

System Board 6276

MAXREFDES111#: ISOLATED 24V TO 5V 2W FLYBACK POWER SUPPLY

Overview

Maxim's power supply experts have designed and built a series of isolated, industrial power-supply reference designs. Each of these power supplies efficiently converts 24V into useful voltage rails at a variety of power levels. Every power rail is isolated with a readily available transformer from multiple, global vendors, providing for quick, convenient transformer selection. Each design has been tested for load and line regulation, as well as efficiency and transient performance. As with all Maxim reference designs, the BOM, schematics, layout files, and Gerber files are all available. In addition, boards are available for purchase; most boards feature through-hole pins for immediate board placement and accelerated prototyping.

MAXREFDES111# has an efficient flyback topology with 24V input, and a 5V output at 2W of power (0.4A). The design features the MAX17498B, a peak-current-mode converter with internal n-channel MOSFET switch. This entire circuit fits on a 36mm x 20mm (1.4in x 0.8in) board.

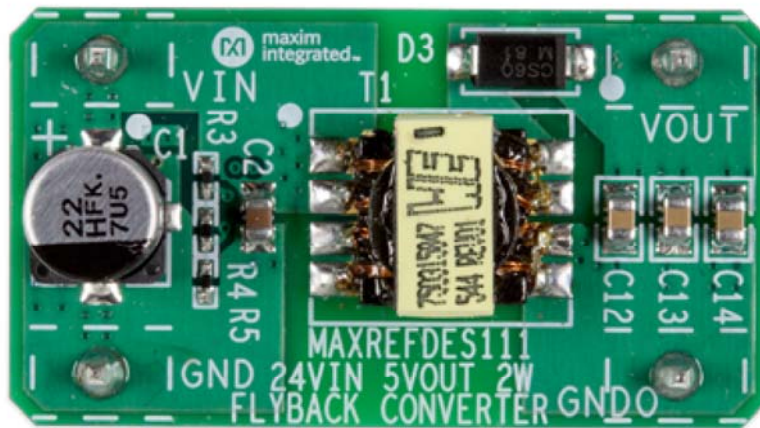
Features

- Functional Insulation
- Compact and Flexible
- Minimal External Components
- Robust Operation in Adverse Industrial Environments
- 5V 400mA with 20% Overrange Current
- $\pm 5\%$ Output Accuracy

Applications

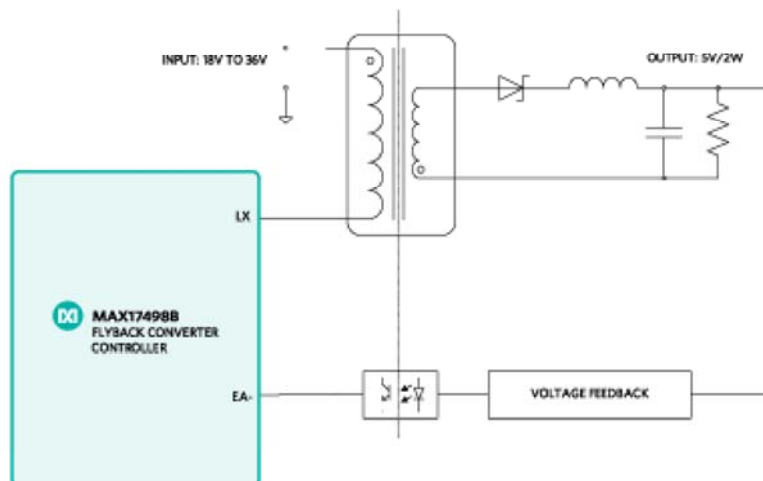
- Industrial control and automation
- Process control
- PLC
- Telecom and Datacom power supplies

MAXREFDES111# System Board



Enlarge+

MAXREFDES111# Reference Design Block Diagram



System Board 6276

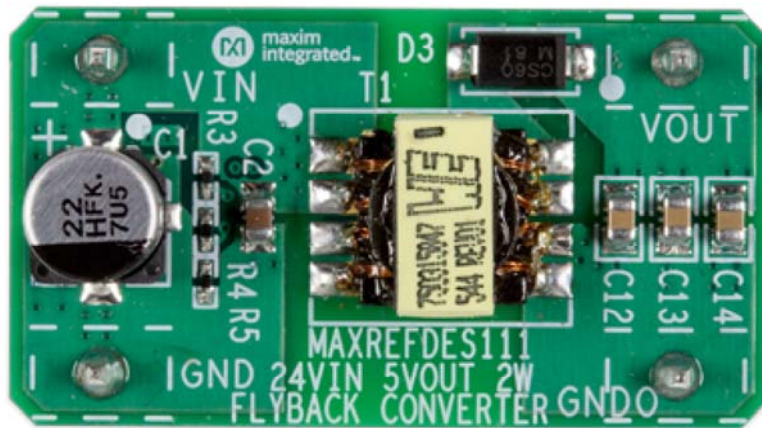
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Details

Introduction

Isolated power supplies provide reliable power regulation for a variety of applications. Transformer selection is often the most difficult step in isolated power design. The MAXREFDES111# is a compact 24V input flyback-converter module that features 5V at 400mA output. Multiple transformers (Würth Electronics 750315847, HanRun HR041087, and Sumida 06343-T588) have been qualified for this design, simplifying the process of transformer selection. In addition, through-hole pins on the bottom side of the module allows quick and easy integration of this power converter into the main system. Pins are 15mm (0.6in) from power to ground, and 28mm (1.1in) from the input side to the output side.

MAXREFDES111# System Board



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The MAX17498B is a peak-current-mode controller for design of wide input-voltage flyback and boost regulators. The reference design operates over an 18V to 36V input voltage range, and provides up to 400mA (plus 20% overhead) at 5V output. The device uses an internal n-channel MOSFET to implement switching and internal current sensing for current-mode control and overcurrent protection of the flyback converter. The device incorporates a flexible error amplifier and an accurate reference voltage to enable the end user to regulate both positive and negative outputs. The device has a fixed switching frequency of 500kHz.

The input undervoltage lockout (EN/UVLO) is provided for programming the input-supply start voltage (set to 18V in the design), and to ensure proper operation during brownout conditions. The EN/UVLO input is also used to turn on/off the IC. The overvoltage input (OVI) protection scheme is provided to make sure that the controller shuts down when the input supply exceeds its maximum allowed value (set to 36V in the design).

A capacitor is connected to the SS pin to program the soft-start period; hence, reducing the input inrush current during startup. Hiccup-mode overcurrent protection and thermal shutdown are provided to minimize dissipation in overcurrent and overtemperature fault conditions.

The reference design delivers a peak efficiency of 79% with the supplied components when the input is 24V. This general-purpose power solution can be used in many different types of power applications, such as programmable logic controllers (PLC), industrial process control, industrial sensors, telecom power supplies, isolated battery chargers, servers, and embedded computing.

System Diagram

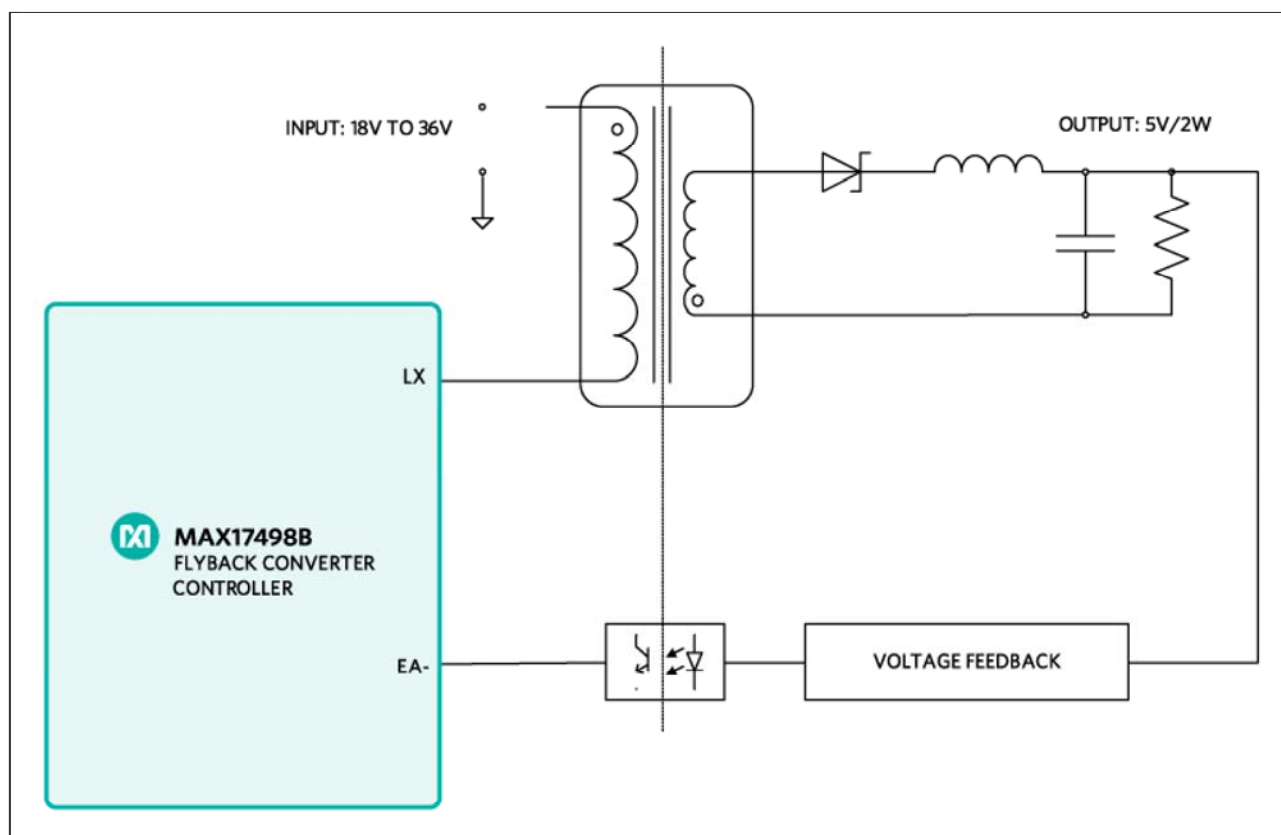


Figure 1. MAXREFDES111# reference design block diagram.

Detailed Circuit Description

The MAXREFDES111# reference design contains all the control circuitry and electric components required for designing an 18V to 36V wide-input, 5V/2W output isolated flyback-converter power supply.

The flyback DC-DC converter operates at a fixed 500kHz operating frequency and achieves up to 79% efficiency. The design provides cycle-by-cycle, primary-side current-limit protection using the MAX17498B's internal MOSFET switch, which is connected at the LX input. Resistor R6 sets the circuit peak-current limit to 1.3A using transformer T1's primary winding and the IC internal switch. The design features an RCD snubber network (R1, C3, and D1) to minimize leakage, energy ringing, and to clamp the voltage at the LX input. The surface-mount transformer provides galvanic isolation up to +1500V for the output.

The isolated +5V output is set using the transformer secondary-side, opto-coupler (U2), shunt regulator (U3), resistors (R9, R19, R20), and various other components. The circuit startup process begins when the voltage at V_{IN} is greater than the circuit's +18V startup voltage threshold and a current-limit fault is not present. Resistors R3, R4, and R5 set the startup voltage and overvoltage-protection voltages to 18V and 36V, respectively. Soft-

start capacitor C10 programs the circuit soft-start period to 5ms. Upon the circuit rising above its startup voltage, the LX node begins switching and energy is transferred from the transformer primary side to the secondary side for the regulated +5V output.

The secondary side of the circuit consists of a diode (D3), an inductor (L1), and a few output capacitors. When the MOSFET on the primary side is off, the transformer pushes the current to the load at the output and the remaining energy is stored in the output capacitors. When the MOSFET is on, the diode prevents the current flow back into the transformer and discharges the output capacitors.

Startup Voltage and Input Overvoltage Protection Setting (EN/UVLO, OVI)

The MAX14798B's EN/UVLO pin serves as an enable/disable input, as well as an accurate programmable input UVLO pin. The devices do not commence startup operation unless the EN/UVLO pin voltage exceeds 1.23V (typ). The devices turn off if the EN/UVLO pin voltage falls below 1.17V (typ). A resistor-divider from the input DC bus to ground can be used to divide down and apply a fraction of the input DC voltage to the EN/UVLO pin. The same resistor-divider can be modified with an additional resistor to implement input overvoltage protection in addition to the EN/UVLO functionality. When voltage at the OVI pin exceeds 1.23V (typ), the devices stop switching and resume switching operations only if voltage at the OVI pin falls below 1.17V (typ).

For the expected values of the startup DC input voltage (V_{START}) and overvoltage-protection voltage (V_{OVI}), the resistor values for the divider can be calculated as follows:

$$V_{START} = (R3 + R4 + R5)/(R4 + R5) \times 1.23 \text{ (V)}$$

$$V_{OVI} = (R3 + R4 + R5)/R5 \times 1.23 \text{ (V)}$$

If $R3 = 549\text{k}\Omega$, $R4 = 20\text{k}\Omega$, and $R5 = 20\text{k}\Omega$, then:

$$V_{START} = 18.11\text{V}, V_{OVI} = 36.22\text{V}.$$

Current Limiting

The IC features current limiting for the transformer's primary side by monitoring the peak current entering the MAX14798B's LX input. Resistor R6 sets the current limit to 1.3A. The IC turns off its internal switch when the peak current reaches the current limit. To reconfigure the peak current limit to a different value, use the following equation to choose a new R6 resistor:

$$R6 = 50 \times I_{PEAK}$$

where I_{PEAK} is in A and R6 is in k.

Quick Start

Required equipment:

- MAXREFDES111# board
- One 24V DC power supply
- One electronic load
- One voltmeter
- One ammeter

Procedure

The MAXREFDES111# board is fully assembled and tested. Use the following steps to verify board operation.

1. Turn off the power supply.
2. Connect the positive terminal of the power supply to the V_{IN} pin of the MAXREFDES111# board.
3. Connect the negative terminal of the power supply to the GND pin of the MAXREFDES111# board.
4. Connect the V_{OUT} connector of the MAXREFDES111# board to the positive terminal of the electronic load.
5. Connect the negative terminal of the electronic load to the positive terminal of the ammeter.
6. Connect the negative terminal of the ammeter to the GNDO connector of the MAXREFDES111# board.
7. Connect the voltmeter across the VOUT and the GNDO connectors of the MAXREFDES111# board.
8. Turn on the power supply.
9. Set the electronic load to a constant current between 0mA to 600mA.
10. Verify the voltmeter reading is $5V \pm 0.25V$.

Lab Measurements

The MAXREFDES111# design was verified and tested under full input range and different output load conditions.

Data were gathered from MAXREFDES111A#. All versions perform similarly.

The power efficiency vs. load current is illustrated in **Figure 2**.

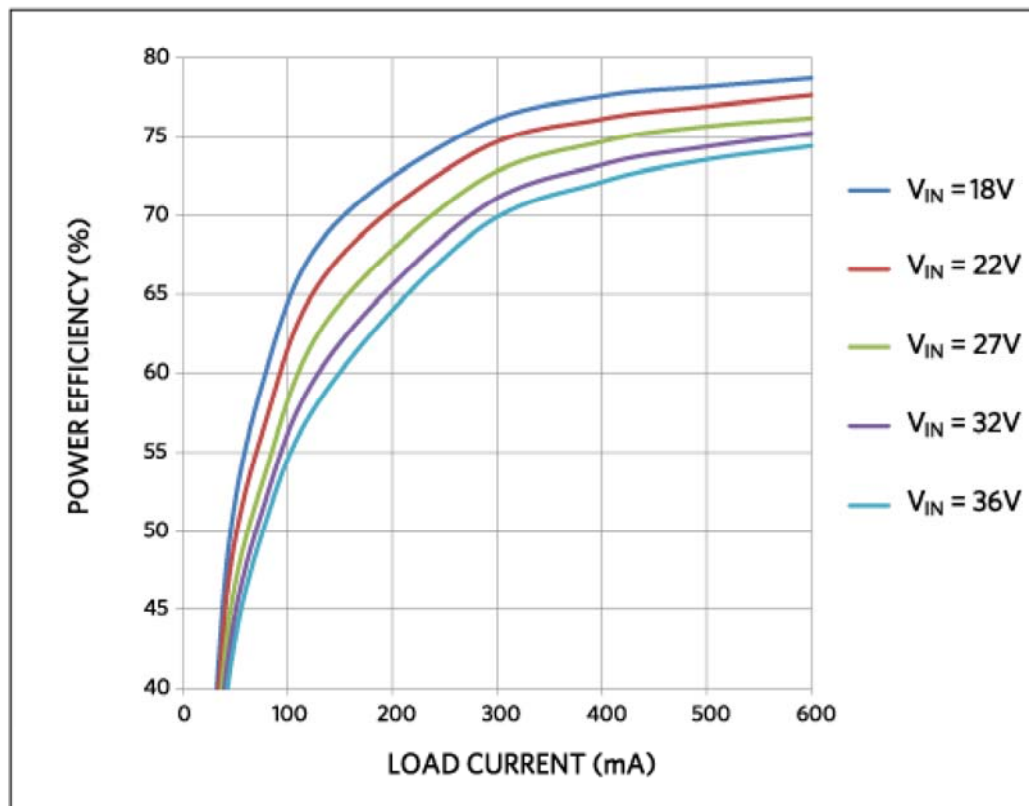


Figure 2. Power efficiency vs. load current.

Figure 3 displays the output ripple at full load (ripple + spike is 50mV_{P-P}) when the input is 24V.

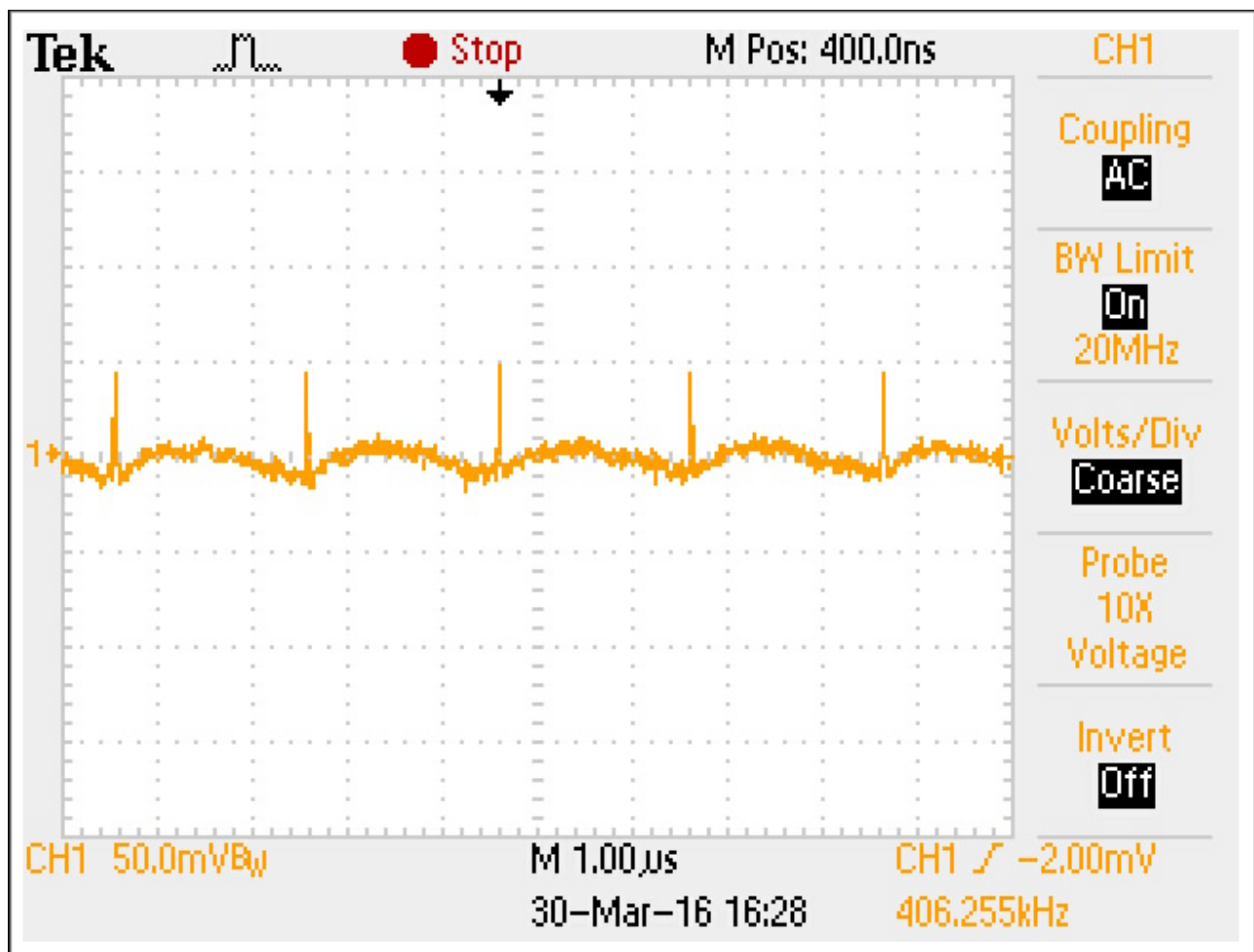


Figure 3. Output ripple at 500mA load, $5V_{OUT}$.

Figure 4 displays the load transient response when the load is stepped from 5mA to 200mA, and then dropped back to 5mA again. The output transient spike is about 200mV. The input is 24V and output is 5V.

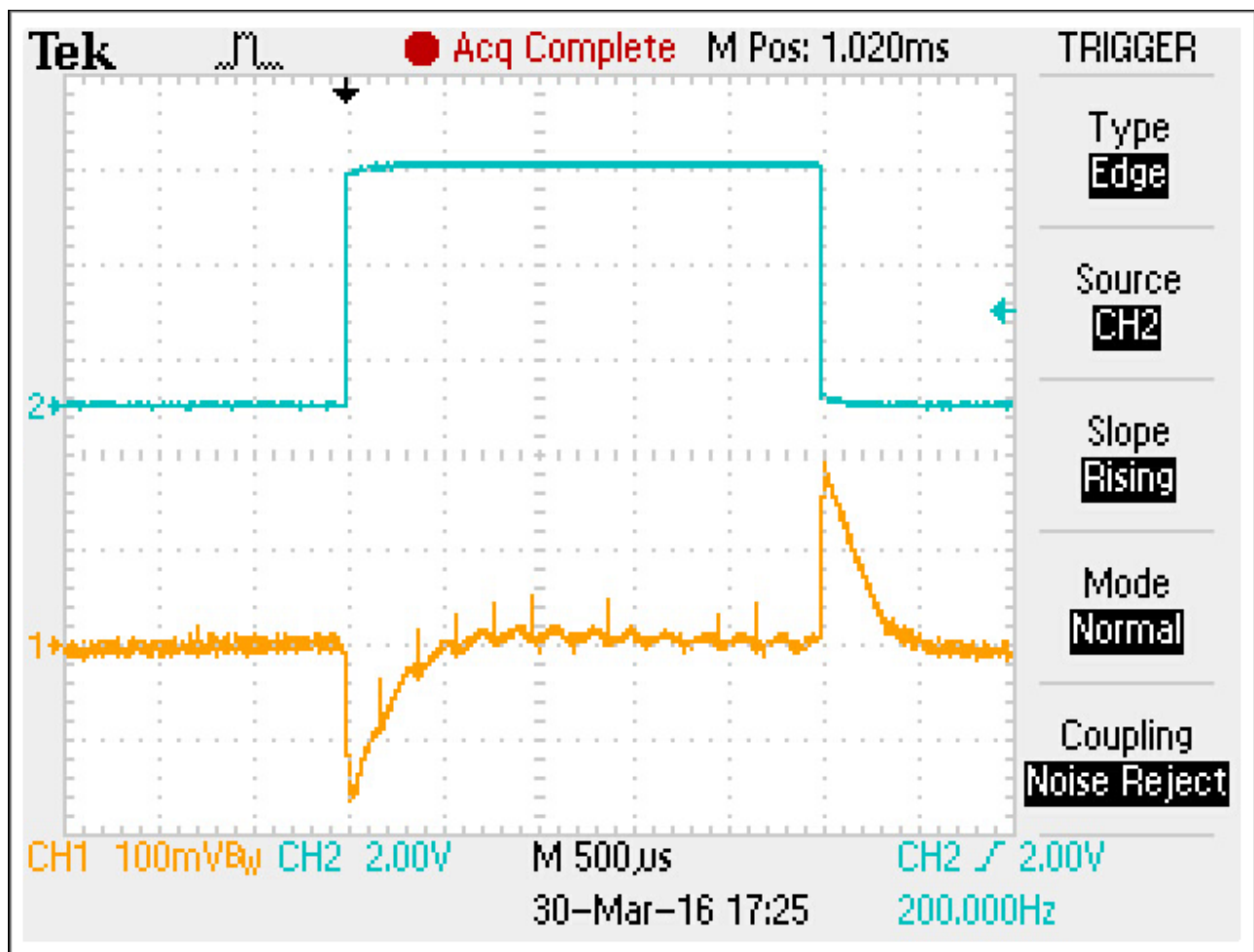


Figure 4. Transient response when load steps from 5mA to 200mA.

Figure 5 shows the load transient response when the load is stepped from 200mA to 500mA, and then dropped back to 200mA again. The transient voltage is about 200mV. The input is 24V, and the output is 5V.

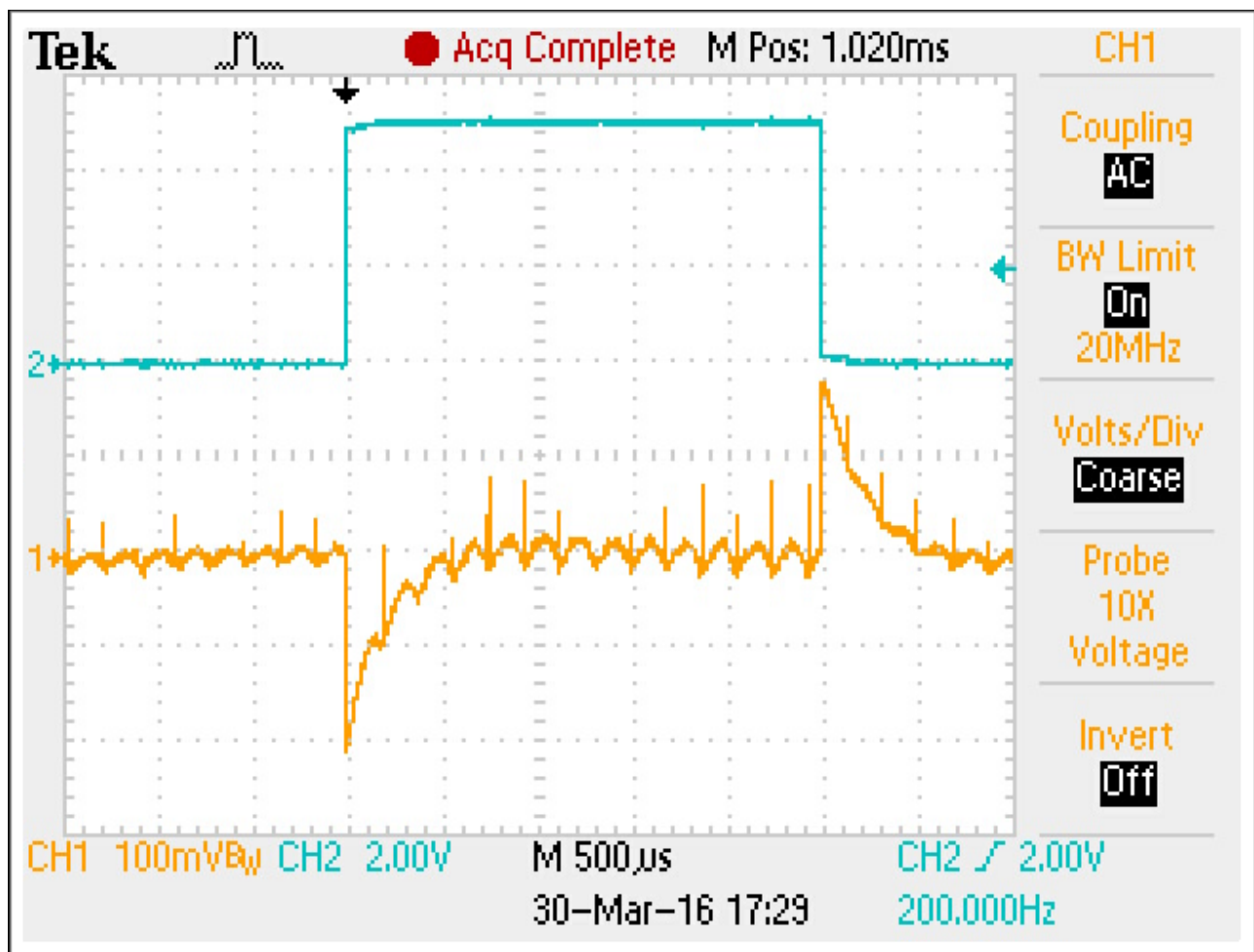


Figure 5. Transient response when load steps from 200mA to 500mA.

Part Number

MAXREFDES111A#



Enlarge+Transformer Vendor

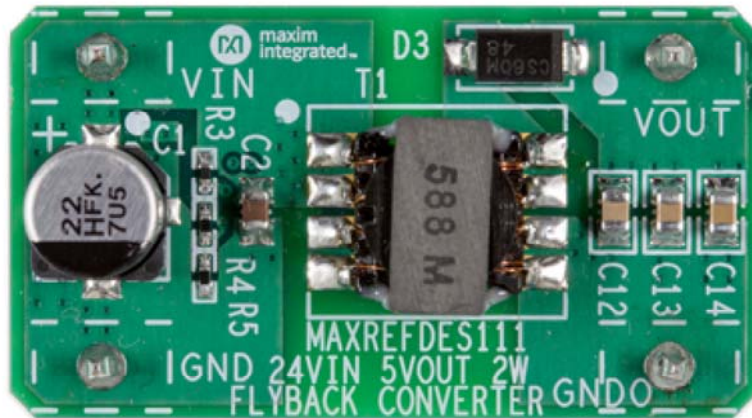
Würth

Transformer Part Number

750315847

Part Number

MAXREFDES111B#



Enlarge+Transformer Vendor

Sumida

Transformer Part Number

06343-T588

Part Number

MAXREFDES111C#



Enlarge+Transformer Vendor

Hanrun

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Design Resources

Quick Start

Required equipment:

- MAXREFDES111# board
- One 24V DC power supply
- One electronic load
- One voltmeter
- One ammeter

▲ Procedure

The MAXREFDES111# board is fully assembled and tested. Use the following steps to verify board operation.

1. Turn off the power supply.
2. Connect the positive terminal of the power supply to the V_{IN} pin of the MAXREFDES111# board.
3. Connect the negative terminal of the power supply to the GND pin of the MAXREFDES111# board.
4. Connect the V_{OUT} connector of the MAXREFDES111# board to the positive terminal of the electronic load.
5. Connect the negative terminal of the electronic load to the positive terminal of the ammeter.
6. Connect the negative terminal of the ammeter to the GNDO connector of the MAXREFDES111# board.

7. Connect the voltmeter across the VOUT and the GNDO connectors of the MAXREFDES111# board.
8. Turn on the power supply.
9. Set the electronic load to a constant current between 0mA to 600mA.
10. Verify the voltmeter reading is $5V \pm 0.25V$.

All Design Files

[Download All Design Files](#)

Hardware Files:

[Schematic](#)

[Bill of Materials \(BOM\)](#)

[PCB Layout](#)

[Fab Package](#)

[PCB CAD](#)

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Order

Key:  Material Analysis  Non-cancelable and Non-returnable

Symbols in part number: **+** Lead-free, RoHS compliant **-** Not qualified as lead-free RoHS **#** RoHS compliant, lead exemption

**Budgetary price. Some parts do not have standard pricing and need to be quoted.*

Part Number

MAXREFDES111B#

Price /Unit*

BUY

status

Active

Part Number

MAXREFDES111C#

Price /Unit*

BUY

status

Active

Part Number

MAXREFDES111A#

Price /Unit*

BUY

status

Active

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