DEMO CIRCUIT 861A
QUICK START GUIDE

DUAL, SPI PROGRAMABLE GAIN AMPLIFIER

LTC6912-1 AND LTC6912-2

DESCRIPTION

DC861A-A or -B demonstration circuit features a dual digitally programmable gain amplifier (PGA) IC, LTC6912-1 (DC861A-A) or LTC6912-2 (DC861A-B). The LTC®6912 is a family of dual channel, low noise, digitally programmable gain amplifiers (PGA) that are easy to use and occupy very little PC board space. The gains for both channels are independently programmable using a 3-wire SPI interface to select voltage gains of 0, 1, 2, 5, 10, 20, 50, and 100V/V (LTC6912-1); and 0, 1, 2, 4, 8, 16, 32, and 64V/V (LTC6912-2). All gains are inverting. The LTC6912 consists of 2 matched amplifiers with rail-to-rail outputs. Operating from single or split supplies from 2.7V to 10.5V total, the LTC6912-X is offered in tiny SSOP-16 and DFN-12 Packages (the DC861 board contains an LTC6912 in the SSOP-16).

The demo board highlights the following:

1. Two independent digitally programmable gain amplifiers.
2. A 2:1 Analog MUX with a dual PGA.
3. Daisy chain of two dual PGAs (must use two DC861boards).
4. A 4:1 Analog MUX with quad PGAs (must use two DC861boards).

On board switches and a 4-Digit LED display provide the user with the means to input PGA settings to a PIC (micro-controller). The PIC sends the settings to the PGA using a 3-wire SPI interface. Jumpers on board configure the demonstration circuit as a dual PGA or a 2:1 analog MUX. A flat ribbon cable and a connector are provided for the daisy-chain connection of two DC861 boards.

The DC861 demonstration circuit is a stand-alone board (computer control is not required).

Figure 1. Demonstration Circuit DC861A-A (LTC6912-1).

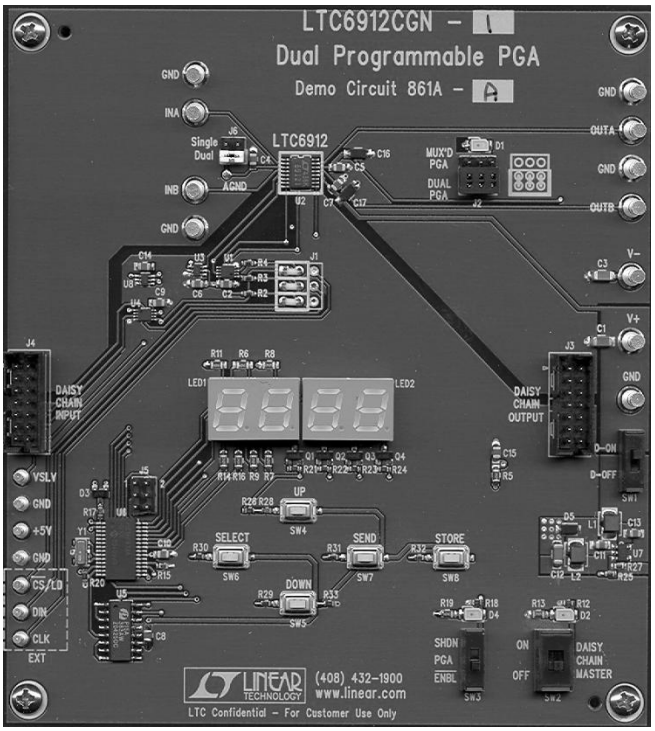


Figure 2. Block Diagram, LTC6912-1/2, SSOP -16 Package.

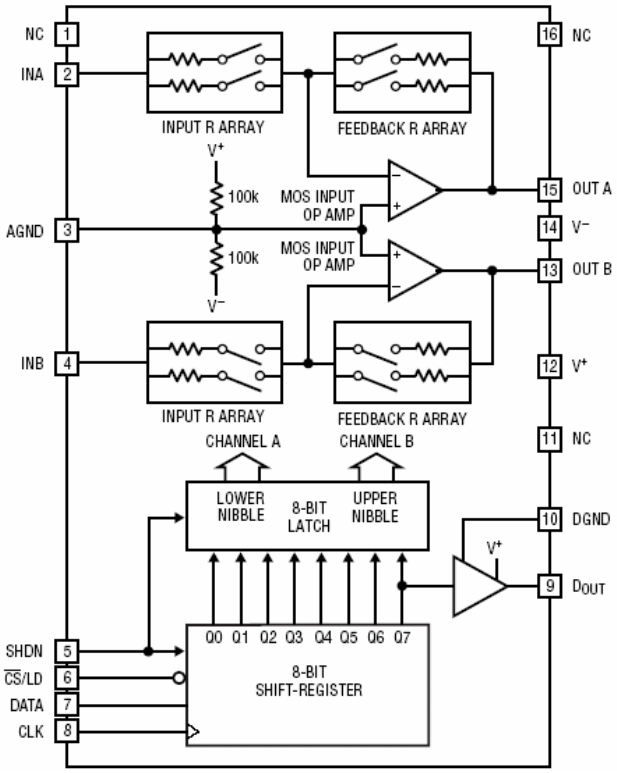


Table 1. LTC6912-1 GAIN SETTINGS AND PROPERTIES

UPPER/LOWER NIBBLE (Note 1)				NOMINAL VOLTAGE GAIN		MAXIMUM LINEAR INPUT RANGE (V_{P-P})			NOMINAL INPUT IMPEDANCE (kΩ)	NOMINAL OUTPUT IMPEDANCE (Ω)
Q7 Q3	Q6 Q2	Q5 Q1	Q4 Q0	Volts/Volt	dB	Dual 5V Supply	Single 5V Supply	Single 3V Supply		
0	0	0	0	0	–120	10	5	3	(Open)	0.4
0	0	0	1	–1	0	10	5	3	10	0.7
0	0	1	0	–2	6	5	2.5	1.5	5	3.4
0	0	1	1	–5	14	2	1	0.6	2	3.4
0	1	0	0	–10	20	1	0.5	0.3	1	3.4
0	1	0	1	–20	26	0.5	0.25	0.15	1	6.4
0	1	1	0	–50	34	0.2	0.1	0.06	1	15
0	1	1	1	–100	40	0.1	0.05	0.03	1	30
1	0	X	X	0	–120	10	5	3	(Open)	(Open)

Table 2. LTC6912-2 GAIN SETTINGS AND PROPERTIES

UPPER/LOWER NIBBLE (Note 1)				NOMINAL VOLTAGE GAIN		MAXIMUM LINEAR INPUT RANGE (V_{P-P})			NOMINAL INPUT IMPEDANCE (kΩ)	NOMINAL OUTPUT IMPEDANCE (Ω)
Q7 Q3	Q6 Q2	Q5 Q1	Q4 Q0	Volts/Volt	dB	Dual 5V Supply	Single 5V Supply	Single 3V Supply		
0	0	0	0	0	–120	10	5	3	(Open)	0.4
0	0	0	1	–1	0	10	5	3	10	0.7
0	0	1	0	–2	6	5	2.5	1.5	5	3.4
0	0	1	1	–4	12	2.5	1.25	0.75	2.5	3.4
0	1	0	0	–8	18.1	1.25	0.625	0.375	1.25	3.4
0	1	0	1	–16	24.1	0.625	0.3125	0.188	1.25	6.4
0	1	1	0	–32	30.1	0.3125	0.156	0.094	1.25	15
0	1	1	1	–64	36.1	0.156	0.078	0.047	1.25	30
1	0	X	X	0	–120	10	5	3	(Open)	(Open)

Note 1: States 13, 14 and 15 (binary 11xx) are not used. Programming a channel to states 8 or higher will configure that particular channel into a low power shutdown state. In addition, programming a channel into state 15 (binary 1111) will cause that particular channel to draw up to 20mA of supply current and is not recommended.

Description of the 3-Wire SPI Interface

Gain control of each amplifier is independently programmable using the 3-wire SPI interface (see Figure 3). Logic levels for the LTC6912 3-wire serial interface are TTL/CMOS compatible. When CS/LD is low, the serial data on DIN is shifted into an 8-bit shift-register on the rising edge of the clock, with the MSB transferred first. Serial data on DOUT is shifted out on the clock's falling edge. A rising edge on CS/LD will latch the shift-register's contents into an 8-bit D-latch and disable the clock internally on the IC. The upper nibble of the D-latch (4 most significant bits), configures the gain for the B-channel amplifier. The lower nibble of the D-latch (4 least significant bits), configures the gain for the A-channel amplifier. Tables 1 and 2 detail the nominal gains and respective gain codes.

Figure 3.Block Diagram, LTC6912-1/2 Serial Interface

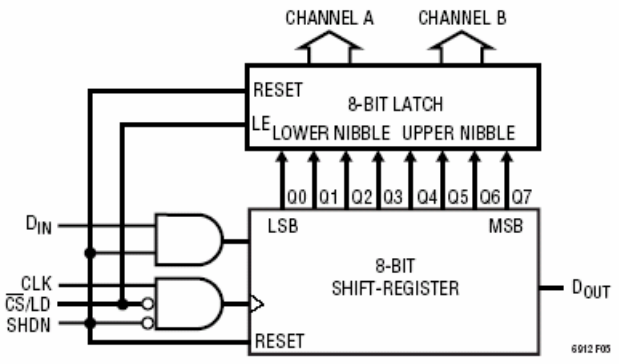
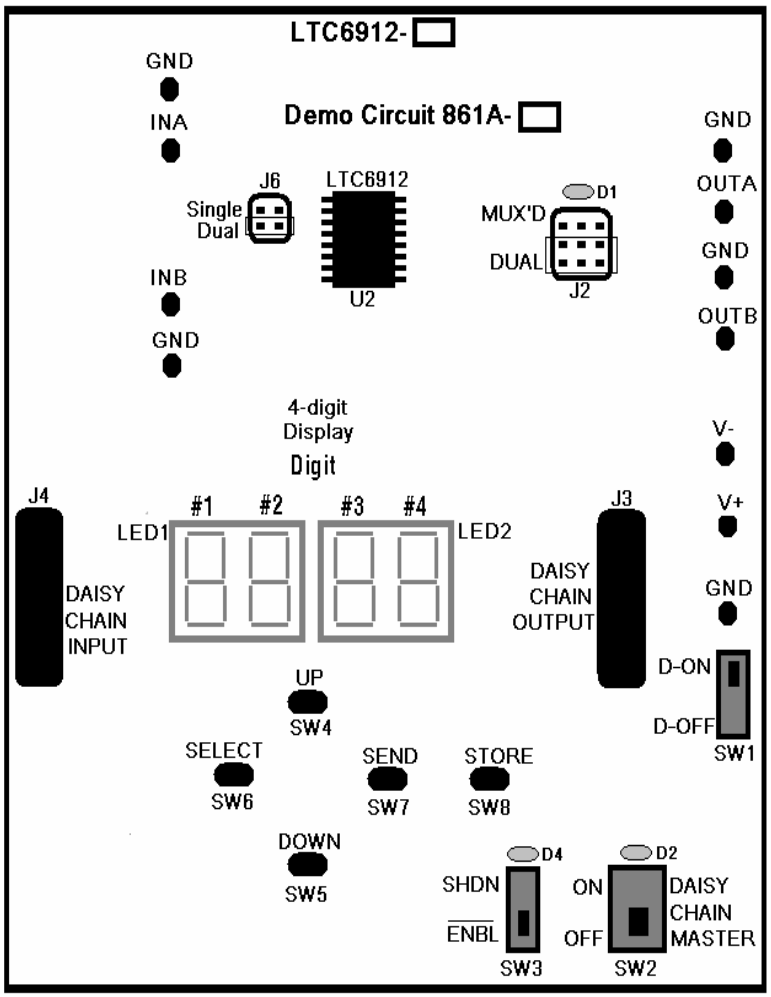


Figure 4. DC861A Inputs, Outputs, Jumpers, Switches and Connectors.

Jumper J6. Sets the LTC6912 for a dual or a single power supply operation. **In a single supply operation, the AGND pin of the LTC6912 is connected to V+/2 thru the J6 jumper and the V- input must be grounded externally. In addition, in a single supply operation the PGA A and B input should have a DC bias equal to V+/2 or be AC coupled.**

Jumper J2: Sets the LTC6912 for a dual PGA or a 2:1 analog MUX operation (the D1 LED is in a 2:1 MUX).



PGA A Input

PGA B Input

PGA A Output

PGA B Output

Jumper J4. Flat ribbon cable connection to a DC861 SPI master in daisy chain operation.

Power Supply Inputs.

Jumper J3. Flat ribbon cable connection to a DC861 SPI slave in daisy chain operation.

the 4-digit LED display shows the LTC6912 gain setting in hex. The display switches to decimal if the SELECT sw is pressed for more than three seconds.

SW1 to D-On: Provides power to the digital circuits and 4-digit LED.
SW1 to D-Off: Turns off power to the digital circuits and 4-digit LED.

SELECT SW: Selects 1 of 4 digits (the selected digit is blinking).
Pressing the SELECT SW for more than three seconds changes the LED display to show the LTC6912 setting in decimal.
UP SW: Increments selected digit.
DOWN SW: Decrements selected digit.
SEND SW: Sends SPI control to the LTC6912.
STORE SW: Stores last SPI control setting (available on power-up).

SW3 to ENBL: Power is on for the LTC6912.
SW3 to SHDN: Sets the LTC6912 to a hardware shut down (D4 LED is on in SHDN).
For normal board operation, set SW3 to ENBL.

SW2 to OFF: Sets the board for stand-alone or slave operation.
SW2 to ON: Sets the board as master SPI controller in a two DC861 board connection (the D2 LED is on in daisy chain master operation).

Initial Setup Procedure:

The following is an initial set-up guide to the function of the board's jumpers, switches and connectors (see Figure 4).

A. Dual PGA (one DC861)

1. Connect a DC861 board as shown in Figure 5.
   (J2-Dual, J6-DUAL, SW1-D-ON, SW2-OFF, SW3-ENBL).
2. Set the power supply to ±5V and turn it on.
3. Turn on the sinewave generator and set it to a 1Vp-p, 1kHz sinewave
   (refer to Tables 1 or 2 for the nominal PGA A and B input impedance).
4. On power up the 4-digit LED display shows the LTC6912 gain settings in hex
   (The gain setting shown on power up is the last stored setting).
   Holding the SELECT sw for more than three seconds changes the display to show decimal digits
   The correspondence between a hex number and a PGA setting is shown on Table 3.
   (See Figure 6 for display examples in hex and decimal digits).
6. Use the SELECT and UP and DOWN switches to select the gain and press the SEND switch to send the data to the LTC6912 (for a quick board test, set the PGA A and B gain to one (0dB) and the oscilloscope channels #1 and #2 connected to OUT A and OUT B respectively should show a 1Vp-p, 1kHz sinewave (1Vp-p input times one).

Table 3. Hex and Decimal Digits and PGA Settings.

Hex (Note 1)	LTC6912-1 Gain	Decimal	LTC6912-2 Gain	Decimal
0	0 (-120dB) (**Note 2**)	00	0 (-120dB) (**Note 2**)	00
1	-1	01	-1	01
2	-2	02	-2	02
3	-5	05	-4	04
4	-10	10	-8	08
5	-20	20	-16	16
6	-50	50	-32	32
7	-100	1H	-64	64
8	0 (-120dB) (**Note 3**)	H1	0 (-120dB) (**Note 3**)	H1
9	0 (-120dB) (**Note 3**)	H1	0 (-120dB) (**Note 3**)	H1
A	0 (-120dB) (**Note 3**)	H1	0 (-120dB) (**Note 3**)	H1
β	0 (-120dB) (**Note 3**)	H1	0 (-120dB) (**Note 3**)	H1

Note 1: The hex digits C, D, E and F are not used.

Note 2: The input is high impedance and the output is low impedance.

Note 3: The input and output are high impedance.

B. 2:1 Analog MUX

1. Connect a DC861 board as shown in Figure 5.
   (J2-Dual, J6-MUX'D, SW1-D-ON, SW2-OFF, SW3-ENBL).
2. Set the power supply to ±5V and turn it on.
3. Turn on the sinewave generator and set it to a 1Vp-p, 1kHz sinewave
   (refer to Tables 1 or 2 for the nominal PGA A and B input impedance).
4. Connect one oscilloscope channel to an output (in a MUX operation OUT A and B are shorted).
5. Use the SELECT and UP and DOWN switches to set the gain to one (0dB) for PGA A and two (6dB) for PGA B and press the SEND switch to send the data to the LTC6912.
6. Pressing the SEND switch repeatedly will show on the LED display an 01 or an 02 (the 2:1 MUX gain switches from one to two) and the output between OUT A or OUT B (the oscilloscope display should alternately show a 1Vp-p and a 2Vp-p, 1kHz sinewave (the 2:1 MUX switches between amplifier gains one and two).

C. QUAD PGA (Daisy Chain Operation of two DC861)

Note: In a daisy chain mode, the PGA settings are set in hex and on SEND the settings are shown in decimal.

1. Connect two DC861 boards as shown in Figure 7.
   (jumpers and switches on master and slave boards, J2-Dual, J6-DUAL, SW1-D-ON, SW3-ENBL).
2. On the master board set SW2 to ON and on the slave board set SW2 to OFF.
3. Set the power supply to ±5V and turn it on.
4. Turn on the sinewave generator and set it to a 0.1V p-p (100mV), 1kHz sinewave
   (refer to Tables 1 or 2 for the nominal PGA A and B input impedance).
5. The 4-digit display on the slave board should be blank and the gain settings for all four PGAs shown in hex digits on the master board's 4-digit LED display.
6. Use the SELECT and UP and DOWN switches to set on the master's display the gains in hex of the four PGAs as follows: #1 digit to 4, #2 digit to 3, #3 digit to 2 and #1 digit to 1.

Note: Before the SEND sw is pressed, the master display shows the PGA gain from left to right in the same sequence of the 16-bit SPI word (the setting for the slave PGA B is sent first then the setting for the slave PGA A, then the setting for the master PGA B and last the setting for the master PGA A).

7. Press the SEND switch to send the data to the LTC6912 on the master and slave boards.
8. The master and slave display and oscilloscope display should show:
   a. Master display digits #1 and 2, PGA B gain=02 and on oscilloscope channel #2 a 0.2Vp-p, 1kHz sinewave.
   b. Master display digits #3 and 4, PGA A gain=01 and on oscilloscope channel #1 a 0.1Vp-p, 1kHz sinewave.
   c. Slave display digits #1 and 2, PGA B gain=10 (LTC6912-1) or PGA B gain=08 (LTC6912-2) and on oscilloscope channel #4 a 1.0Vp-p, 1kHz sinewave (LTC6912-1) or a 0.8Vp-p, 1kHz sinewave (LTC6912-2).
   d. Slave display digits #3 and 4, PGA A gain=05 (LTC6912-1) or PGA B gain=04 (LTC6912-2) and on oscilloscope channel #3 a 0.5Vp-p, 1kHz sinewave (LTC6912-1) or a 0.5Vp-p, 1kHz sinewave (LTC6912-2).

(See Figure 7 example).

D. A 4:1 Analog MUX PGA (Daisy Chain Operation of two DC861)

Note: In a daisy chain mode, the PGA settings are set in hex and on SEND the settings are shown in decimal.

1. Connect two DC861 boards as shown in Figure 7.
   (jumpers and switches on master and slave boards, J2-Dual, J6-MUX'D, SW1-D-ON, SW2-OFF, SW3-ENBL).
2. On the master board set SW2 to ON and on the slave board set SW2 to OFF.
   Note: The daisy chain flat ribon cable shorts the master board's OUT A and B to the slave board's OUT A and B.
3. Set the power supply to ±5V and turn it on.
4. Turn on the sinewave generator and set it to a 0.1V p-p (100mV), 1kHz sinewave
   (refer to Tables 1 or 2 for the nominal PGA A and B input impedance).
5. The 4-digit display on the slave board should be blank and the gain settings for all four PGAs shown in hex digits on the master board's 4-digit LED display.
6. Use the SELECT and UP and DOWN switches to set on the master's display the gains in hex of the four PGAs as follows: #1 digit to 4, #2 digit to 3, and #3 digit to 2 and #1 digit to 1.
7. Press the SEND switch repeatedly and the display will show in sequence:
   a. on the master display 01 then 02 then on the slave display 10 and 05 (LTC6912-1) or
   b. on the master display 01 then 02 then on the slave display 08 and 04 (LTC6912-2).
   The oscilloscope display should show in sequence:
   a. 0.1Vp-p, 1kHz sine, 0.2Vp-p, 1kHz sinewave, 1.0Vp-p, 1kHz sinewave and 0.5Vp-p (for an LTC6912-1) or
   b. 0.1Vp-p, 1kHz sine, 0.2Vp-p, 1kHz sinewave, 0.8Vp-p, 1kHz sinewave and 0.4Vp-p (for an LTC6912-2).

ADDITIONAL BOARD FUNCTIONS

Note A: For the lowest analog noise and distortion tests, set SW1 to D-OFF after pressing the SEND sw. When SW-1 is set to D-OFF, the board's digital circuits are disconnected and the LTC6912 is a fixed gain amplifier (dual or single depending if the J6 junper is in DUAL or MUX'D position). The amplifier's gain is the last setting before the SEND sw is pressed.

Note B. For an optional external serial control of the LTC6912, remove the jumper wires of J1 from 1-2, 4-5 and 7-8 and connect jumper wires to 2-3, 5-6 and 8-9 (see DC861 schematic). The external SPI control inputs are the CLK, DN and CS/LD miniature turrets under connector J4 (on the lower left corner of DC861).

Note C. The VSLV miniature turret under the J4 connector is for monitoring the digital 5V voltage of the slave board in a daisy chain connection. The +5V miniature turret under the J4 connector is for monitoring the DC861 5V switching regulator that provides power to the board's digital circuits.

Figure 5. Dual PGA or 2:1 MUX Quick Set-Up (Dual Supply Operation)

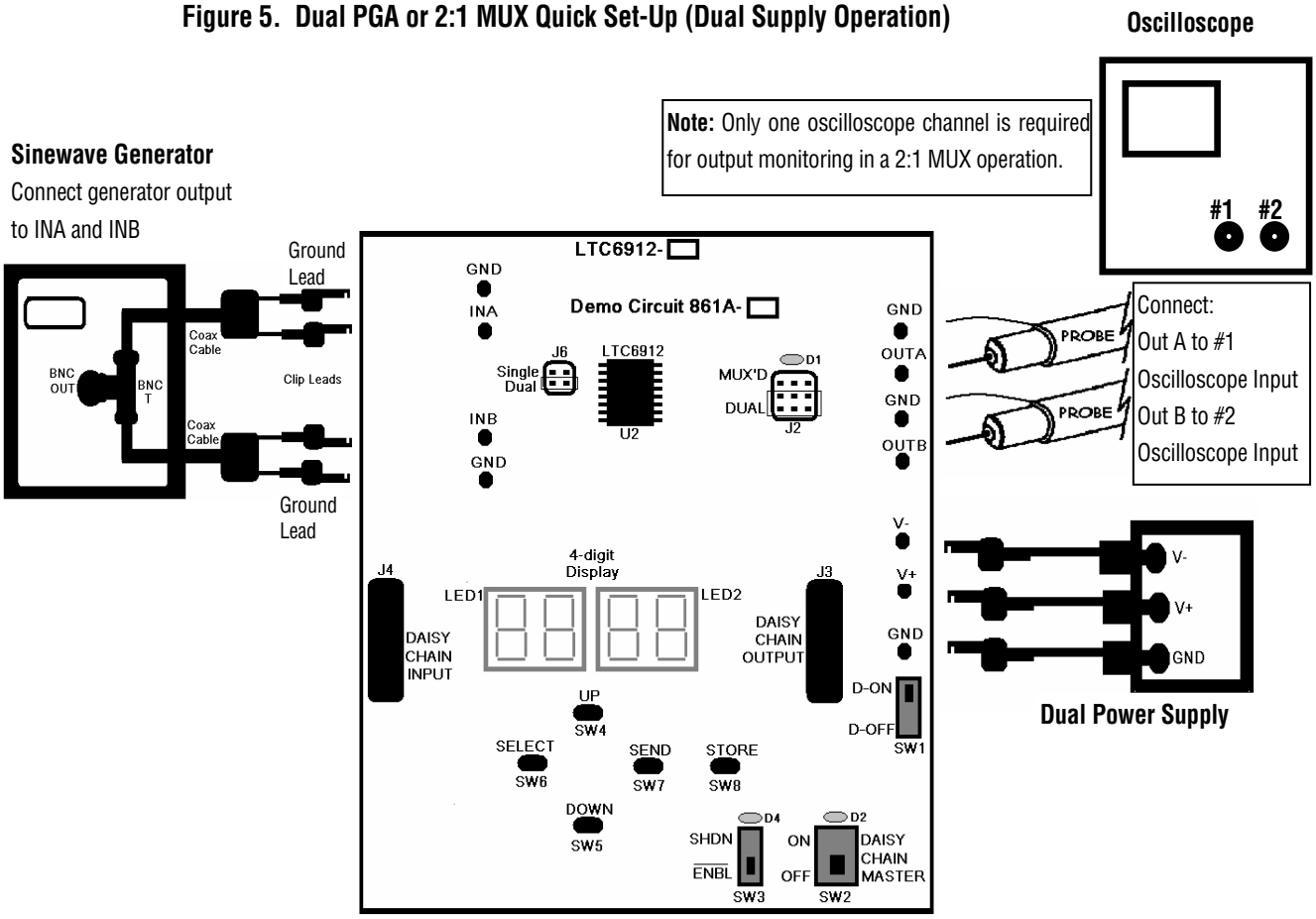


Figure 6. LED Display Examples in Hex and Decimal (LTC6912-1 or LTC6912-2)

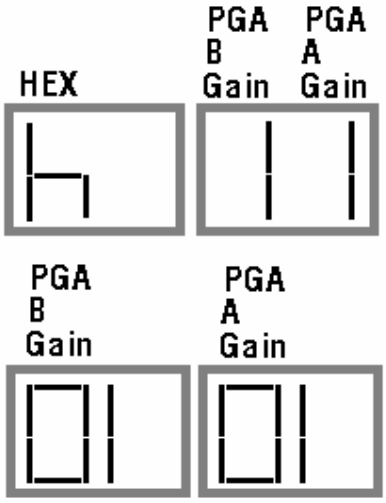
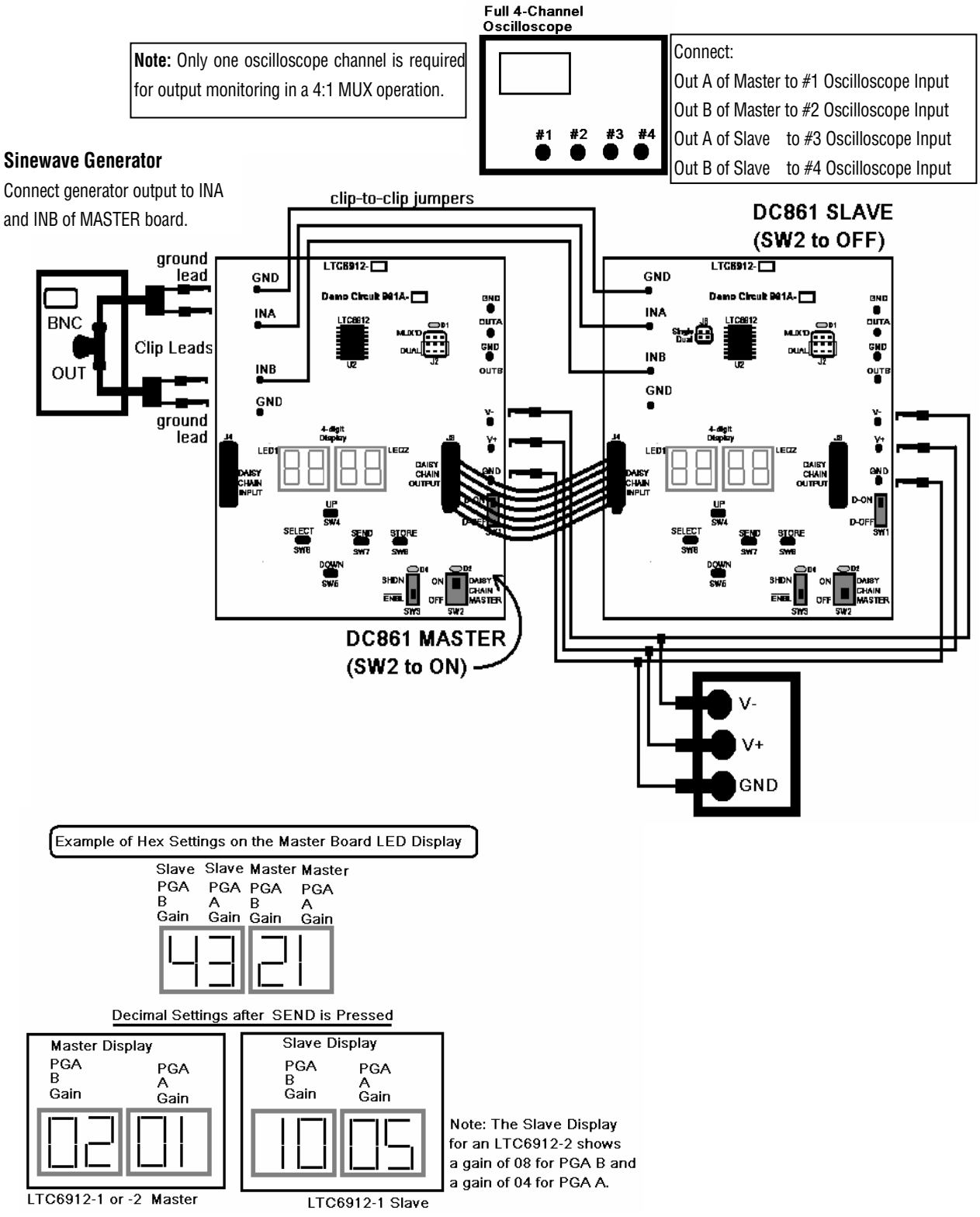


Figure 7. Quad PGA or 4:1 MUX Daisy Chain Quick Set-Up (Dual Supply Operation)



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