V_S = 5V, Gain = 2, R_L = Open			–1			–1		ppm/°C
	V_S = 5V, Gain = 4, R_L = Open			–7			–7		ppm/°C
	V_S = 5V, Gain = 8, R_L = Open			–21			–21		ppm/°C
	V_S = 5V, Gain = 16, R_L = Open			–28			–28		ppm/°C
	V_S = 5V, Gain = 32, R_L = Open			–40			–40		ppm/°C
	V_S = 5V, Gain = 64, R_L = Open			–115			–115		ppm/°C
Channel-to-Channel Gain Temperature Coefficient Match	V_S = 5V, Gain = 1, R_L = Open			0			0		ppm/°C
	V_S = 5V, Gain = 2, R_L = Open			–0.5			–0.5		ppm/°C
	V_S = 5V, Gain = 4, R_L = Open			0.5			0.5		ppm/°C
	V_S = 5V, Gain = 8, R_L = Open			0.5			0.5		ppm/°C
	V_S = 5V, Gain = 16, R_L = Open			1.0			1.0		ppm/°C
	V_S = 5V, Gain = 32, R_L = Open			4.0			4.0		ppm/°C
	V_S = 5V, Gain = 64, R_L = Open			4.0			4.0		ppm/°C
Channel-to-Channel Isolation (Note 7)	f = 200kHz								
	V_S = 5V, Gain = 1, R_L = 10k			110			110		dB
	V_S = 5V, Gain = 8, R_L = 10k			110			110		dB
	V_S = 5V, Gain = 64, R_L = 10k			93			93		dB
Offset Voltage Magnitude Referred to INA or INB Pins (Note 8)	Gain = 1	●		2.0	22		2.0	22	mV
	Gain = 8	●		1.1	12		1.1	14	mV
Offset Voltage Magnitude Drift Referred to INA or INB Pins (Note 8)	Gain = 1			12			20		µV/°C
	Gain = 8			6.8			11		µV/°C
DC Input Resistance at INA or INB Pins (Note 9)	DC V_{INA} or V_{INB} = 0V								
	Gain = 0	●		>100			>100		MΩ
	Gain = 1	●		10			10		kΩ
	Gain = 2	●		5			5		kΩ
	Gain = 4	●		2.5			2.5		kΩ
	Gain > 4	●		1.25			1.25		kΩ

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications that apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, AGND = 2.5V, Gain = 1 (Digital Inputs 001), R_L = 10k to midsupply point, unless otherwise noted.

PARAMETER	CONDITIONS		C/I GRADES MIN	C/I GRADES TYP	C/I GRADES MAX	H GRADE MIN	H GRADE TYP	H GRADE MAX	UNITS
LTC6911-2 Only									
DC Input Resistance Match $R_{INA} - R_{INB}$	Gain = 1	●		10			10		Ω
	Gain = 2	●		5			5		Ω
	Gain = 4	●		2			2		Ω
	Gain > 4	●		1			1		Ω
DC Small-Signal Output Resistance at OUTA or OUTB Pins	DC V_{INA} or V_{INB} = 0V								
	Gain = 0			0.4			0.4		Ω
	Gain = 1			0.7			0.7		Ω
	Gain = 2			1.0			1.0		Ω
	Gain = 4			1.9			1.9		Ω
	Gain = 8			3.4			3.4		Ω
	Gain = 16			6.4			6.4		Ω
	Gain = 32			15			15		Ω
	Gain = 64			30			30		Ω
Wideband Noise (Referred to Input)	f = 1kHz to 200kHz								
	Gain = 0 (Output Noise Only)			7.4			7.4		μV_{RMS}
	Gain = 1			12.4			12.4		μV_{RMS}
	Gain = 2			8.5			8.5		μV_{RMS}
	Gain = 4			6.5			6.5		μV_{RMS}
	Gain = 8			5.5			5.5		μV_{RMS}
	Gain = 16			5.2			5.2		μV_{RMS}
	Gain = 32			4.9			4.9		μV_{RMS}
	Gain = 64			4.3			4.3		μV_{RMS}
Voltage Noise Density (Referred to Input)	f = 50kHz								
	Gain = 1			28.0			28.0		$nV/\sqrt{Hz}$
	Gain = 2			19.0			19.0		$nV/\sqrt{Hz}$
	Gain = 4			14.8			14.8		$nV/\sqrt{Hz}$
	Gain = 8			12.7			12.7		$nV/\sqrt{Hz}$
	Gain = 16			11.8			11.8		$nV/\sqrt{Hz}$
	Gain = 32			11.5			11.5		$nV/\sqrt{Hz}$
	Gain = 64			10.9			10.9		$nV/\sqrt{Hz}$
Total Harmonic Distortion	Gain = 8, f_{IN} = 10kHz, V_{OUT} = $1V_{RMS}$			–90			–90		dB
				0.003			0.003		%
	Gain = 8, f_{IN} = 100kHz, V_{OUT} = $1V_{RMS}$			–82			–82		dB
				0.008			0.008		%
Gain-Bandwidth Product	Gain = 64, f_{IN} = 200kHz	●	6	11	17	6	11	17	MHz

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: The LTC6911C and LTC6911I are guaranteed functional over the operating temperature range of –40°C to 85°C. The LTC6911H is guaranteed functional over the operating temperature range of –40°C to 125°C.

Note 3: The LTC6911C is guaranteed to meet specified performance from 0°C to 70°C. The LTC6911C is designed, characterized and expected to meet specified performance from –40°C to 85°C but is not tested or QA sampled at these temperatures. LTC6911I is guaranteed to meet specified performance from –40°C to 85°C. The LTC6911H is guaranteed to meet specified performance from –40°C to 125°C.

Note 4: Output voltage swings are measured as differences between the output and the respective supply rail.

Note 5: Extended operation with output shorted may cause junction temperature to exceed the 150°C limit and is not recommended.

Note 6: Gain is measured with a DC large-signal test using an output excursion between approximately 30% and 70% of the total supply voltage.

Note 7: Channel-to-channel isolation is measured by applying a 200kHz input signal to one channel so that its output varies $1V_{RMS}$ and measuring the output voltage RMS of the other channel relative to AGND with its input tied to AGND. Isolation is calculated:

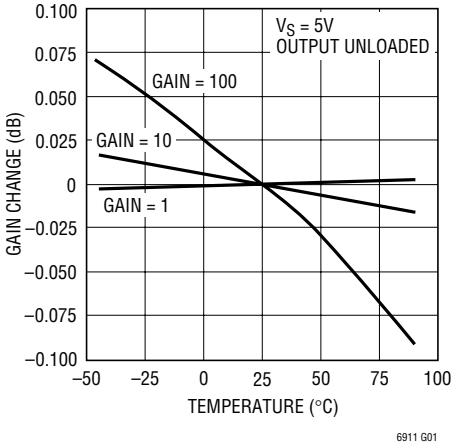
$$\text{Isolation}_A = 20 \bullet \log_{10} \frac{V_{OUTB}}{V_{OUTA}},\ \text{Isolation}_B = 20 \bullet \log_{10} \frac{V_{OUTA}}{V_{OUTB}}$$

Note 8: Offset voltage referred to the INA or INB input is (1 + 1/G) times the offset voltage of the internal op amp, where G is the nominal gain magnitude. See Applications Information.

Note 9: Input resistance can vary by approximately ±30% part-to-part at a given gain setting (input resistance match remains as specified).

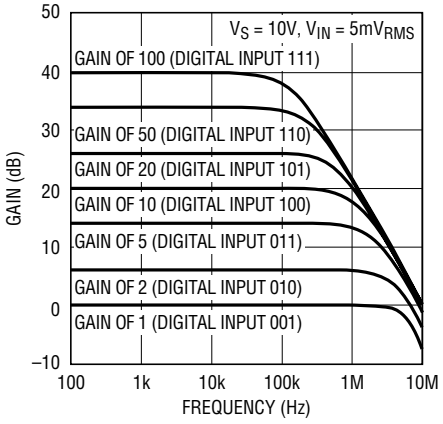
TYPICAL PERFORMANCE CHARACTERISTICS (LTC6911-1)

LTC6911-1 Gain Shift vs Temperature



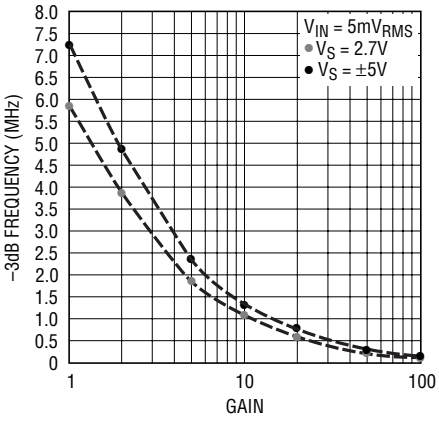
6911 G01

LTC6911-1 Frequency Response



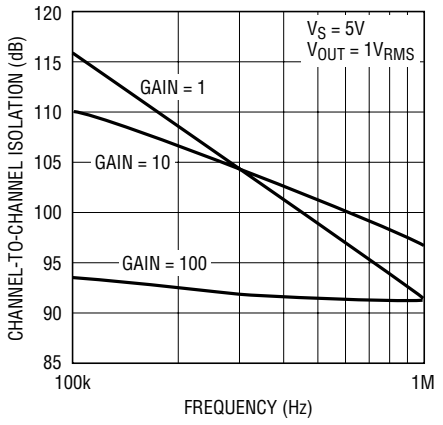
6911 G02

LTC6911-1 –3dB Bandwidth vs Gain Setting



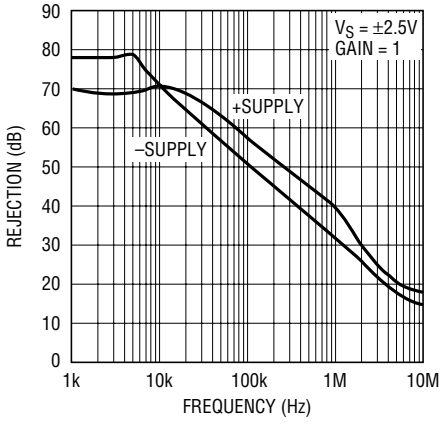
6911 G03

LTC6911-1 Channel Isolation vs Frequency



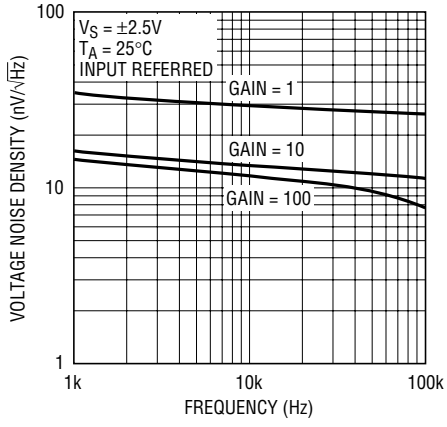
6911 G04

LTC6911-1 Power Supply Rejection vs Frequency



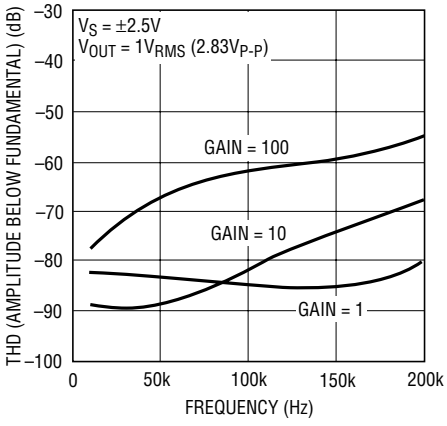
6911 G05

LTC6911-1 Noise Density vs Frequency



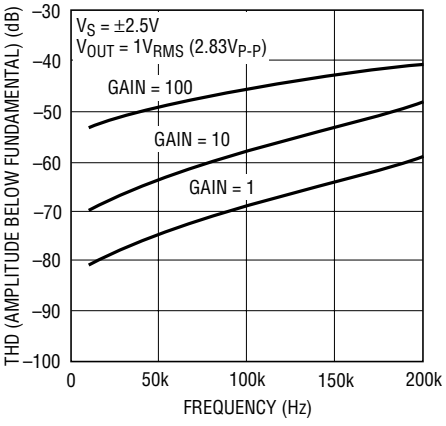
6911 G06

LTC6911-1 Distortion vs Frequency with Light Loading (R_L = 10k)



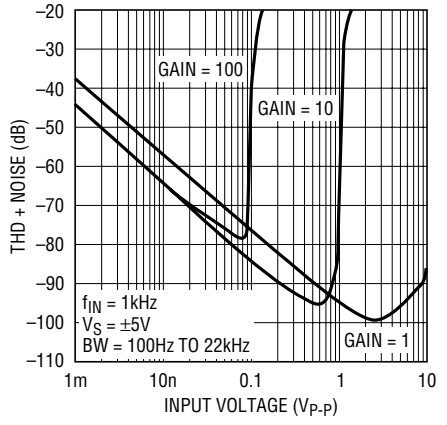
6911 G07

LTC6911-1 Distortion vs Frequency with Heavy Loading (R_L = 500Ω)



6911 G08

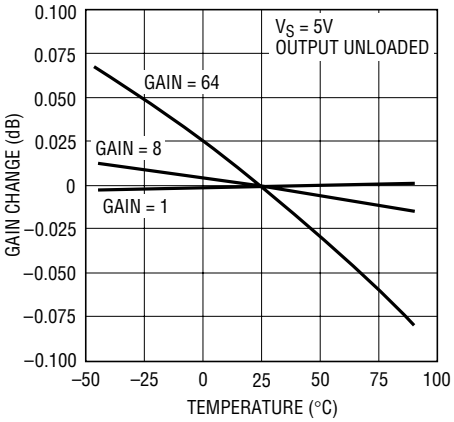
LTC6911-1 THD + Noise vs Input Voltage



6911 G09

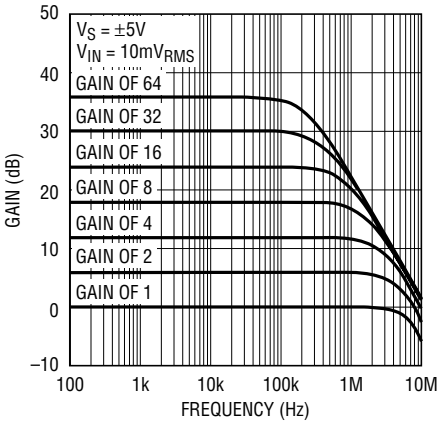
TYPICAL PERFORMANCE CHARACTERISTICS (LTC6911-2)

LTC6911-2 Gain Shift vs Temperature



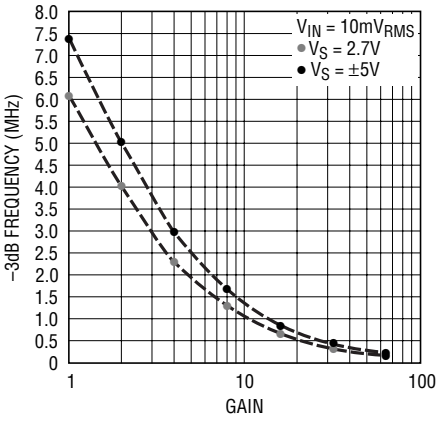
6911 G010

LTC6911-2 Frequency Response



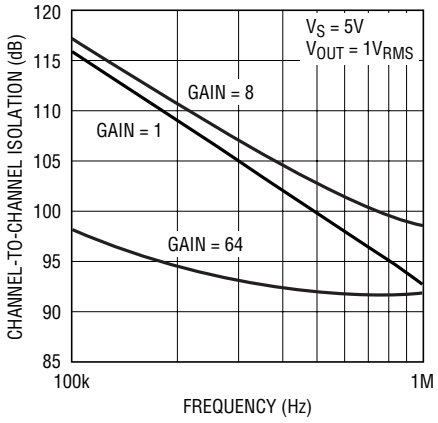
6911 G11

LTC6911-2 –3dB Bandwidth vs Gain Setting



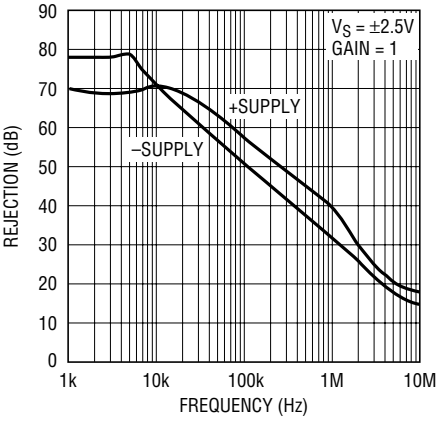
6911 G12

LTC6911-2 Channel Isolation vs Frequency



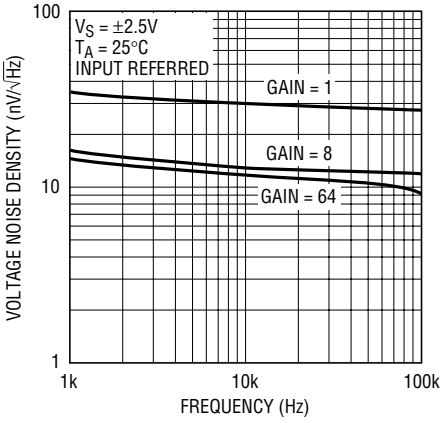
6911 G13

LTC6911-2 Power Supply Rejection vs Frequency



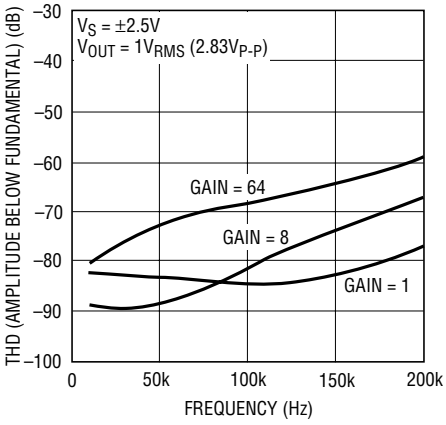
6911 G14

LTC6911-2 Noise Density vs Frequency



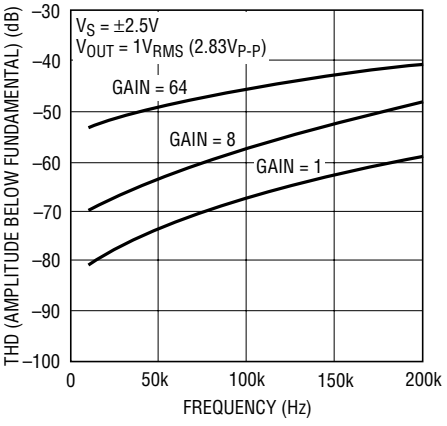
6911 G15

LTC6911-2 Distortion vs Frequency with Light Loading (R_L = 10k)



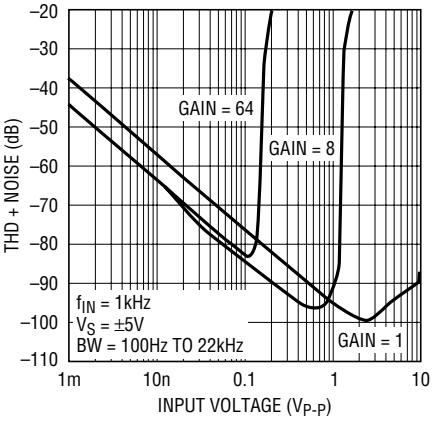
6911 G16

LTC6911-2 Distortion vs Frequency with Heavy Loading (R_L = 500Ω)



6911 G17

LTC6911-2 THD + Noise vs Input Voltage



6911 G18

PIN FUNCTIONS

INA (Pin 1): Analog Input. The input signal to the A channel amplifier of the LTC6911-X is the voltage difference between the INA and AGND pin. The INA pin connects internally to a digitally controlled resistance whose other end is a current summing point at the same potential as the AGND pin (Figure 1). At unity gain (digital input 001), the value of this input resistance is approximately 10kΩ and the INA pin voltage range is rail-to-rail (V^+ to V^-). At gain settings above unity, the input resistance falls. The linear input range at INA also falls inversely proportional to the programmed gain. Tables 1 and 2 summarize this behavior. The higher gains are designed to boost lower level signals with good noise performance. In the "zero" gain state (digital input 000), analog switches disconnect the INA pin internally and this pin presents a very high input resistance. The input may vary from rail to rail in the "zero" gain setting, but the output is insensitive to it and is forced to the AGND potential.

Circuitry driving the INA pin must consider the LTC6911-X's input resistance, its lot-to-lot variance, and the variation of this resistance from gain setting to gain setting. Signal sources with significant output resistance may introduce a gain error as the source's output resistance and the LTC6911-X's input resistance form a voltage divider. This is especially true at higher gain settings where the input resistance is the lowest.

In single supply voltage applications, it is important to remember that the LTC6911-X's DC ground reference for both input and output is AGND, not V^-. With increasing gains, the LTC6911-X's input voltage range for an unclipped output is no longer rail-to-rail but diminishes inversely to gain, centered about the AGND potential.

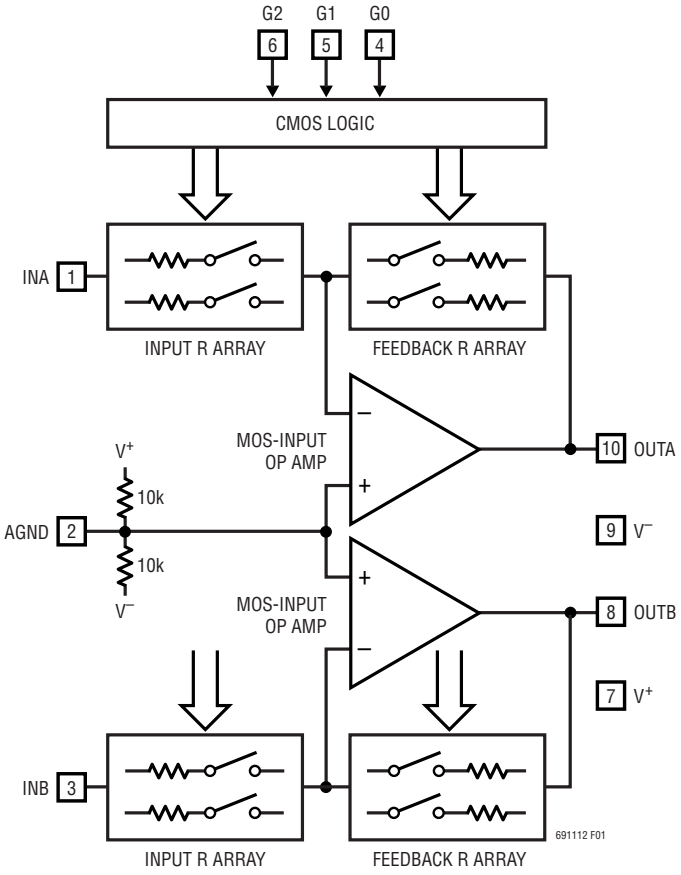


Figure 1. Block Diagram

PIN FUNCTIONS

AGND (Pin 2): Analog Ground. The AGND pin is at the midpoint of an internal resistive voltage divider, developing a potential halfway between the V^+ and V^- pins, with an equivalent series resistance to the pin of nominally 5kΩ (Figure 1). AGND is also the noninverting input to both the internal channel A and channel B amplifiers. This makes AGND the ground reference voltage for the INA, INB, OUTA and OUTB pins. Recommended analog ground plane connection depends on how power is applied to the LTC6911-X (see Figures 2, 3 and 4). Single power supply applications typically use V^- for the system signal ground. The analog ground plane in single supply applications should therefore tie to V^-, and the AGND pin should be bypassed to this ground plane by a high quality capacitor of at least 1µF (Figure 2). The AGND pin provides an internal analog reference voltage at half the V^+ supply voltage. Dual supply applications with symmetrical supplies (such as ±5V) have a natural system ground plane potential of zero volts, which can be tied directly to the AGND pin, making the zero volt ground plane the input and output reference voltage for the LTC6911-X (Figure 3). Finally, if dual asymmetrical power supplies are used, the supply ground is still the natural ground plane voltage. To maximize signal swing capability with an asymmetrical supply, however, it is often desirable to refer the LTC6911-X's analog input and output to a voltage equidistant from the two supply rails V^+ and V^-. The AGND pin will provide such a potential when open-circuited and bypassed with a capacitor (Figure 4).

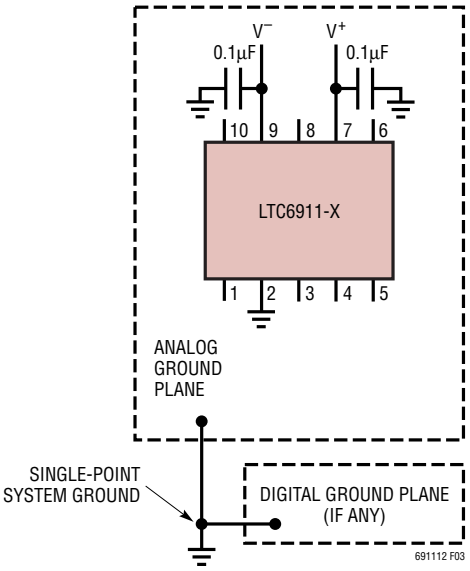


Figure 3. Dual Supply Ground Plane Connection

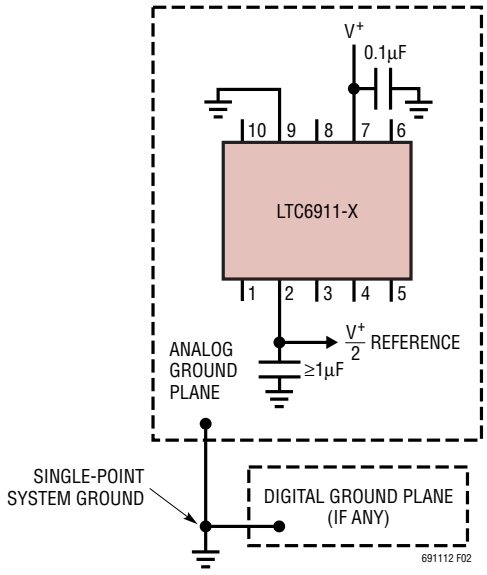


Figure 2. Single Supply Ground Plane Connection

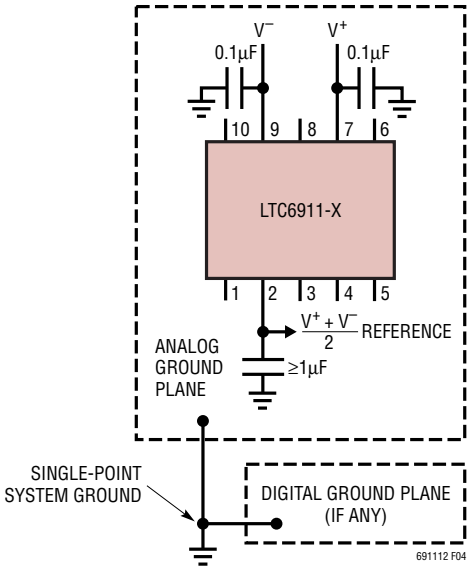


Figure 4. Asymmetrical Dual Supply Ground Plane Connection

PIN FUNCTIONS

In noise sensitive applications where AGND does not directly tie to a ground plane, as in Figures 2 and 4, it is important to AC-bypass the AGND pin. Otherwise, channel-to-channel isolation is degraded and wideband noise will enter the signal path from the thermal noise of the internal voltage divider resistors that present a Thévenin equivalent resistance of approximately 5kΩ. This noise can reduce SNR by at least 3dB at high gain settings. An external capacitor from AGND to the ground plane, whose impedance is well below 5kΩ at frequencies of interest, will filter and suppress this noise. A 1µF high quality capacitor is effective for frequencies down to 1kHz. Larger capacitors extend this suppression to lower frequencies. This issue does not arise in dual supply applications because the AGND pin ties directly to ground.

In applications requiring an analog ground reference other than half the total supply voltage, the user can override the built-in analog ground reference by tying the AGND pin to a reference voltage within the AGND voltage range specified in the Electrical Characteristics table. The AGND pin will load the external reference with approximately 5kΩ returned to the half-supply potential. AGND should still be capacitively bypassed to a ground plane as noted above. Do not connect the AGND pin to the V^- pin.

INB (Pin 3): Analog Input. Refer to INA pin description.

G0, G1, G2 (Pins 4, 5, 6): CMOS-Level Digital Gain Control Inputs. G2 is the most significant bit (MSB) and G0 is the least significant bit (LSB). These pins control the voltage gain settings for both channels (see Tables 1 and 2). Each channel's gain cannot be set independent of the other channel. The logic input pins (G pins) are allowed to swing from V^- to 10.5V above V^-, regardless of V^+ so long as the logic levels meet the minimum requirements specified in the Electrical Characteristics table. The G0, G1 and G2 pins are high impedance CMOS logic inputs, but have small pull-down current sources (<10µA) which will force both channels into the "zero" gain state (digital input 000) if the logic inputs are externally floated. No speed limitation is associated with the digital logic because it is memoryless and much faster than the analog signal path.

V^-, V^+ (Pins 7, 9): Power Supply Pins. The V^+ and V^- pins should be bypassed with 0.1µF capacitors to an adequate analog ground plane using the shortest possible wiring. Electrically clean supplies and a low impedance ground are important for the high dynamic range available from the LTC6911-X (see further details under the AGND pin description). Low noise linear power supplies are recommended. Switching power supplies require special care to prevent switching noise coupling into the signal path, reducing dynamic range.

OUTB (Pin 8): Analog Output. This is the output of the B channel internal operational amplifier and can swing rail-to-rail (V^+ to V^-) as specified in the Electrical Characteristics table. The internal op amp remains active at all times, including the zero gain setting (digital input 000). For best performance, loading the output as lightly as possible will minimize signal distortion and gain error. The Electrical Characteristics table shows performance at output currents up to 10mA, and the current limits which occur when the output is shorted to mid-supply at 2.7V and ±5V supplies. Signal outputs above 10mA are possible but current-limiting circuitry will begin to affect amplifier performance at approximately 20mA. Long-term operation above 20mA output is not recommended. Do not exceed a maximum junction temperature of 150°C. The output will drive capacitive loads up to 50pF. Capacitances higher than 50pF should be isolated by a series resistor to preserve AC stability.

OUTA (Pin 10): Analog Output. Refer to OUTB pin description.

APPLICATIONS INFORMATION

Functional Description

The LTC6911-1/LTC6911-2 are small outline, wideband inverting 2-channel amplifiers whose voltage gain is digitally programmable. Each delivers a choice of eight voltage gains, controlled by the 3-bit digital parallel interface (G pins), which accept CMOS logic levels. The gain code is always monotonic; an increase in the 3-bit binary number (G2 G1 G0) causes an increase in the gain. Tables 1 and 2 list the nominal voltage gains for LTC6911-1 and LTC6911-2 respectively. Gain control within each amplifier occurs by switching resistors from a matched array in or out of a closed-loop op amp circuit using MOS analog switches (Figure 1). Bandwidth depends on gain setting. Curves in the Typical Performance Characteristics section show measured frequency responses.

Digital Control

Logic levels for the LTC6911-X digital gain control inputs (Pins 4, 5, 6) are nominally rail-to-rail CMOS, but can swing above V^+ so long as the positive swing does not exceed 10.5V with respect to $V^–$. Each logic input has a small pull-down current source which can sink up to 10µA and is used to force the part into a gain of "zero" if the logic inputs are left unconnected. A logic 1 is nominally V^+. A logic 0 is nominally $V^–$ or alternatively, 0V when using ±5V supplies. The parts are tested with the values listed in the Electrical Characteristics table. Digital Input "High" and "Low" voltages are 10% and 90% of the nominal full excursion on the inputs. That is, the tested logic levels are 0.27V and 2.43V with a 2.7V supply, 0.5V and 4.5V with a 5V supply, and 0.5V and 4.5V with ±5V supplies. Do not attempt to drive the digital inputs with TTL logic levels. TTL logic sources should be adapted with suitable pull-up resistors to V^+ keeping in mind the internal pull-down current sources so that for a logic 1 they will swing to the positive rail.

Timing Constraints

Settling time in the CMOS gain-control logic is typically several nanoseconds and is faster than the analog signal path. When amplifier gain changes, the limiting timing is analog, not digital, because the effects of digital input changes are observed only through the analog output (Figure 1). The LTC6911-X's logic is static (not latched) and therefore lacks bus timing requirements. However, as with any programmable-gain amplifier, each gain change causes an output transient as the amplifier's output moves, with finite speed, toward a differently scaled version of the input signal. Varying the gain faster than the output can settle produces a garbled output signal. The LTC6911-X analog path settles with a characteristic time constant or time scale, τ, that is roughly the standard value for a first order band limited response:

$$\tau = 0.35/(2\pi f_{-3dB})$$

See the –3dB BW vs Gain Setting graph in the Typical Performance Characteristics.

Offset Voltage vs Gain Setting

The Electrical Characteristics table lists DC gain dependent voltage offset error in two gain configurations. The voltage offsets listed, $V_{OS(IN)}$, are referred to the input pin (INA or INB). These offsets are directly related to the internal amplifier input voltage offset, $V_{OS(OA)}$, by the magnitude of programmed gain, G:

$$V_{OS(OA)} = V_{OS(IN)}\left(\frac{G}{1+G}\right)$$

The input referred offset, $V_{OS(IN)}$, for any gain setting can be inferred from $V_{OS(OA)}$ and the gain magnitude, G. For example, an internal offset $V_{OS(OA)}$ of 1mV will appear referred to the INA and INB pins as 2mV at a gain setting

APPLICATIONS INFORMATION

of 1, or 1.5mV at a gain setting of 2. At high gains, $V_{OS(IN)}$ approaches $V_{OS(OA)}$. (Offset voltage is random and can have either polarity centered on 0V.) The MOS input circuitry of the internal op amp in Figure 1 draws negligible input currents (unlike some op amps), so only $V_{OS(OA)}$ and G affect the overall amplifier's offset.

AC-Coupled Operation

Adding capacitors in series with the INA and INB pins convert the LTC6911-X into a dual AC-coupled inverting amplifier, suppressing the input signal's DC level (and also adding the additional benefit of reducing the offset voltage from the LTC6911-X's amplifier itself). No further components are required because the input of the LTC6911-X biases itself correctly when a series capacitor is added. The INA and INB analog input pins connect internally to a resistor whose nominal value varies between 10k and 1k depending on the version of LTC6911 used (see the rightmost column of Tables 1 and 2). Therefore, the low frequency cutoff will vary with capacitor and gain setting. For example, if a low frequency corner of 1kHz or lower on the LTC6911-1 is desired, use a series capacitor of 0.16µF or larger. A 0.16µF capacitor has a reactance of 1kΩ at 1kHz, giving a 1kHz lower –3dB frequency for gain settings of 10V/V through 100V/V. If the LTC6911-1 is operated at lower gain settings with an 0.16µF capacitor, the higher input resistance will reduce the lower corner frequency down to 100Hz at a gain setting of 1V/V. These frequencies scale inversely with the value of the input capacitor used.

Note that operating the LTC6911 family in "zero" gain mode (digital inputs 000) open circuits the INA and INB pins and this demands some care if employed with a series AC-coupled input capacitor. When the chip enters the zero gain mode, the opened INA or INB pin tends to sample and freeze the voltage across the capacitor to the value it held just before the zero gain state. This can place the INA or INB pin at or near the DC potential of a supply rail (the INA or INB pin may also drift to a supply potential in this state due to small junction leakage currents). To prevent driving the INA or INB pin outside the supply limit and potentially damaging the chip, avoid AC input signals in the zero gain state with an AC-coupled capacitor. Also, switching later to a nonzero gain value will cause a transient pulse at the output of the LTC6911-1 (with a time constant set by the capacitor value and the new LTC6911-1 input resistance value). This occurs because the INA and INB pins return to the AGND potential forcing transient current sourced by the amplifier output to charge the AC-coupling capacitor to its proper DC blocking value.

SNR and Dynamic Range

The term "dynamic range" is much used (and abused) with signal paths. Signal-to-noise ratio (SNR) is an unambiguous comparison of signal and noise levels, measured in the same way and under the same operating conditions. In a variable gain amplifier, however, further characterization is useful because both noise and maximum signal level in the amplifier will vary with the gain setting, in general. In the LTC6911-X, maximum output signal is independent of gain (and is near the full power supply voltage, as detailed in the Swing sections of the Electrical Characteristics table). The maximum input level falls with increasing gain, and the input-referred noise falls as well (as also listed in the table). To summarize the useful signal range in such an amplifier, we define Dynamic Range (DR) as the ratio of maximum input (at unity gain) to minimum input-referred noise (at maximum gain). This DR has a physical interpretation as the range of signal levels that will experience an SNR above unity V/V or 0dB. At a 10V total power supply, DR in the LTC6911-X (gains 0V/V to 100V/V) is typically 120dB (the ratio of a nominal $9.9V_{P-P}$, or $3.5V_{RMS}$ (maximum input), to the $3.8\mu V_{RMS}$ (high gain input noise). The SNR of an amplifier is the ratio of input level to input-referred noise, and can be 110dB with the LTC6911 family at unity gain.

APPLICATIONS INFORMATION

Construction and Instrumentation Cautions

Electrically clean construction is important in applications seeking the full dynamic range of the LTC6911 family of dual amplifiers. It is absolutely critical to have AGND either AC bypassed or wired directly, using the shortest possible wiring, to a low impedance ground return for best channel-to-channel isolation. Short, direct wiring will minimize parasitic capacitance and inductance. High quality supply bypass capacitors of 0.1µF near the chip provide good decoupling from a clean, low inductance power source. But several cm of wire (i.e., a few microhenrys of inductance) from the power supplies, unless decoupled by substantial capacitance (>10µF) near the chip, can create a high-Q LC resonance in the hundreds of kHz in the chip's supplies or ground reference. This may impair circuit performance at those frequencies. A compact, carefully laid out printed circuit board with a good ground plane makes a significant difference in minimizing distortion and maximizing channel isolation. Finally, equipment to measure amplifier performance can itself add to distortion or noise floors. Checking for these limits with wired shorts from INA to OUTA and INB to OUTB in place of the chip is a prudent routine procedure.

TYPICAL APPLICATION

Expanding an ADC's Dynamic Range

Figure 5 shows a compact 2-channel data acquisition system for wide ranging input levels. This figure combines an LTC6911-X programmable amplifier (10-lead MSOP) with an LTC1865 analog-to-digital converter (ADC) in an 8-lead MSOP. This ADC has 16-bit resolution and a maximum sampling rate of 250ksps. An LTC6911-1, for example, expands the ADC's input amplitude range by 40dB while operating from the same single 5V supply. The 499Ω resistor and 270pF capacitor couple cleanly between the LTC6911-X's output and the switched-capacitor inputs of the LTC1865.

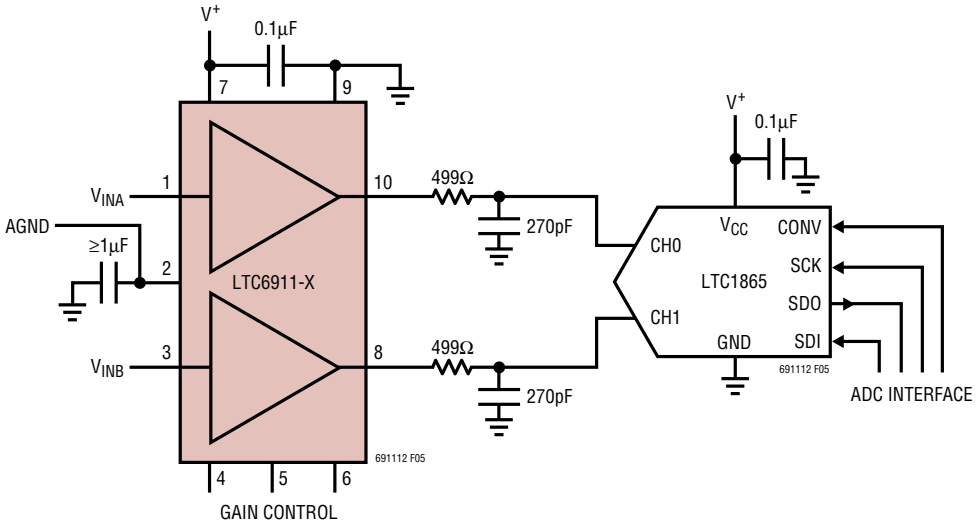
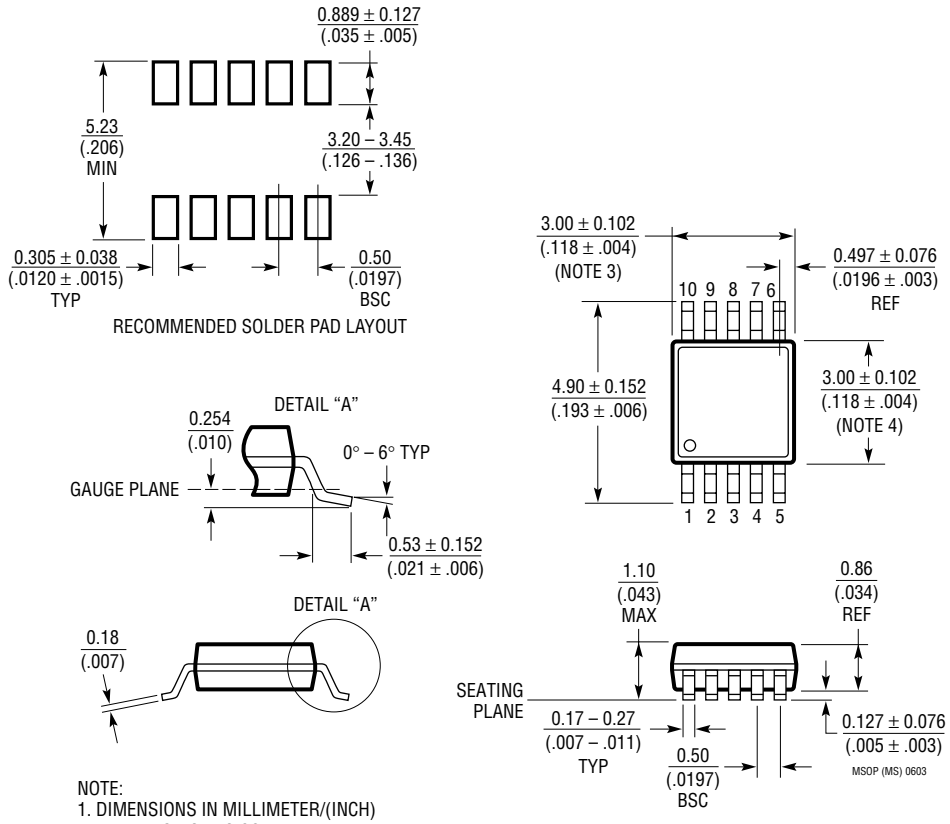


Figure 5. Expanding a Dual Channel ADC's Dynamic Range

PACKAGE DESCRIPTION

MS Package
10-Lead Plastic MSOP
(Reference LTC DWG # 05-08-1661)



NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
   MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
   INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX