XTR111 Demonstration Fixture

This user's guide describes the characteristics, operation, and use of the XTR111EVM evaluation module (EVM). This EVM features the XTR111 voltage-to-current converter and has a flexible configuration, allowing for evaluation suitable to a variety of applications.

The following related documents are available through the Texas Instruments web site at www.ti.com.

Related Documentation from Texas Instruments

Documenr	Literature Number
XTR111 Product Data Sheet	SBOS375
QFN / SON PCB Attachment Application Note	SLUA271
Quad Flatpack No-Lead Logic Packages Application Note	SCBA017

1 XTR111 and XTR111EVM Overview

1.1 XTR111

The XTR111 is a precision voltage-to-current converter designed for standard 0mA to 20mA or 4mA to 20mA analog signals, but it can source up to 36mA. The ratio between input voltage and output current is set by the single resistor, R_{SET}. This reference resistor is an external device because absolute accuracy is required and the performance can be selected to meet the application requirements.

The circuit can also be modified for voltage output.

An external P-MOSFET ensures high output resistance and a broad compliance voltage range extending from 2V below the positive supply (VSP) to voltages well below the negative supply (Gnd).

The adjustable 3V to 15V sub-regulator output provides the supply voltage for additional circuitry.

An error flag ($\overline{EF}$) is provided to indicate fault conditions on the current output. This flag indicates open load or high load resistance.

The XTR111 also provides output disable control (OD). OD must be asserted low to activate the output.

The XTR111 is available in either a DFN surface-mount package or an MSOP PowerPAD™ package.

1.2 XTR111EVM Overview

The XTR111EVM is intended to provide basic evaluation of XTR111 functionality. The fixture layout is not intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing.

The layout of the XTR111EVM printed circuit board (PCB) is designed to provide:

- Easy handling of the small device package. A mechanical drawing of the recommended land pattern is found at the end of the product data sheet.
- Easy access to all pins of the device.
- Space for optional resistors and capacitors, as well as for the load resistor and a signal low-pass filter. Components are placed with adequate spacing, to allow modification and population with SOIC or leaded components.
- Resistors in the I/O connections to add additional handling protection for the EVM (these resistors may not be used in the final circuit).
- Open space around the IC to allow eventual re-soldering.

The external MOSFET mounted to the EVM is selected randomly from the available sources. Refer to the manufacturer's product data sheet for specification and limits.

The XTR111EVM is initially configured to a basic setup for 0mA to 20mA with 0V to 4V input . Note that the accuracy of **R5** (R_{SET}) used in the EVM is only 0.1%, whereas the XTR111 has greater accuracy. The other resistors are standard 1%. The voltage regulator is set to 5V.

The EVM requires one external supply voltage. The supply voltage range is 8V to 40V.

Refer to the XTR111 product data sheet for comprehensive information about the XTR111 and possible device configurations. Figure 1 shows the XTR111 EVM.

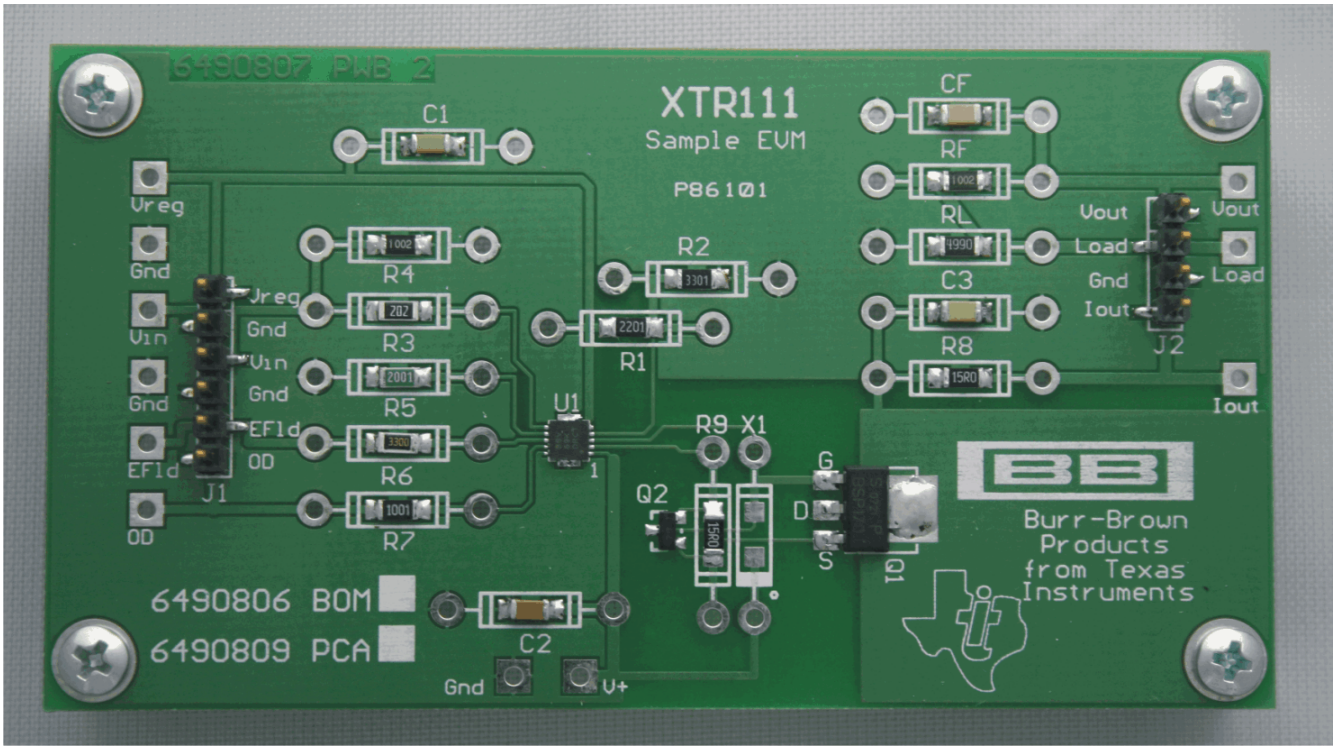

Figure 1. XTR111EVM

2 Quick Start Setup and Use

Follow these procedures to set up and use the XTR111EVM. See Figure 2.

- Connect an external dc supply voltage of approximately +24V to the **V+** connector, referenced to the **Gnd** connector.
- Connect **OD** to **Gnd** (to enable the output).
- Connect $\mathbf{I_{OUT}}$ to **Load**.
- Turn power on. Expect a supply current of less than 0.6mA (without load and after charging the bypass capacitors). The voltage at **Vout** should stay close to **Gnd** with a small amount of offset (use an oscilloscope to observe the output signal).
- Connect a function generator or signal source to **Vin** referenced to **Gnd**. With R_{SET} of 2kΩ, the voltage at Vin must be set within 0V to 4V for 0mA to 20mA output.
- Connect **Iout** to **Load** and measure the voltage at **Vout**, or disconnect **Iout** from **Load** and then measure **Iout**.

Note: The accuracy for V to I conversion relies on R5 (R_{SET}); RL is only a conventional 1% resistor.

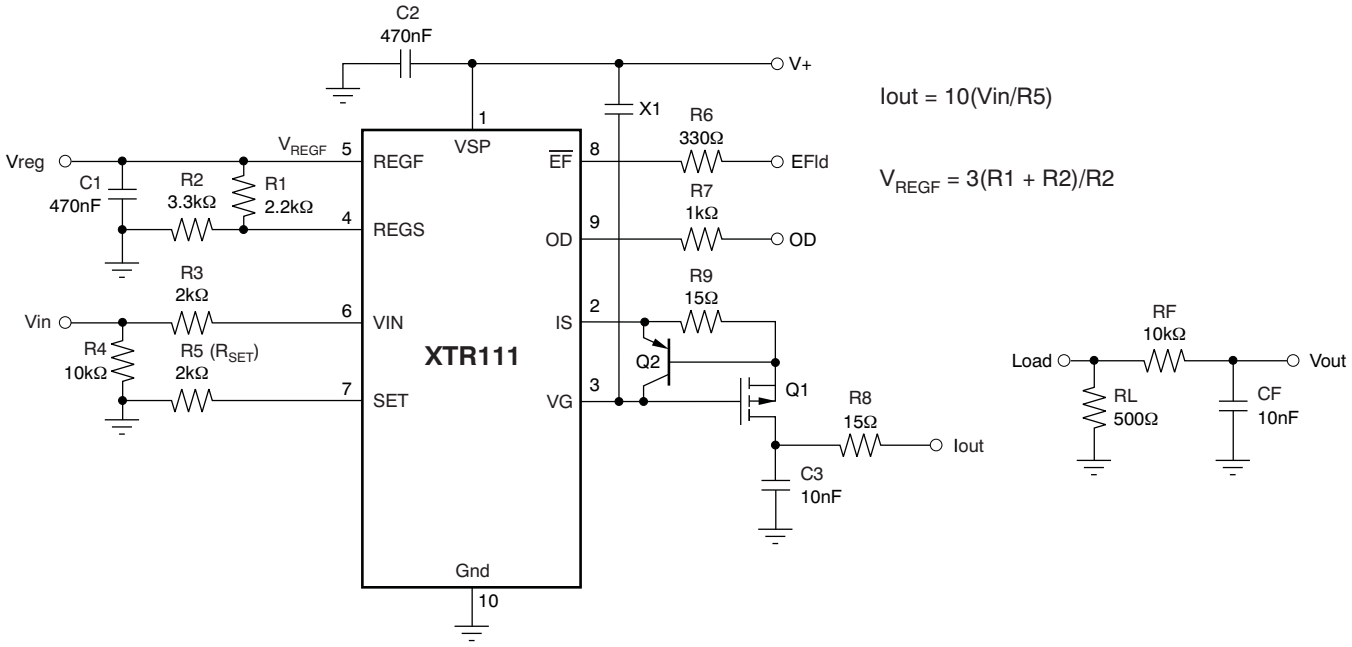

Figure 2. XTR111 EVM Circuit

3 Description of Components

This section summarizes the XTR111EVM components. (See also Figure 3).

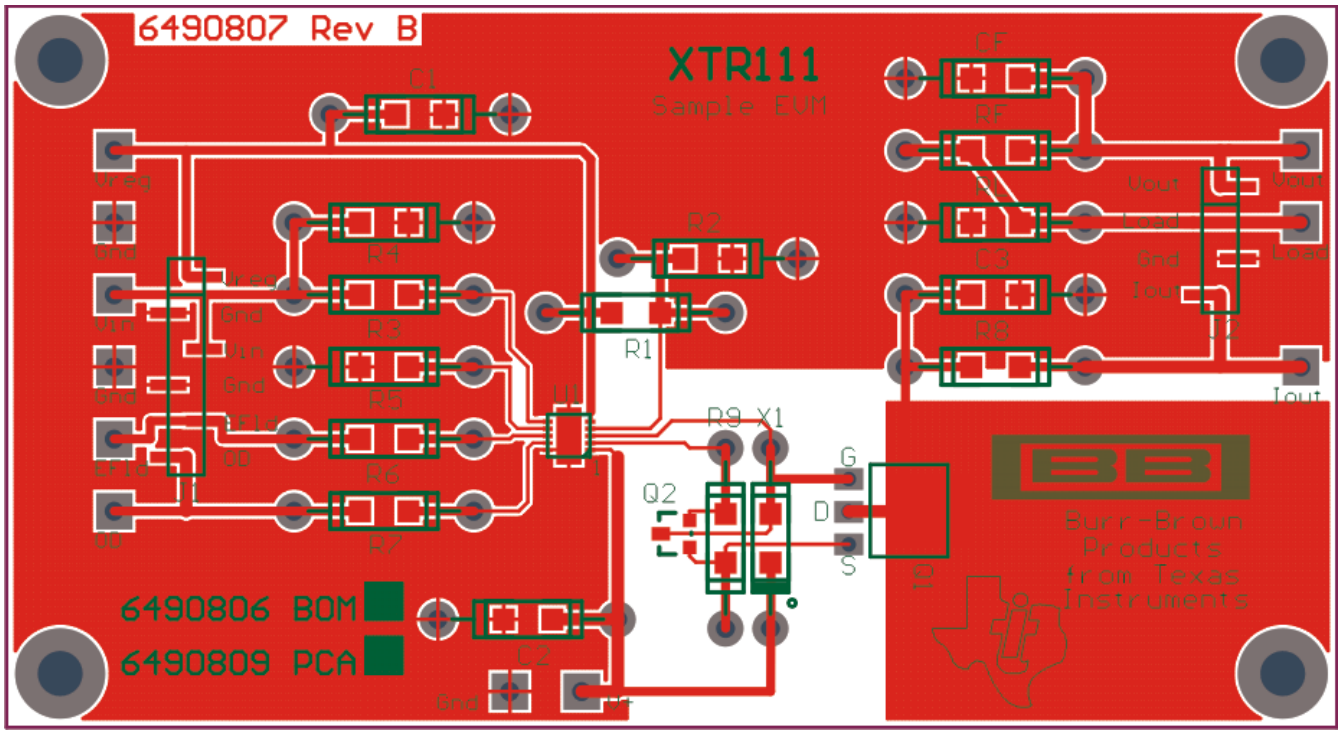

Figure 3. XTR111EVM PCB (Top Layer)

- **R1 and R2** adjust the output voltage of the voltage regulator. Both resistors influence drift and dc accuracy. **Vreg** is set to 5V.
- **R3** matches R5 (R_{SET}) for approximate cancellation of the bias current. This resistor also limits the current into the input if a signal is connected while power is off.
- **R4** is used on the EVM input to provide a signal reference while no signal is connected.
- **R5 (R_{SET}):** This resistor defines the voltage-to-current conversion ratio. It influences drift and dc accuracy (a 0.1%, 25ppm resistor is soldered in). With R_{SET} = 2kΩ, the circuit converts 0V to 4V into 0mA to 20mA (Iout = 10 × Vin/R_{SET}).
- **R6** and **R7** are used to protect the digital I/O on the EVM.
- **OD** connected to **Gnd** activates the output. Left unconnected, a logic high or connection to **Vreg** disables the output.
- **$\overline{\text{EF}}$** is an open-drain output with internal weak pull-up. A low indicates an error. For secure operation, a pull-up resistor to logic supply is recommended. See the *Digital I/O* section.
- **R8** can be used to decouple the drain connection from the outgoing wire. It can form a filter together with C3 to decouple the output from interfering signals.
- **RL** (500Ω) converts the output current into voltage, referred to **Gnd**, if **Iout** is connected to **Load**.
- **RF** forms a low-pass filter together with CF.
- **R9** (15Ω) limits the current to approximately 37mA.

With RF = 10kΩ and CF = 10nF, τ = 100µs.

- **C1** is the capacitive bypass and capacitive load for the voltage regulator.
- **C2** is the supply bypass capacitor; use 100nF or larger.
- **CF** is part of the signal filter, together with RF.
- **X1** is a placeholder for a capacitor that slows down gate control. It reduces the influence of the drain to gate capacitance. This capacitor is normally not required.
- **Gnd:** There is only one ground for this circuit. A single-sided PCB was chosen for the EVM.

Refer to the product data sheet for options and details.

4 Digital I/O

The error flag $\overline{EF}$ is an open-drain output with an internal pull-up current of only 1µA to approximately 5V. This small current allows the user to observe the error flags with the 10MΩ scope probe on the EVM. For normal operation, with connection to external logic inputs, an external pull-up resistor to logic supply is recommended. The control input for OD is internally pulled high with 4µA. If this input is left unconnected, the XTR111 is in disable mode; therefore, connection to this pin is normally required.

4.1 Current Output

The XTR111 is designed for use with a discrete P-Channel MOSFET. This FET extends the voltage compliance for the controlled current to a potential well below the negative supply voltage, because it is not limited to the negative supply. It also eases circuit protection and heat dissipation.

4.2 Layout and Grounds

The XTR111EVM has the load resistor connected to the main GND. If this configuration is not desired for testing, Iout (not connected to **Load**) can be connected to an external load. The resistor R5 (R_{SET}) defines the voltage to current ratio; therefore, the reference point for this resistor is the signal input reference, as well. On the EVM, it is just connected to **Gnd**. Note that the exposed thermal flag must be connected to the most negative supply (normally **Gnd**).

The XTR111 uses internal chopping techniques to maintain its high accuracy and low drift. Therefore, sufficient supply bypassing with a low ESR capacitor is recommended.

Note: The EVM layout provides only marginal heat sinking for the XTR111 package. It is assumed sufficient for the purpose of the EVM because the fixture is mainly intended for quick and easy evaluation of the XTR111.

5 Bill of Materials

Table 1 shows the parts list for the XTR111_Test_Board.

Table 1. XTR111_Test_Board Parts List

No.	Quantity	Value	Ref Des	Description	Vendor	Part Number
1	1	2.2k	R1	Resistor, 2.2k 1% 1206	Vishay/Dale	CRCW12062K20FKEA
2	1	3.3k	R2	Resistor, 3.3k 1% 1206	Vishay/Dale	CRCW12063K30FKEA
3	1	2.0k	R3	Resistor, 2.0k 1% 1206	Vishay/Dale	CRCW12062K00FKEA
4	2	10.0k	R4, RF	Resistor, 10.0k 1% 1206	Vishay/Dale	CRCW120610K0FKEA
5	1	2.0k	R5	Resistor, TNPW1206 2K00 0.1% T-9 E52 e3	Vishay/Dale	TNPW12062K00BEEN
6	1	330	R6	Resistor, 330 1% 1206	Vishay/Dale	CRCW1206300RFKEA
7	1	1.0k	R7	Resistor, 1.0k 1% 1206	Vishay/Dale	CRCW12061K00FKEA
8	2	15	R8, R9	Resistor, 15 1% 1206	Vishay/Dale	CRCW120615R0FKEA
9	1	500	RL	Resistor, 499 1% 1206	Vishay/Dale	CRCW1206499RFKEA
10	2	470nF	C1, C2	Capacitor, Ceramic, 470nF, 1206	Kemet	C1206C474K5RACTU
11	2	10nF	C3, CF	Capacitor, Ceramic, 10nF, 1206	Kemet	C1206C103K5RACTU
12	1	N/A	U1	IC, XTR111,Precision Voltage-to-Current Converter/Transmitter	Texas Instruments	XTR111AIDRCT
13	1	N/A	Q1	MOSFET, P-CH, 60V 1.9A SOT223	Infineon	BSP170PE6327T
14	1	N/A	Q2	Transistor, PNP General purpose	Fairchild	MMBT5087
15	Optional/ Not Installed	N/A	X1	DIODE ZENER 16V 500MW SOD-123	Discrete Semiconductor Products	BZT52C16-7
16	1	N/A	J1	Terminal Strip, 6 pos, .025in sq, Single Row, Vertical, SMT	Samtec	TSM-106-01-L-SV
17	1	N/A	J2	Terminal Strip, 4 pos, .025in sq, Single Row, Vertical, SMT	Samtec	TSM-104-01-L-SV
18	4	N/A	See photo or example	Screw, Machine, Phillips, Panhead 4-40X1/4 SS	Building Fasteners	PMSSS 440 0025 PH
19	4	N/A	See photo or example	Standoffs, Hex , 4-40 Threaded, 0.500" length, 0.250" OD	Keystone Electronics	2203

Revision History

Changes from A Revision (September, 2008) to B Revision **Page**

- Revised statement about MSOP package option availability..... 1
- Added *Bill of Materials* table 6

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 0V to 12V or 0V to (V+) – 2.3V, whichever is less, and the output voltage range of 0mA to 36mA or 0V to 12V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than +50°C. The EVM is designed to operate properly with certain components above +50°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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