Circuits from the Lab® Reference Designs

Circuits from the Lab® reference designs are engineered and tested for quick and easy system integration to help solve today's analog, mixed-signal, and RF design challenges. For more information and/or support, visit www.analog.com/CN0417.

Devices Connected/Referenced	
ADL5606	1800 MHz to 2700 MHz, 1 W RF Driver Amplifier
LTM8045	Inverting or SEPIC µModule, DC-to-DC Converter with Up to 700 mA Output Current

USB Powered 2.4 GHz RF Power Amplifier

EVALUATION AND DESIGN SUPPORT

Circuit Evaluation Boards

CN-0417 Circuit Evaluation Board (EVAL-CN0417-EBZ)

Design and Integration Files

Schematics, Layout Files, Bill of Materials

CIRCUIT FUNCTION AND BENEFITS

Most of the modern radio-link systems capable of transmitting signals have limited output power. Depending on the environment and signal power, the range of transmission varies. For longer range of operation or enviroments with more RF interference, a higher output power is required. In this case, RF power amplifiers are used to increase the magnitude of power of transmitted signals to a level high enough to reach a given distance.

The circuit shown in Figure 1 is a small USB powered RF power amplifier optimized for 2400 MHz operation. The amplifier typically provides 20 dB of gain through its RF band of operation, boosting signals for various communication protocols such as ISM, MC-GSM, W-CDMA, TD-SCDMA and LTE. It requires 5 V USB supply for normal operation. The input and output, both populated with edge mounted SMA connectors, are dc blocked and matched to 50 Ω for ease of use.

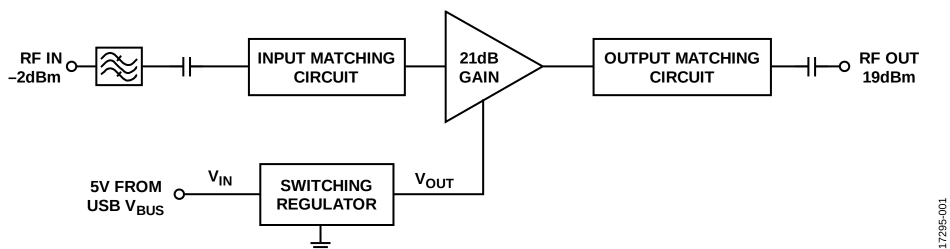

Figure 1. Block Diagram of EVAL-CN0417-EBZ

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 www.analog.com
Fax: 781.461.3113

CIRCUIT DESCRIPTION

Amplifier

The ADL5606 is a broadband, two-stage, 1 W RF driver amplifier that operates over a frequency range of 1800 MHz to 2700 MHz. The device can be used in a wide variety of wired and wireless communication protocols, including ISM, MC-GSM, W-CDMA, TD-SCDMA, and LTE.

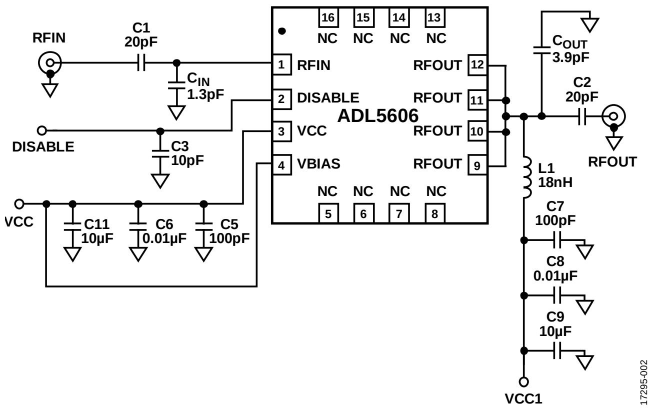

Figure 2. Basic Connections on ADL5606

The ADL5606 operates on a 5 V supply voltage and a supply current of 362 mA. The driver also incorporates a fast power up/power-down function for time division duplex (TDD) applications such as WiMAX and Wi-Fi, applications that require a power saving mode and applications that intermittently transmit data. When disabled, the ADL5606 draws approximately 4 mA of current from the power supply and 1.4 mA from the DISABLE pin.

Impedance Matching

The RF input (Pin 1) and RF outputs (Pin 9 to Pin 12) of the ADL5606 can be matched to 50 Ω with at most one external component and the microstrip line used as an inductor.

The recommended component values for ADL5606 matching are provided in the product data sheet for three frequency bands: 1960 MHz, 2140 MHz, and 2630 MHz. For this application, the recommended matching capacitances values used were from the 2630 MHz operation.

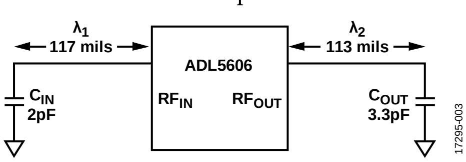

Figure 3. ADL5606 Matching Network Parameters

The placement of these matching capacitances are critical. The recommended spacing for ADL5606 matching is provided in the product data sheet for three frequency bands: 1960 MHz, 2140 MHz, and 2630 MHz. For this application, the recommended spacing used was for the 2630 MHz operation. This was further optimized from simulations in Advanced Design System (ADS) for the desired 2400 MHz operation. Results from simulation gave 117 mils for the input matching length and 113 mils for the output matching length. The component spacing is referenced from the center of the matching component to the edge of the ADL5606.

Bandpass Filter

The input signal is filtrated by this bandpass filter and centers it at 2450 MHz with a 100 MHz bandwidth of operation. Figure 2 shows the electrical performance of the bandpass filter.

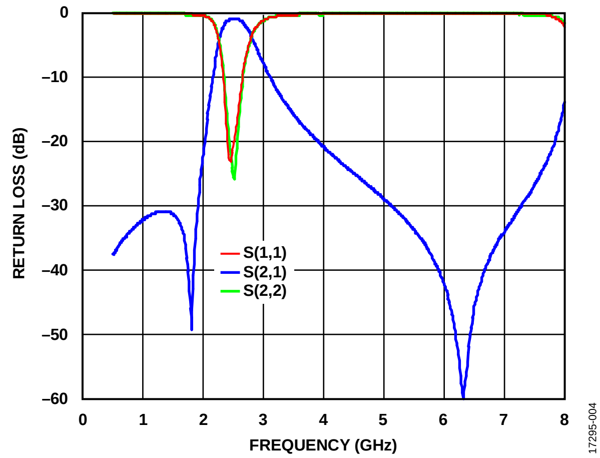

Figure 4. Typical Electrical Performance of Bandpass Filter

It has a frequency of operation from 2400 MHz to 2500 MHz, return loss of 1.5 dB maximum and return loss of 9.5 dB maximum. The input power to the bandpass filter is at 2 W maximum.

USB Power Management

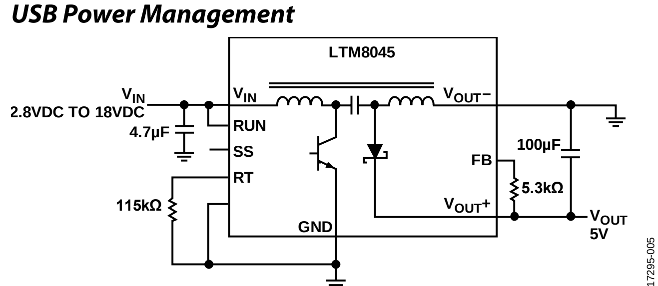

Figure 5. Basic SEPIC Connections for LTM8045 with 5 volts Output

The circuit is powered by the 5 V V_{BUS} voltage available on the USB port, which is then regulated by the LTM8045.

The LTM8045 is an integrated switching dc-to-dc converter that contains a current mode controller, power switching element, power coupled inductor, power Schottky diode, and a modest amount of input and output capacitance.

The device is configured as a SEPIC converter capable of accepting input voltage up to 18 V dc. The output is adjustable between 2.5 V and 15 V. It can provide approximately 430 mA at V_{IN} = 5 V when V_{OUT} = 5 V or −5 V.

The LTM8045 output voltage is set by connecting the feedback resistor (R_{FB}) from V_{OUT}+ to the FB pin. This voltage serves as the supply voltage for the amplifier ADL5606. Its value is determined from the following equation:

$$R_{FB} = \frac{V_{OUT} - 1.215}{0.0833}(\text{k}\Omega)$$

The LTM8045 has an operational switching frequency range between 200 kHz and 2 MHz. The switching frequency of the

LTM8045 is configured using an external resistor from the RT pin to ground. Value of the eternal resistor can be determined using the following equation:

$$R_T = \frac{91.9}{f_{OSC}} - 1(\text{k}\Omega)$$

where f_{OSC} is the typical switching frequency in MHz.

Though the LTM8045 is flexible enough to accommodate a wide range of operating frequencies, a haphazardly chosen one may result in undesirable operation under certain operating or fault conditions. A frequency that is too high can reduce efficiency, generate excessive heat, or even damage the LTM8045 in some fault conditions. A frequency that is too low can result in a final design that has too much output ripple or too large of an output capacitor.

The recommended switching frequency and resistor value for optimal efficiency over the given input and output conditions are provided in the LTM8045 data sheet. In the circuit, the R_T resistor value is achieved by using two resistors in parallel to provide two places for feedback that sum together with a double filter, achieving a better filter performance.

Because the LTM8045 is a coupled inductor SEPIC, it is susceptible to large switching spikes. That is why in addition to ferrite bead at the output, an LC filter stage was for the switching spikes at 80 MHz to 150 MHz.

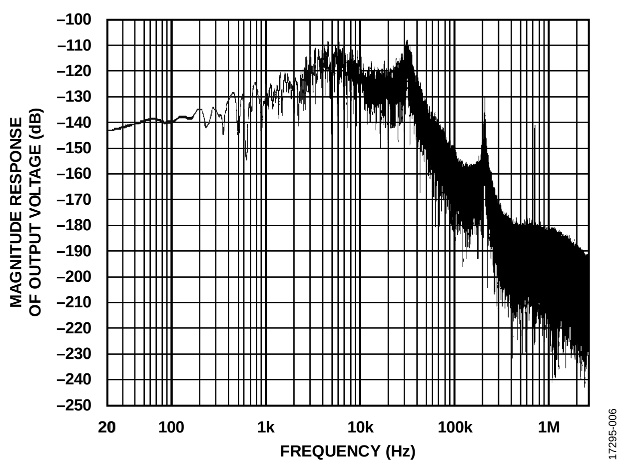

Figure 6. Output Filter Simulation for the LTM8045 Using LTSPICE

RF Performance

When the circuit is functioning, the input signal is amplified from the RF input to output at typical 20 dB gain. Figure 8 shows the S-parameters of the circuit.

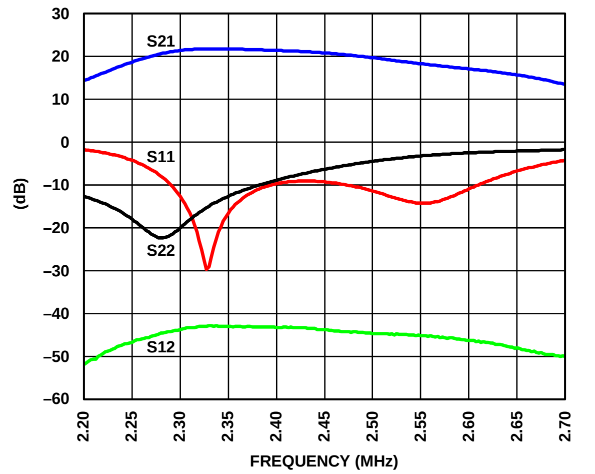

Figure 7. S-Parameters of EVAL-CN0417-EBZ

Thermal Considerations

When in operation, the power dissipation and board properties must be considered. Because the size of the board is quite small, the board temperature reaches approximately 80°C around the vicinity of the ADL5606. To spread this heat evenly and keep the board temperature below 80°C, the ground copper plane was made thicker at 3 oz, and more vias were added around the ADL5606 chip. Sigrity simulation can also be used to estimate the board temperature.

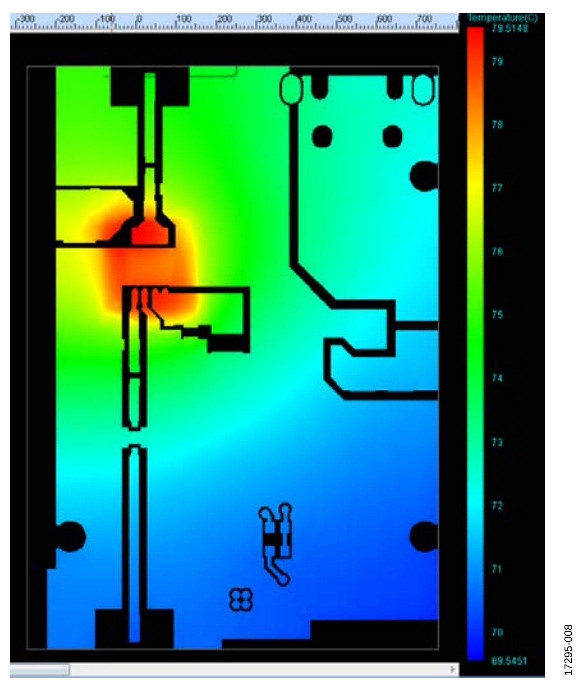

Figure 8. Board Temperature Simulation at Normal Operation

COMMON VARIATIONS

For a different frequency band of operation, the ADL5604 and ADL5605 can be used. The ADL5604 is capable of a wide frequency of operation from 700 MHz to 2700 MHz, with a typical gain of 12.2 dB. The ADL5605 operates from 700 MHz to 1000 GHz at 23 dB typical gain.

Analog Devices, Inc., driver amplifiers are available in a wide range of medium power general-purpose amplifiers covering the frequency range from 400 MHz (IF) to RF microwave and W-band (86 GHz). These driver amplifiers include output powers from 15 dBm up to approximately 1 W and covers various frequencies, bandwidths, and gain levels.

CIRCUIT EVALUATION AND TEST

Equipment Needed

The following equipment is needed:

- EVAL-CN0417-EBZ circuit evaluation board
- RF signal source (RF signal generator, ADALM-Pluto)
- Micro-USB power adaptor or micro-USB to USB cable
- SMA to SMA cable

Getting Started

Connect the RF signal to J1 of the EVAL-CN0417-EBZ.

Functional Block Diagram

Figure 10 shows the functional block diagram of the test setup.

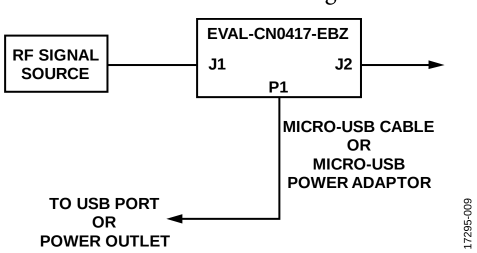

Figure 9. Test Setup Functional Block Diagram

Setup and Test

Directly connect the RF output port of the RF signal source to the EVAL-CN0417-EBZ RF input (J1). The RF output of the EVAL-CN0417-EBZ (J2) is then connected to the desired equipment or device under test (DUT) that needs the amplified signal through an SMA male to SMA male cable.

Plug in the micro-USB end of the second micro-USB power adaptor to P1 of the EVAL-CN0417-EBZ. Plug the other end to a power outlet or a PC USB port. The EVAL-CN0417-EBZ then automatically turns on.

Figure 10. Top View of EVAL-CN0417-EBZ Board

Figure 11. Bottom View of EVAL-CN0417-EBZ Board

Figure 11 shows a photograph of the top of the EVAL-CN0417-EBZ. The bottom view in Figure 12 shows the EVAL-CN0417-EBZ connected to a micro-USB cable for supply

For complete information and details regarding test setup and how to use the software and hardware combined, see the CN-0417 User Guide.

LEARN MORE

Musceac, Adrian. "RF power amplifiers for SDR." qradiolink.org. 2017.

Data Sheets and Evaluation Boards

ADL5606 Data Sheet

LTM8045 Data Sheet

REVISION HISTORY

11/2018—Revision 0: Initial Version