

# Quad 12-/10-/8-Bit PWM to VOUT DACs with 10ppm/°C Reference

## DESCRIPTION

Demonstration circuit 2197A features the [LTC®2645](#), Quad 12-/10-/8-Bit PWM to VOUT DACs with 10ppm/°C reference in a tiny 4.9mm × 4mm 16-lead MSOP package. DC2197A-A is populated with the 2.5V, 12-bit version of the LTC2645.

The LTC2645 measures the period and pulse width of the Pulse Width Modulation (PWM) input and updates the voltage output DAC at each rising edge. The PWM frequency can be any frequency between 30Hz and 100kHz. The input

level can be between 1.71V and 5.5V, set by a separate IOVCC pin. This device solves many of the problems associated with filtering a PWM signal to produce an analog voltage, producing a fast-settling, accurate analog voltage in response to a digital PWM input.

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

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## BOARD PHOTO

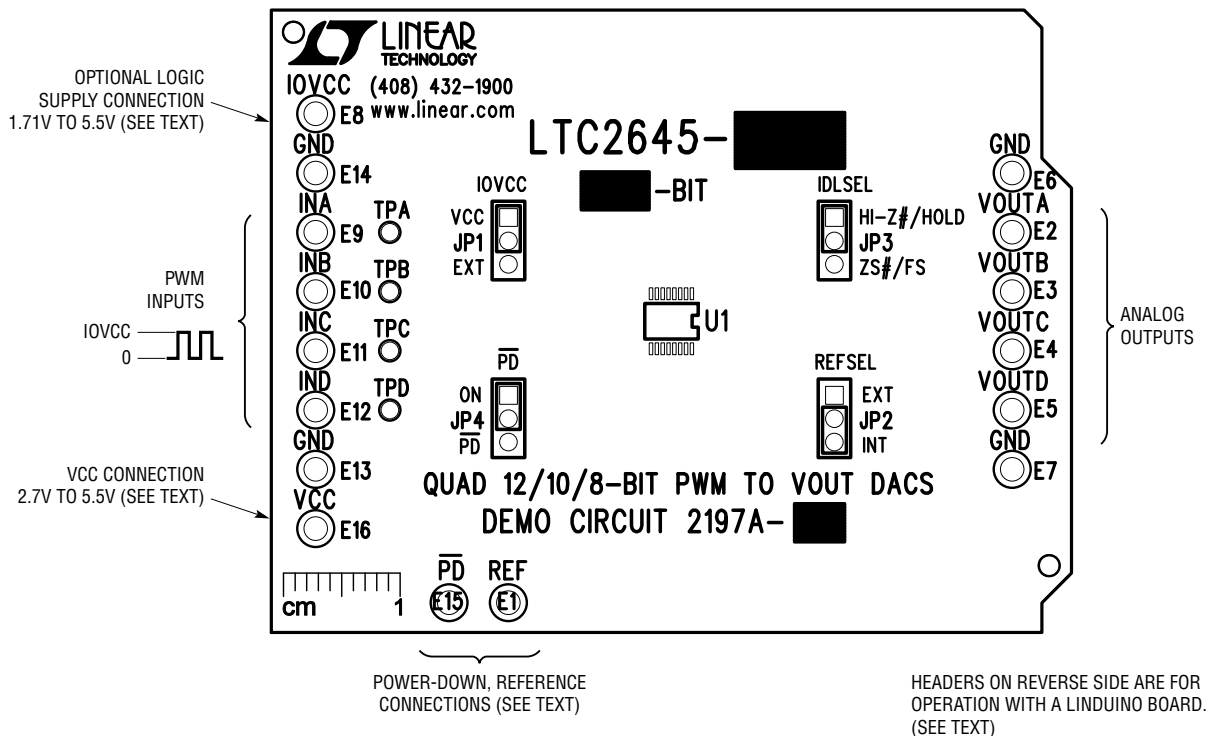


Figure 1. Basic Connections

## QUICK START PROCEDURE

### Standalone Operation

DC2197A makes evaluation of the LTC2645 very easy. Figure 1 shows the basic connections to operate the DC2197A as a standalone board. Connect a 2.7V to 5.5V supply to the VCC turret and a GND turret. IOVCC is connected to VCC by default such that the input logic level matches the VCC supply. If a different logic level is required, move the IOVCC jumper to the EXT position and connect a supply equal to the PWM signals' logic level to the IOVCC and GND turrets. There is no sequencing requirement between VCC and IOVCC.

Any convenient PWM source can be used. A pulse generator with a computer interface (GPIB, USB, Ethernet, etc.) can be used for characterization. In the end application, signals can originate from an FPGA, microcontroller, programmable logic controller (PLC), optocoupler, etc.

### Linduino Operation

DC2197A is in an “Arduino Shield” form factor, compatible with Linear Technology’s DC2026 Linduino board and other Arduino Uno compatible boards. This provides a convenient way to evaluate the LTC2645 under computer control. The Linduino board has two PWM outputs with 16-bit resolution and four with 8-bit resolution. INA and INB are connected to 16-bit PWM capable outputs on digital pins 9 and 10, INC and IND are connected to 8-bit PWM capable outputs on digital pins 5 and 6; these can be remapped by removing R8 – R11 and making appropriate connections to TPA – TPD. The Linduino program (“sketch”) provides a simple terminal interface allowing voltages or codes to be entered manually. It can also be controlled by any programming language that can communicate with a USB virtual COM port (Matlab, Python, C++, C#, etc.) The program can be modified as desired to change or add functionality.

Install the DC2197A onto the DC2026 as shown in Figure 2. Ensure that the IOVCC jumper is set to VCC.



## QUICK START PROCEDURE

### Altera C5G Board Operation

Altera's C5G evaluation board for the Cyclone 5 GX FPGA has an Arduino shield port that is compatible with the DC2197A. The C5G provides 5V to the LTC2645's VCC supply, so IOVCC must be changed to 3.3V to match the voltage of the digital signals coming from the FPGA. Remove the IOVCC jumper and solder a 100Ω resistor from the IOVCC turret post to the test point indicated in Figure 3. Make sure gaps between connectors in the upper and lower rows line up properly. The upper row (JP3 and JP4 on the C5G board) will match perfectly; JP10 will

have two empty holes on the left-hand side and JP11 will have two empty holes on the right-hand side.

A Quartus archive project and FPGA configuration binary file are included with the DC2197A design files. The program sends PWM signals to all four DACs. Two quadrature numerically controlled oscillators supply data to the PWM generator. While not normally intended for AC signal generation, this demonstration shows the cycle by cycle updating operation of the LTC2645. Figure 4 shows all four DAC outputs, and Figure 5 shows the details of the relationship between the PWM input and DAC output.

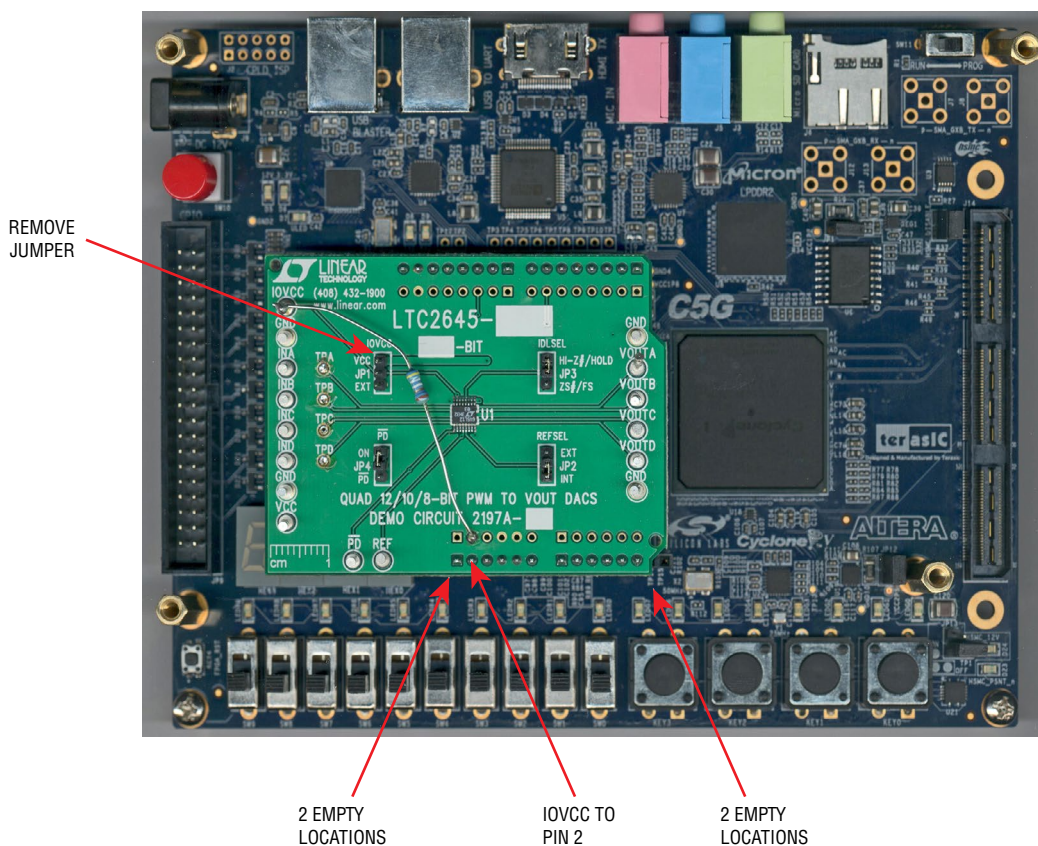
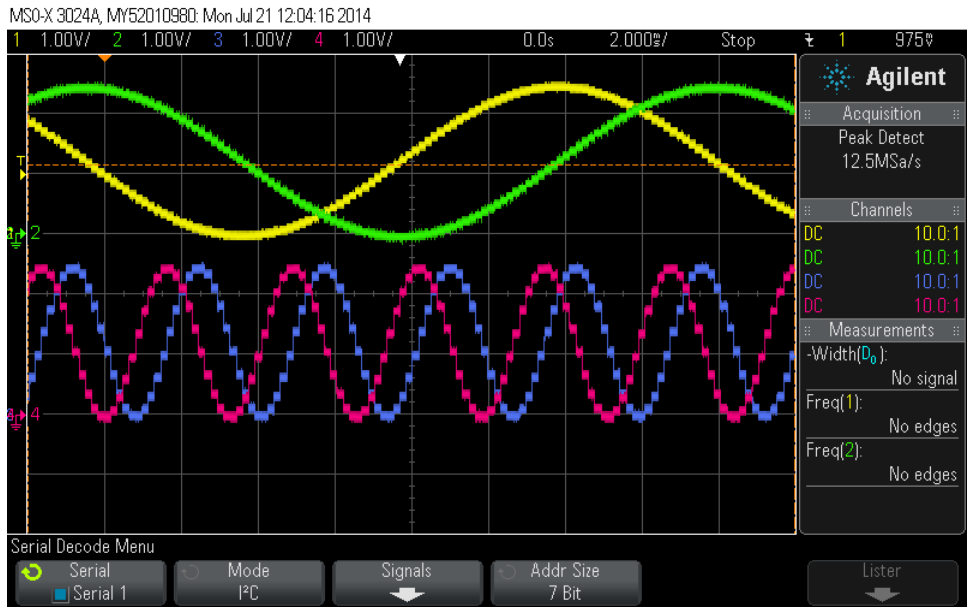
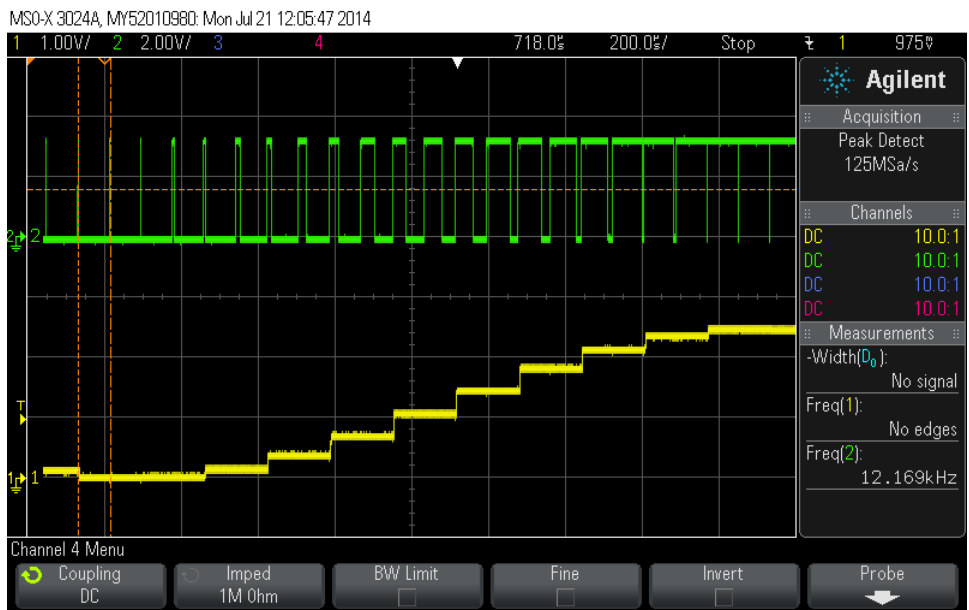


Figure 3. Altera C5G Connections

**QUICK START PROCEDURE**



**Figure 4. Altera Program Operation**



**Figure 5. PWM Details**

## QUICK START PROCEDURE

### EXTERNAL CONNECTIONS

**GND:** Four ground turrets are provided. These are connected directly to the ground plane and are the common connection for all supplies and signals.

**IOVCC:** I/O supply voltage that sets the high level of the PWM inputs. Connect to digital supply voltage between 1.71 and 5.5V. Often this can be connected to the same supply as the device that is providing the PWM signal (processor, FPGA, etc.).

**INA, INB, INC, IND:** PWM Inputs. Logic high level is determined by IOVCC.

**VOUTA, VOUTB, VOUTC, VOUTD:** DAC Voltage Outputs.

**VCC:** Analog Supply. Connect to low noise power supply between 2.7V and 5.5V.

**$\overline{\text{PD}}$ :** Active Low Power-Down Input. This signal may be driven externally if the  $\overline{\text{PD}}$  jumper is removed.

**REF:** Reference Output/Input. When the REFSEL jumper is set to INT, the LTC2645's internal reference can be measured at this point. Nominal impedance is 500 $\Omega$ . If it is used to drive external circuits it must be buffered appropriately. When REFSEL is set to EXT, an external reference between 1V and VCC may be connected to this point.

**Arduino Shield Connections** (IOL1, IOH1, ADO, POWER headers installed on back side of board) – These headers mate with the DC2026 Linduino and other Arduino Uno compatible microcontroller boards.

### JUMPERS

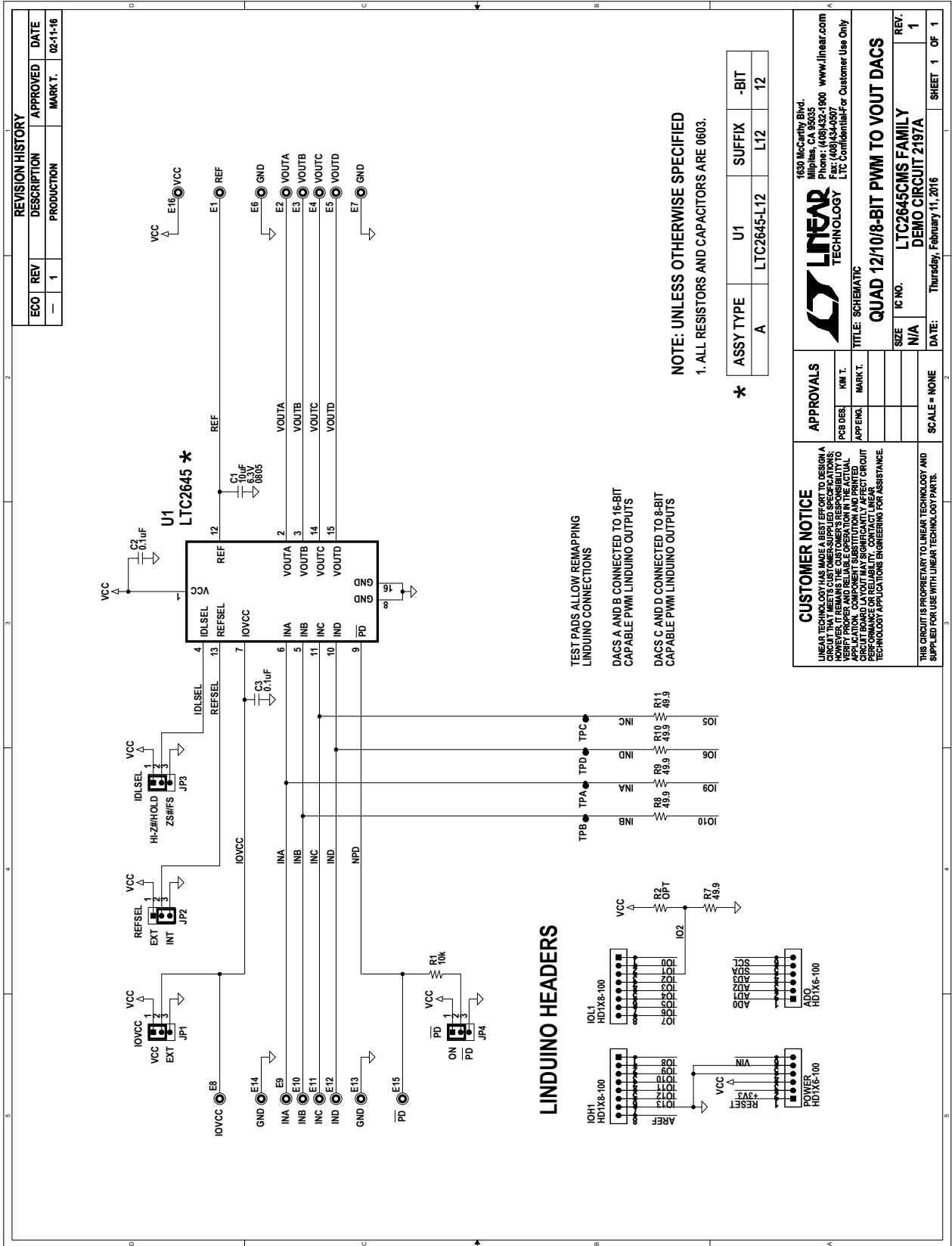
**IOVCC:** Set to VCC to connect IOVCC directly to VCC (default). No connection to the IOVCC turret is required in this case. Set to EXT if a separate supply is connected to the IOVCC turret.

**$\overline{\text{PD}}$ :** Power Down – Set to ON to enable normal operation (default.) Set to  $\overline{\text{PD}}$  to put the LTC2645 into shutdown mode.

**IDLSEL:** Idle Mode Select Input. Determines the DAC behavior when the PWM input remains high or low for more than the Idle Mode Timeout time (50ms minimum, 70ms maximum). When set to HI-Z#/HOLD (default), a low level on a PWM input will set the DAC output to a high-impedance state. A high level will cause the DAC output to hold its last value. When set to ZS#/FS, a low level on a PWM input will set the DAC output to zero-scale, and a high level will set the DAC output to full-scale.

**REFSEL:** Set to INT (default) to use the internal reference. Set to EXT to supply an external reference to the REF turret post.

**SCHEMATIC DIAGRAM**





# DEMO MANUAL DC2197A

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