

# LTC2602

## Dual 16-Bit Rail-to-Rail V<sub>OUT</sub> DAC

### DESCRIPTION

Demonstration circuit 778A features the [LTC<sup>®</sup>2602](#) dual 16-Bit DAC. This device establishes a new board-density benchmark for 16-bit DACs and advances performance standards for output drive, load regulation, and crosstalk in single-supply, voltage-output DACs.

DC778A has many features for evaluating the performance of the LTC2602. Onboard 5V, 4.096V, and 2.5V precision references are provided, and the LTC2602 may be powered by the 5V reference for evaluating rail-to-rail operation.

Another feature of this board is the onboard LTC2422 20-bit ADC for monitoring DAC output voltage. The 16ppm total error of this device is adequate for taking meaningful measurements of various LTC2602 parameters.

**Design files for this circuit board are available at <http://www.linear.com/demo>**

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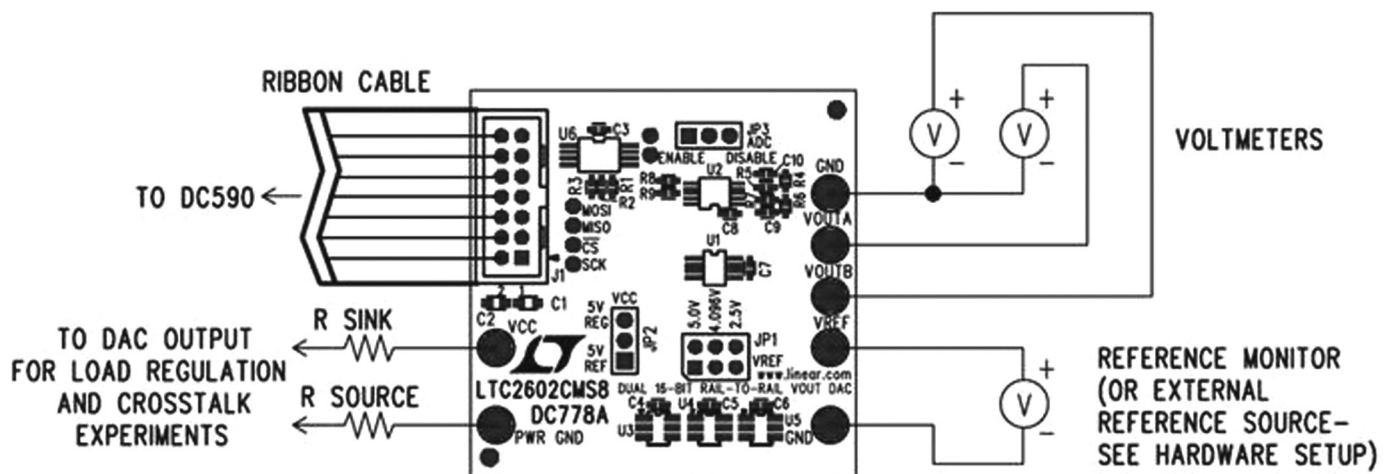


Figure 1. Proper Measurement Equipment Setup

### PERFORMANCE SUMMARY

PARAMETER	CONDITION	VALUE
Resolution		16 Bits
Monotonicity	$V_{CC} = 5V, V_{REF} = 4.096V$	16 Bits
Differential Nonlinearity	$V_{CC} = 5V, V_{REF} = 4.096V$	$\pm 1\text{LSB}$
Integral Nonlinearity	$V_{CC} = 5V, V_{REF} = 4.096V$	$\pm 12\text{LSB}$ Typical
Load Regulation	$V_{CC} = V_{REF} = 5V, \text{Mid-Scale}, I_{OUT} = \pm 15\text{mA}$	2LSB/mA Max
DC Crosstalk	Due to load current change on any other channel	3.5 $\mu\text{V}/\text{mA}$

## QUICK START PROCEDURE

Connect the DC778A to a DC590 USB serial controller using the supplied 14-conductor ribbon cable. Connect the DC590 to a host PC with a standard USB A/B cable. Run the QuikEval™ evaluation software supplied with the DC590 or download it from [www.linear.com/software](http://www.linear.com/software). The

correct control panel will be loaded automatically. Click the COLLECT button to begin outputting codes to the DAC and reading back the resulting output voltage.

Complete software documentation is available from the Help menu item, as features may be added periodically.

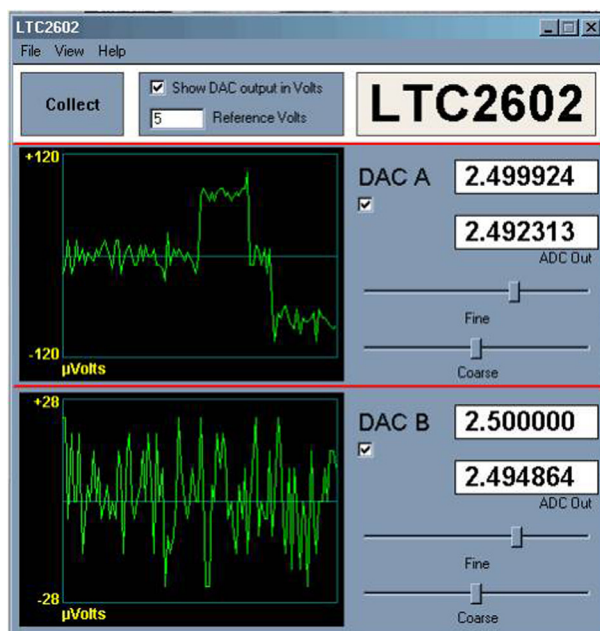


Figure 2. QuikEval Software Screenshot

## HARDWARE SETUP

### Jumpers

**JP1** –  $V_{REF}$  Select. Select 5V, 4.096V or 2.5V reference. To apply an external reference through the VREF turret, remove this jumper.

**JP2** –  $V_{CC}$  Select.  $V_{CC}$  is taken either from the onboard 5V reference or the 5V regulated supply from the controller board. Selecting the 5V reference for  $V_{CC}$  and  $V_{REF}$  allows characterization of rail-to-rail operation of the LTC2600.

**JP3** – ADC Disable. Set to ON for operation with the DC590 serial controller. When using in the customer's end application, the ADC can be completely disabled by setting jumper to DISABLE.

For very sensitive noise measurements when using the LTC supplied software, set the output voltage and stop reading voltage via the collect button on the control panel.

### Analog Connections

#### **VOUTA, VOUTB** – LTC2602 Outputs

**VREF** – The VREF turret is connected directly to the reference terminals of the LTC2602 and LTC2422 ADC. When one of the onboard references is being used, the reference voltage may be monitored at this point. An external reference may also be applied to this turret after removing JP1.

### Grounding and Power Connections

**Power ( $V_{CC}$ )** – Normally DC778A is powered by the DC590 controller.  $V_{CC}$  can be supplied to this turret, however the power supply on the DC590 must be disabled! Refer to the DC590 quick start guide for more details on this mode of operation.

## HARDWARE SETUP

**Grounding** – Separate power and signal grounds are provided. Any large currents drawn from the DAC outputs should be returned to the power ground. Also, if an external power supply is connected, the power ground should be used. The signal ground is connected to the exposed

ground planes at the top and bottom edges of the board, and to the two turrets labeled GND. Use signal ground as the reference point for measurements and connections to external circuits.

## EXPERIMENTS

The following experiments are intended to demonstrate some of the outstanding features of the LTC2602. All can be performed using the onboard LTC2422 to monitor the DAC output voltage. The indicated output voltage will typically agree with an HP3458A voltmeter to five digits. If a DAC is sinking or sourcing a significant current, then the output voltage should be measured as close to the DAC as possible.

Most of the data sheet specifications use a 4.096V reference, so this is the preferred reference to use for these experiments. Using the 5V reference has the limitation that  $V_{CC}$  may be slightly lower than  $V_{REF}$ , which may affect the full-scale error. Selecting the 5V reference as the source for  $V_{CC}$  overcomes this, however the total current that the LTC2602 can source will be limited to approximately 5mA.

Using an external power supply is highly recommended for these experiments, especially those that draw significant current. Refer to the DC590 quick start guide for details.

### Resolution

The onboard LTC2422 ADC has an input resolution of 6 $\mu$ V. This will easily resolve a 1LSB (76 $\mu$ V for  $V_{REF} = 5V$ , 62.5 $\mu$ V for  $V_{REF} = 4.096V$ ) change in the LTC2602 output. Set the DAC output to a voltage close to mid-scale. Select the FINE slider on the control panel with the mouse and use the right and left arrow keys to step the output by single LSBs. The change should be clearly visible in the output graph. (It may be necessary to wait for the graph to clear if a large step has just occurred.)

### Integral Nonlinearity

A rough measurement of INL can be taken using the onboard ADC. Measure one of the LTC2602 outputs at code 256 and 65,535 and calculate the slope and intercept using a

spreadsheet. Next, take several readings at intermediate points. The readings should not deviate from the calculated line by more than 64LSBs, and they will typically be within 12LSBs.

### Load Regulation/DC Output Impedance

Select “5V REG” for  $V_{CC}$  source. Set one of the outputs to mid-scale (code 32768.) source or sink 15mA from one of the DAC outputs by pulling it to power ground or  $V_{CC}$  with an appropriate value resistor. The voltage change should be less than 2.25mV, corresponding to an output impedance of 0.15 $\Omega$ . Output impedance is typically less than 0.030 $\Omega$ . (Measure DAC voltage at the output pin if using a voltmeter.)

### Zero-Scale Error

Set one of the DACs to code 0. The measured output should be less than 9mV and will typically be less than 1mV.

### Offset Error

Set one of the DACs to code 256. The output voltage should be within 9mV of the correct value, or  $V_{REF} \times 256/65535$ .

### Gain Error

Set one of the DACs to code 65,535. The output voltage should be within 0.7% of  $V_{REF}$ , and will typically be within 0.2%.

### DC Crosstalk

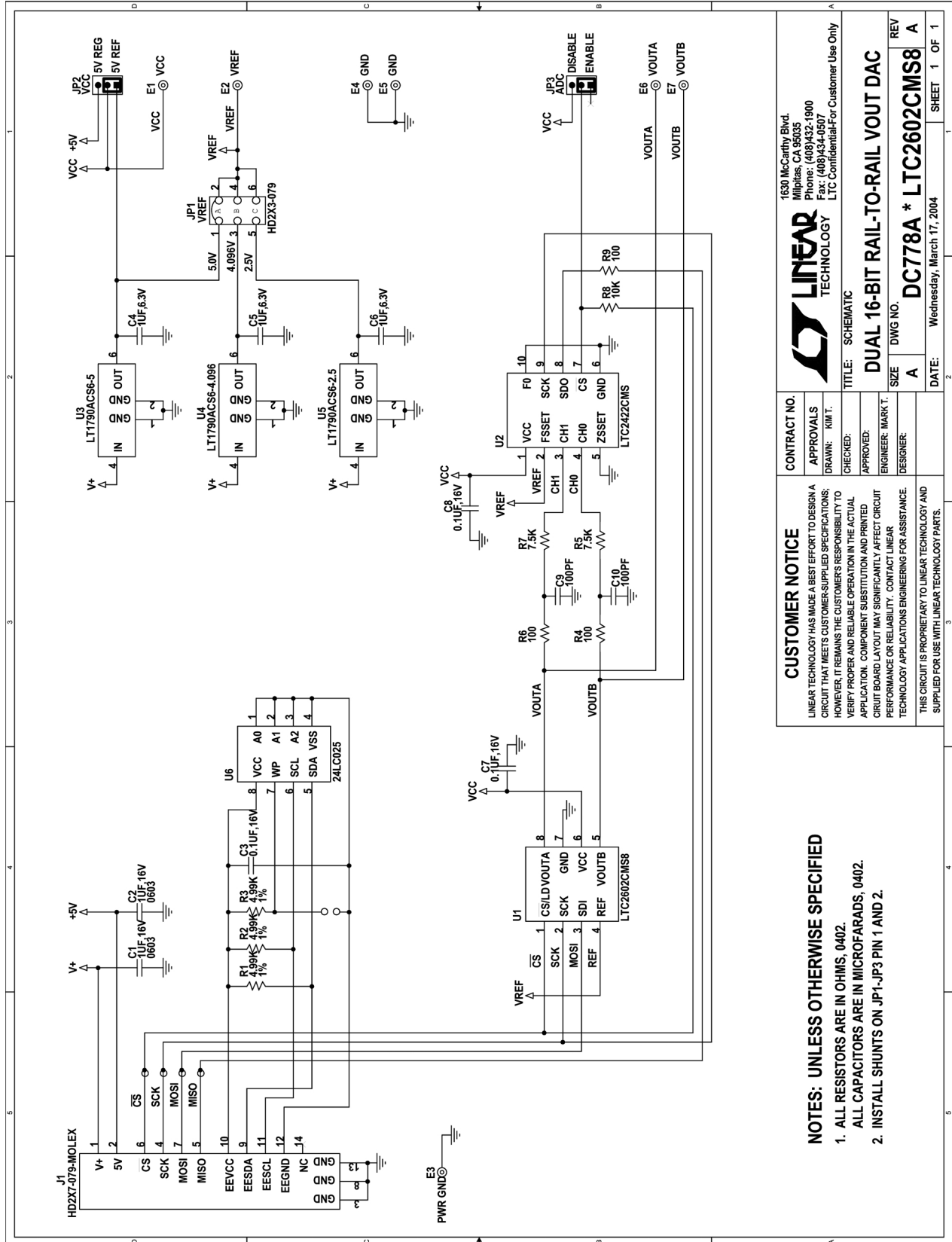
Set one of the DACs to mid-scale. Connect a 250 $\Omega$  resistor from the output to  $V_{CC}$  or power ground (to sink or source 10mA, respectively, when the 5V reference is being used.) The other output should not change by more than 3.5 $\mu$ V per milliamp of load current.

# DEMO MANUAL DC778A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURE/PART NUMBER
1	2	C1, C2	CAP., X7R, 1 $\mu$ F 16V, 0603	TDK, C1608X7R1C105MT
2	3	C3, C7, C8	CAP., X7R, 0.1 $\mu$ F 16V, 0402	TDK, C1005X7R1C104MT
3	3	C4, C5, C6	CAP., X5R, 1 $\mu$ F 6.3V, 0402	TDK, C1005X5R0J105MT
4	2	C9, C10	CAP., NPO, 100PF 50V, 0402	AVX, 04025A101MAT
5	7	E1, E2, E3, E4, E5, E6, E7	TESTPOINT, TURRET, 0.064"	MILL-MAX, 2308-2
6	1	JP1	JMP, 2X3, 0.079CC	COMM-CON, 2202S-06-G2
7	2	JP2, JP3	JMP, 3PIN 1 ROW 0.079CC	COMM-CON, 2802S-03-G1
8	3	SHUNTS FOR JP1-JP3 PIN 1 AND 2	SHUNT, 0.079" CENTER	COMM-CON CCIJ2MM-138G
9	1	J1	HEADER, 2X7PIN, 0.079CC	MOLEX, 87331-1420
10	3	R1, R2, R3	RES., CHIP 4.99k 1/16W 1%, 0402	AAC, CR05-4991FM
11	3	R4, R6, R9	RES., CHIP 100 $\Omega$ 1/16W 5%, 0402	AAC, CR05-101JM
12	2	R5, R7	RES., CHIP 7.5k 1/16W 5%, 0402	AAC, CR05-752JM
13	1	R8	RES., CHIP 10k 1/16W 5%, 0402	AAC, CR05-103JM
14	1	U1	I.C., LTC2602CMS8, MSOP8	LINEAR TECH., LTC2602CMS8
15	1	U2	I.C., LTC2422CMS, MSOP10	LINEAR TECH., LTC2422CMS
16	1	U3	I.C., LT1790ACS6-5, SOT23-6	LINEAR TECH., LT1790ACS6-5
17	1	U4	I.C., LT1790ACS6-4.096, SOT23-6	LINEAR TECH., LT1790ACS6-4.096
18	1	U5	I.C., LT1790ACS6-2.5, SOT23-6	LINEAR TECH., LT1790ACS6-2.5
19	1	U6	I.C., 24LC025, TSSOP8	MICROCHIP, 24LC025

**SCHEMATIC DIAGRAM**



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**CONTRACT NO.**  
**APPROVALS**  
 DRAWN: KMIT.  
 CHECKED:  
 APPROVED:  
 ENGINEER: MARK T.  
 DESIGNER:

**TITLE:** SCHEMATIC  
**DUAL 16-BIT RAIL-TO-RAIL VOUT DAC**  
**DC778A \* LTC2602CMS8**  
 SIZE: A  
 DWG NO. DC778A \* LTC2602CMS8  
 REV: A  
 DATE: Wednesday, March 17, 2004  
 SHEET 1 OF 1

- NOTES: UNLESS OTHERWISE SPECIFIED**
1. ALL RESISTORS ARE IN OHMS, 0402.
  2. ALL CAPACITORS ARE IN MICROFARADS, 0402.
  3. INSTALL SHUNTS ON JP1-JP3 PIN 1 AND 2.



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# DEMO MANUAL DC778A

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This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

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