BURR - BROWN®

XTR501

HIGH CURRENT BRIDGE DRIVER and 4-20mA Transmitter

FEATURES

- SENSOR EXCITATION OF 1W
- VARIABLE EXCITATION VOLTAGE: 1.5V to 5.0V
- SINGLE SUPPLY: 11.4V to 30VDC
- INRUSH CURRENT LIMITING
- 4-20mA TRANSMITTER

APPLICATIONS

- GAS DETECTION SENSORS
- PELLISTOR CATALYTIC DETECTORS
- STRAIN GAGES
- HIGH CURRENT BRIDGES
- LOAD CELLS
- HOT-WIRE ANEMOMETERS

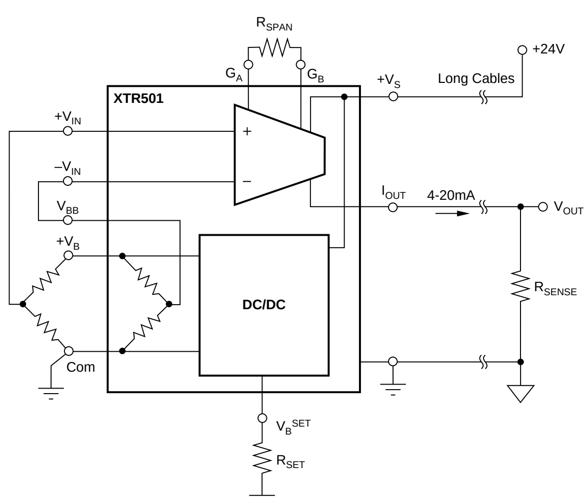
DESCRIPTION

The XTR501 contains a high efficiency DC/DC converter and 4-20mA three wire current transmitter. It provides regulated bridge excitation, optional half bridge, differential inputs and current transmitter necessary for the excitation and signal conditioning of low impedance bridge sensors and high integrity signal transmission.

The DC/DC converter is capable of supplying 1W into a regulated bridge voltage of 1.5V to 5.0V from a supply of 11.4V to 30V. The combination of a low startup current and high efficiency current step-up allows for a combined supply line resistance of up to 100Ω when exciting low impedance sensors.

The instrumentation amplifier of the current transmitter can be used over a wide range of gains, accommodating a variety of input signals and sensors.

The XTR501 is particularly suited to excitation of high current/low impedance sensors used in bridge applications allowing the use of lighter cabling leading to considerable savings on cabling costs.



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SPECIFICATIONS

ELECTRICAL

T_A = +25°C, V_S = 24V, V_{BRIDGE} = 2V, I_{LOAD} = 300mA unless otherwise specified.

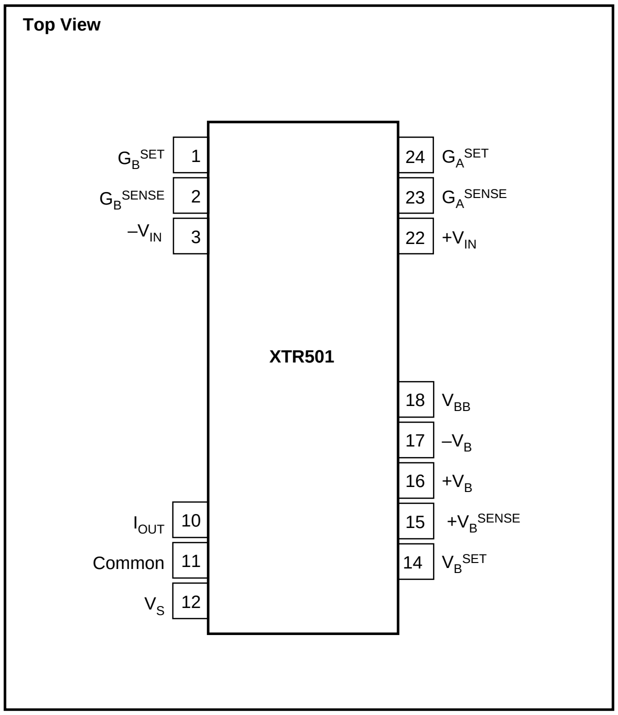
PARAMETER	CONDITIONS	XTR501 MIN	TYP	MAX	UNITS
INSTRUMENTATION AMPLIFIER/CURRENT TRANSMITTER					
SIGNAL OUTPUT					
Output Current Equation	R_G in Ω, V_{IN} in V	$I_O = 0.004 + 0.016\ [(1 + 50k\Omega/R_G)/4.94]\ V_{IN}$			A
Output Current	Linear Operating Range	4		20	mA
Over-scale Limit		25	27		mA
Under-scale Limit			0		mA
ZERO					
Output Current			4		mA
Offset Error			±50	±100	µA
vs Temperature			0.2		µA/°C
vs Supply Voltage	V_S = 11.4V to 30V		0.5	2	µA/V
SPAN					
Span Equation	R_G in Ω, V_{IN} in V	$Span = 0.016[(1 + 50k\Omega/R_G)/4.94]$			A/V
Untrimmed Error	G = 1		±0.2	±2.5	%
	G = 250		±1.5	±10	%
vs Temperature			50		ppm/°C
Nonlinearity	G = 1, I_O = 4mA to 20mA			±0.025	%
INPUT					
Common-Mode Range		0		4.94(1)	V
Offset Voltage			16		mV
vs Temperature			50		µV/°C
vs Supply Voltage			75		dB
Common-Mode Rejection			85		dB
Impedance; Differential, Common-Mode			10^{10} || 6		Ω || pF
DC/DC CONVERTER					
BRIDGE EXCITATION VOLTAGE SOURCE					
Output Voltage		1.5		5	V
vs Temperature	V_{IN} = 0V, G= 1		200		ppm/°C
vs Long Term Stability			100		ppm/1000hrs
Output Power				1	W
Line Voltage Regulation	V_S = 11.4V to 30.0V		0.25		%
Load Voltage Regulation	Load Current 160mA to 340mA		0.25		%
	Load Voltage 2V				
Output Voltage Ripple	Load Current 300mA		150		mV
	Load Voltage 2V				
Output Voltage Ripple Frequency			100		kHz
Output Short-Circuit Current	Limited Duration		2.6		A
Input Current	Output Short-Circuit		150		mA
POWER SUPPLY					
Supply Voltage, V_S		11.4	24	30	V
Supply Current			See Typical Curve		
TEMPERATURE					
Operating		–40		+70	°C
Storage		–40		+85	°C

NOTE: (1) Common-Mode Range is based on a multiple of a bandgap reference of 1.235V.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_S	30V
Input Voltage	10V
Output Power	1W
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	–40°C to +85°C

PIN CONFIGURATION



ORDERING INFORMATION

MODEL	PACKAGE	TEMPERATURE RANGE
XTR501	24-Pin Plastic Module	–40°C to +70°C

PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER(1)
XTR501	24-Pin Plastic Module	902

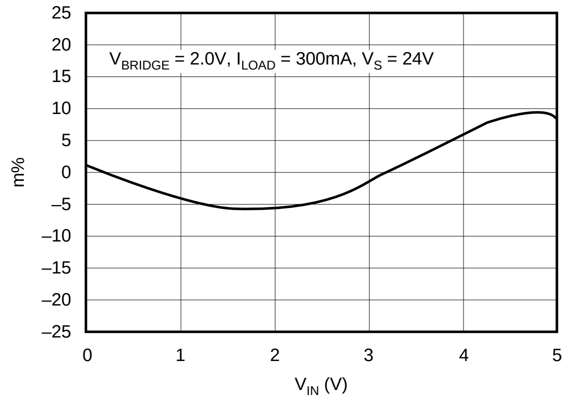
NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

PIN DESCRIPTION

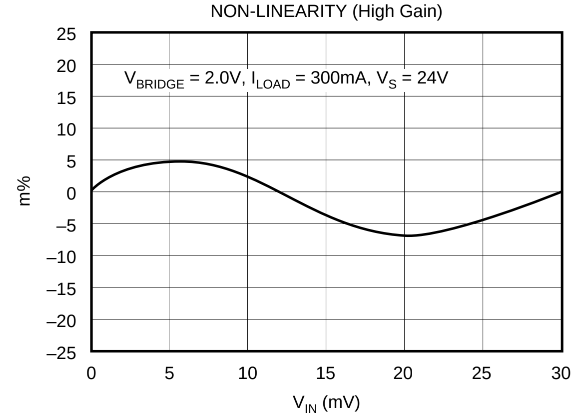
PIN	NAME	DESCRIPTION
1	G_BSET	Connect to R_{SPAN} to set transconductance.
2	G_BSENSE	Sense pin for G_BSET connect to G_ASET.
3	$-V_{IN}$	Inverting input to transmitter.
10	I_{OUT}	Output Current connect through R_{SENSE} to common.
11	Common	Supply return for sense and V_B connectors.
12	V_S	Supply to XTR501 +11.4V to 30.0V.
14	V_BSET	Single resistor to common sets the bridge excitation voltage.
15	$+V_B$SENSE	Positive bridge sense input connect to positive excitation voltage at bridge.
16	$+V_B$	Positive bridge excitation voltage.
17	$-V_B$	Negative bridge excitation voltage.
18	V_{BB}	Output from internal half bridge connect to $-V_{IN}$.
22	$+V_{IN}$	Non-Inverting input to transmitter.
23	G_ASENSE	Sense pin for G_ASET connect to G_ASET.
24	G_ASET	Connect to R_{SPAN} to set transconductance.

TYPICAL PERFORMANCE CURVES

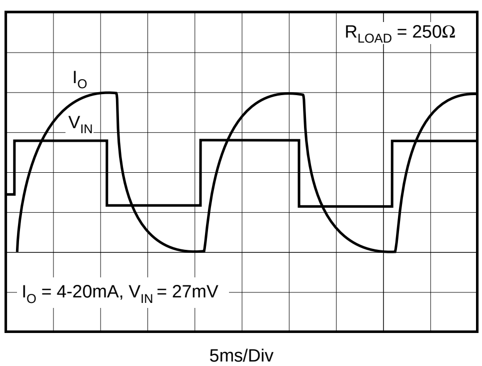
$T_A = +25°C$, $V_S = 24V$, $V_{BRIDGE} = 2V$, $I_{LOAD} = 300mA$ unless otherwise specified.



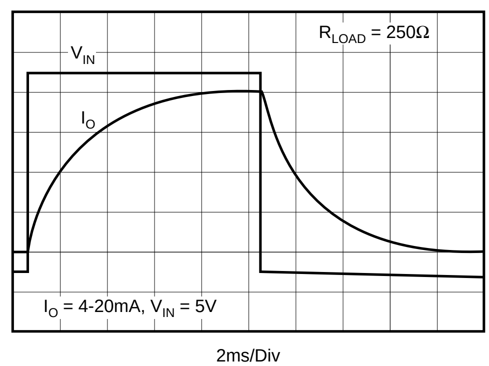
NON-LINEARITY (Low Gain)



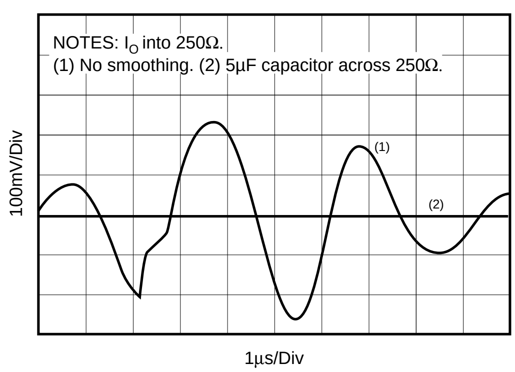
NON-LINEARITY (High Gain)



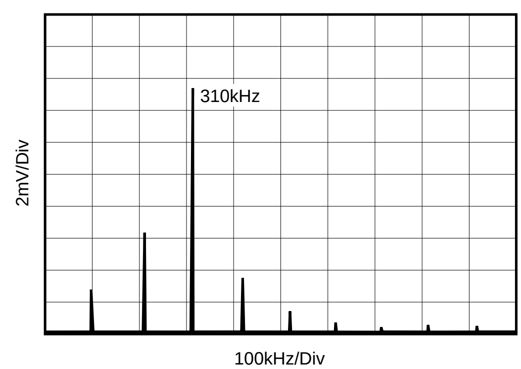
SMALL SIGNAL TRANSIENT RESPONSE



LARGE SIGNAL TRANSIENT RESPONSE



OUTPUT NOISE

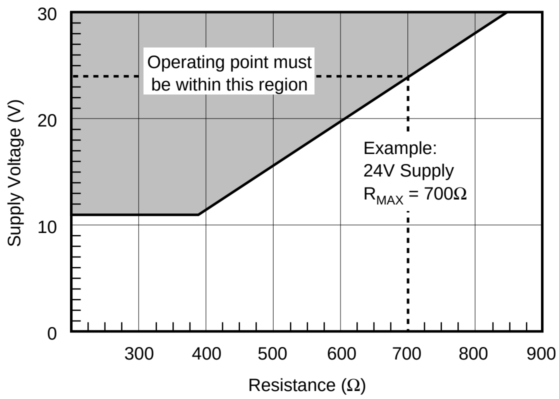


FFT of OUTPUT NOISE

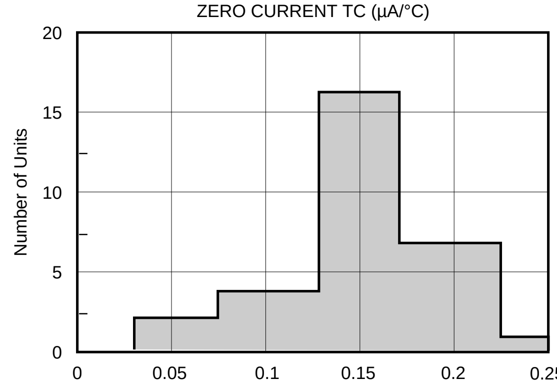
TYPICAL PERFORMANCE CURVES (CONT)

T_A = +25°C, V_S = 24V, V_{BRIDGE} = 2V, I_{LOAD} = 300mA unless otherwise specified.

MAXIMUM CURRENT LOOP RESISTANCE

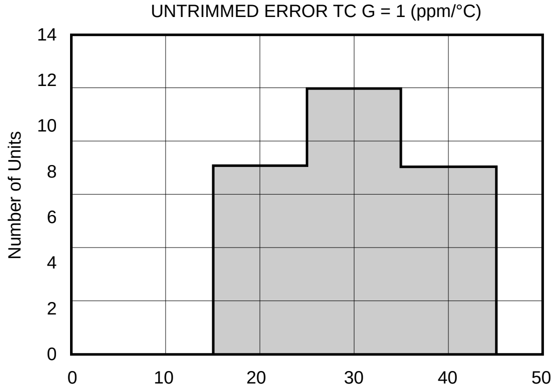


ZERO CURRENT TC (µA/°C)



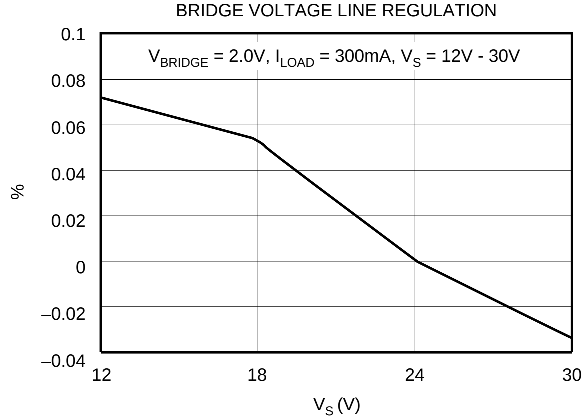
Average = 0.100µA/°C
3σ = 0.115µA/°C

UNTRIMMED ERROR TC G = 1 (ppm/°C)

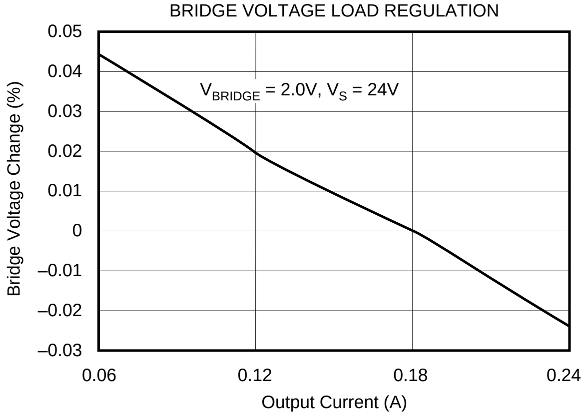


Average = 21ppm/°C
3σ = 25ppm/°C

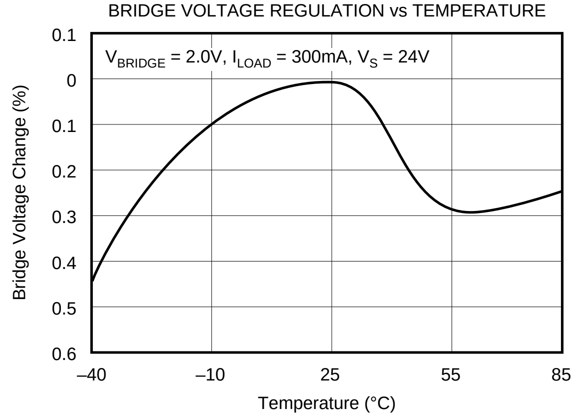
BRIDGE VOLTAGE LINE REGULATION



BRIDGE VOLTAGE LOAD REGULATION

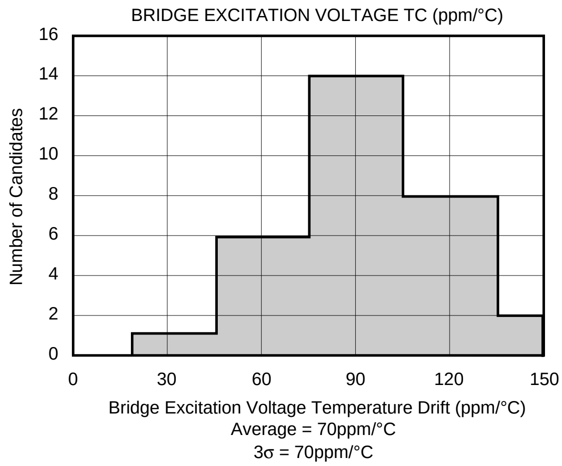


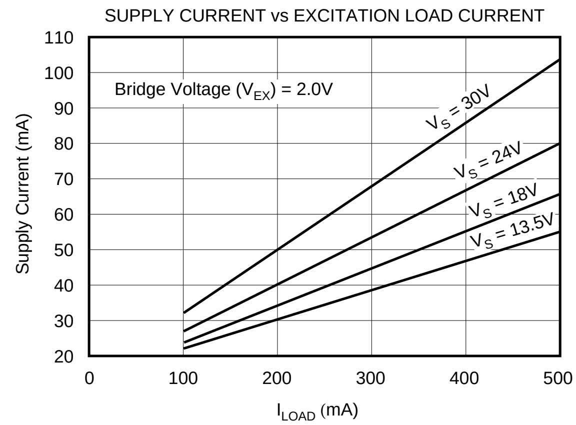
BRIDGE VOLTAGE REGULATION vs TEMPERATURE



TYPICAL PERFORMANCE CURVES (CONT)

$T_A = +25°C$, $V_S = 24V$, $V_{BRIDGE} = 2V$, $I_{LOAD} = 300mA$ unless otherwise specified.





METHOD OF OPERATION

The XTR501 consists of a high efficiency DC/DC converter with current and voltage mode control and a current loop transmitter.

The pulse-width modulation controller monitors the current and voltage control signals and varies the conduction period to regulate the bridge excitation voltage, V_B.

A soft-start feature is provided to negate problems caused by high in-rush currents and lead resistances, thus allowing the XTR501 to be driven through cables of up to 100Ω of supply line resistance with no reduction in performance.

A single resistor, R_{SET}, determines the regulated bridge excitation voltage which may be in the range 1.5V to 5.0V.

The gain of the transconductance amplifier, which forms the current loop transmitter, is again determined by a single resistor R_{SPAN} and allows input voltages from 25mV to drive the 4-20mA current loop.

APPLICATIONS

The XTR501 is designed to be used with a wide range of pellistor catalytic gas detectors. The pellistor gas detector consists of a matched pair of elements; an active bead which is the sensing element, and an inactive bead which is the compensating element. These elements form one side of a Wheatstone bridge arrangement. The bridge serves a dual purpose: to raise the temperature of the elements to about 500°C, which is their working temperature, and to allow detection of the presence of combustible gases through imbalance of the bridge. This happens as the pellistor increases temperature due to oxidation of the flammable gas and thus increases its resistance.

In general, pellistor catalytic gas detectors are limited in use to monitoring up to 100% of the LEL (lower explosive limit). Beyond this point ambiguous results can occur due to the inability of the pellistor to oxidize the gas as the available oxygen decreases (see Figure 3).

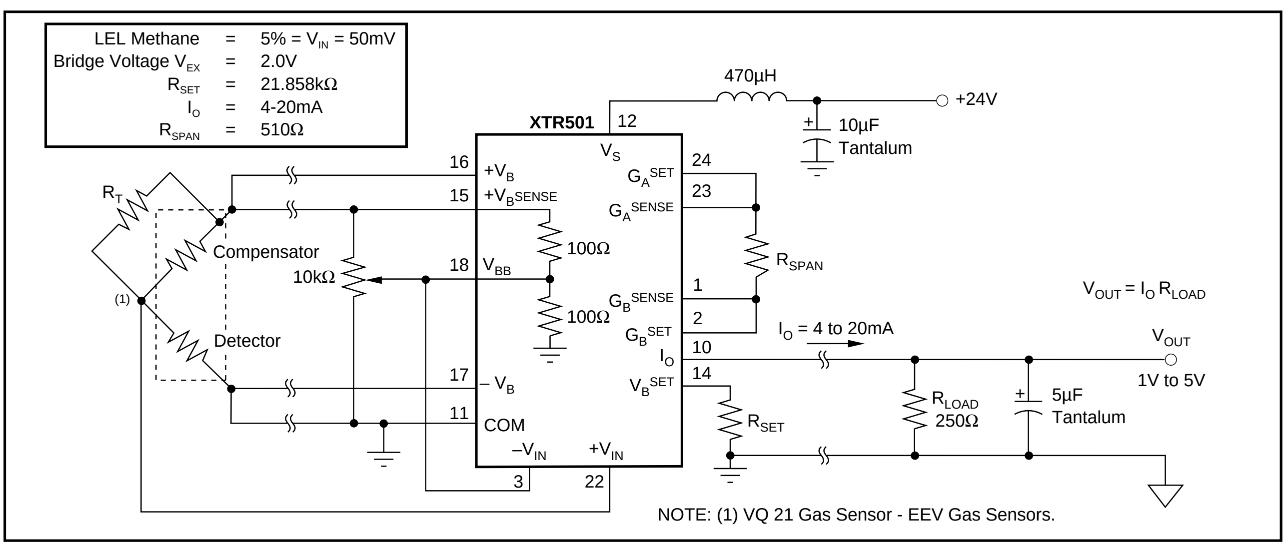


FIGURE 1. Basic Connection

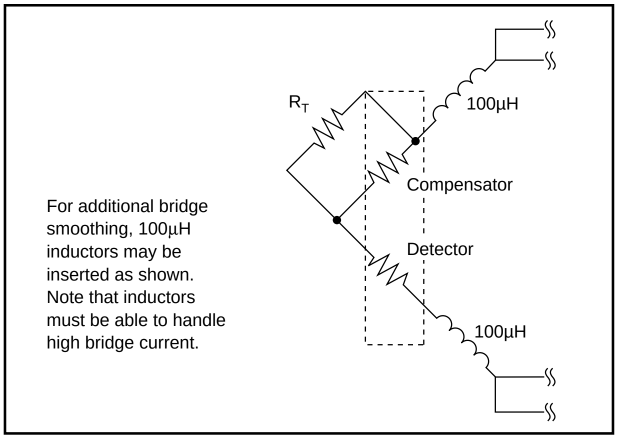


FIGURE 2. Bridge Smoothing.

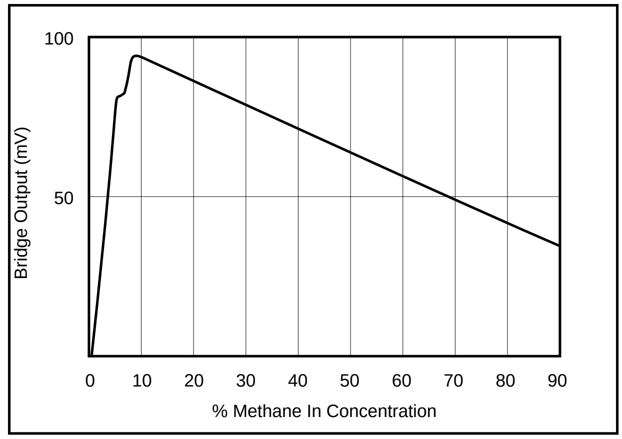


FIGURE 3. Typical Pellistor Response.

An interesting feature of pellistor elements, and those tested in the applications, is that they create a similar bridge output at LEL for almost all hydrocarbons. This feature allows a comparative measurement to be made of one gas when an instrument has been calibrated for another.

e.g. Instrument calibrated for Methane (K=112) measuring Hydrogen (K=85.8).

Actual % of LEL will be 1.31 x meter reading. (112/85.8).

This is an approximation and it is recommended that for exact conversions the instrument should be calibrated using the relevant gases.

Tables of these constants can be sourced through the manufacturers of gas sensing products.

An example of the XTR501 used with a pellistor catalytic gas detector is shown in Figure 1.

To Calculate R_{SET}

See Figure 4. Point (a) will be maintained at 1.235V.

$$\frac{V_B - 1.235}{10k\Omega} = \frac{1.235\left(50k\Omega + R_{SET}\right)}{R_{SET}\ 50k\Omega}$$

$$\frac{50k\Omega\left(V_B - 1.235\right)}{\left(10k\Omega\right)\left(1.235\right)} = \frac{50k\Omega + R_{SET}}{R_{SET}}$$

$$= 1 + \frac{50k\Omega}{R_{SET}}$$

$$\frac{5\left(V_B - 1.235\right)}{1.235} - 1 = \frac{50k\Omega}{R_{SET}}$$

$$R_{SET} = \frac{\left(50k\Omega\right)\left(1.235\right)}{5\left(V_B - 1.235\right) - 1.235}$$

Example:

V_B	R_{SET} Calculated
1.5	Open
2.0	21.858kΩ
3.0	7.891kΩ
4.0	4.815kΩ
5.0	3.464kΩ

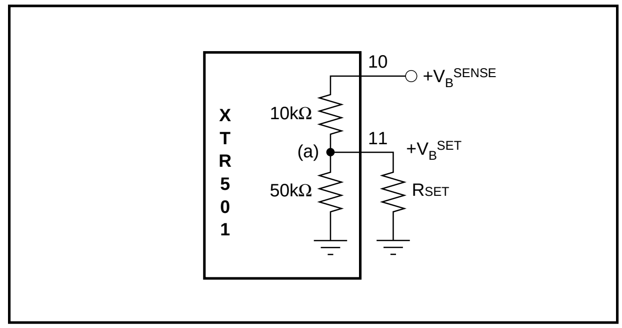


FIGURE 4. Internal Circuit $+V_B^{SET}$.

To Calculate R_{SPAN}

$$I_O = 0.004 + 0.016\left(\frac{1 + 50k\Omega / R_{SPAN}}{4.94}\right)V_{IN}$$

For V_{IN} = 10mV and I_O = 20mA

$$0.02 = 0.004 + 0.016\left(\frac{1 + 50k\Omega / R_{SPAN}}{4.94}\right)0.01$$

$$\frac{0.016}{\left(0.016\right)\left(0.01\right)} = \frac{1 + \left(50k\Omega / R_{SPAN}\right)}{4.94}$$

$$494 = 1 + 50k\Omega / R_{SPAN}$$

$$R_{SPAN} = \frac{50k\Omega}{493}$$

$$= 101.4$$

i.e

$$\frac{4.94}{V_{IN}} = 1 + \frac{50k\Omega}{R_{SPAN}}$$

$$R_{SPAN} = \frac{50k\Omega}{\dfrac{4.94}{V_{IN}} - 1}$$