VOLTAGE TRANSMITTER IC AM401

FEATURES

- **Wide Supply Voltage Range: 6...35V**
- **Wide Operating Temperature Range: –40°C...+85°C**
- **Adjustable Voltage Reference: 4.5 to 10V**
- **Additional Current/Voltage Source**
- **Instrumentation Amplifier Input (Reversible Polarity)**
- **Operation Amplifier Input**
- **Adjustable Gain and Offset**
- **Adjustable Output Voltage Range: 0.5...4.5V, 0...5/10V, other**
- **Protection Against Reverse Polarity**
- **Output Current Limitation**

APPLICATIONS

- Industrial Process Control
- Sensor Transmitter (e.g. pressure)
- Voltage Transmitter

GENERAL DESCRIPTION

The AM401 is a low cost monolithic voltage transmitter, designed for flexible bridge input signal conditioning. The integrated circuit is ideally suited for a wide variety of transducers with an differential output signal. It contains a high accuracy instrumentation amplifier for differential input signals, an operational amplifier output stage, and an adjustable 5 to 10V reference. In addition to these functional elements an auxiliary operational amplifier can be used as a current or voltage source. Output range and gain are adjustable by external resistors. Using the internal instrumentation amplifier the AM401 is a standard sensor transmitter with the possibility to indicate an over range signal. With the freely connectable operational amplifier input this IC can be used as an adjustable voltage–to–voltage transmitter.

DELIVERY

- DIL16 packages (samples)
- SO16(n) packages
- Dice on 5“ blue foil

BLOCK DIAGRAM+

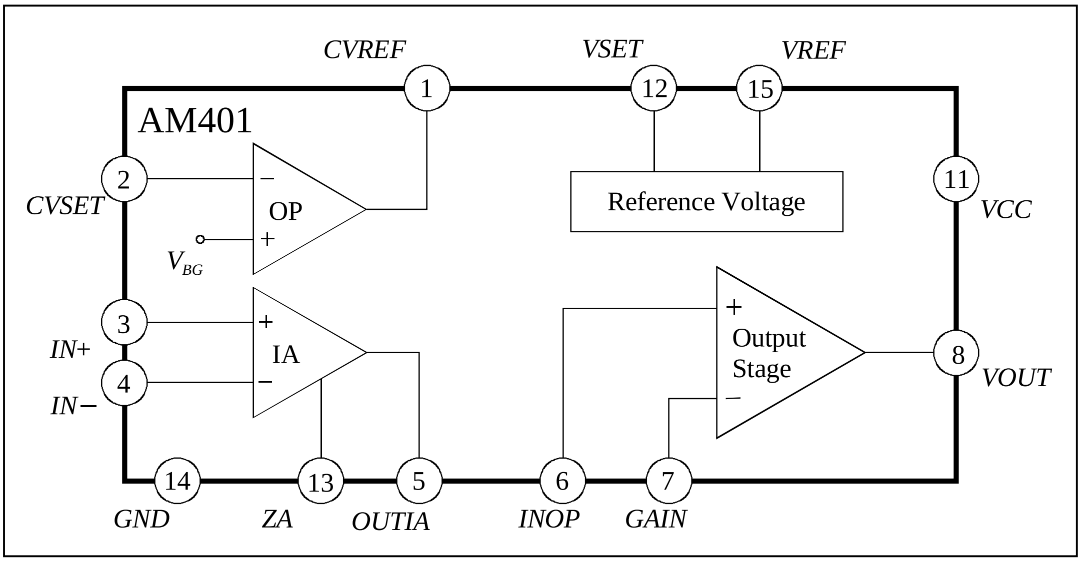

Figure 1

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ELECTRICAL SPECIFICATIONS

T_{amb} = 25°C, V_{CC} = 24V, V_{REF} = 5V, I_{REF} = 1mA (unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Voltage Range	V_{CC}		6		35	V
Quiescent Current	I_{CC}	T_{amb} = – 40...+85°C, I_{REF} = 0mA			1.5	mA
Temperature Specifications						
Operating	T_{amb}		–40		85	°C
Storage	T_{st}		–55		125	°C
Junction	T_J				150	°C
Thermal Resistance	Θ_{ja}	DIL16 plastic package		70		°C/W
	Θ_{ja}	SO16 narrow plastic package		140		°C/W
Voltage Reference						
Voltage	V_{REF}	*VSET* not connected	4.75	5.00	5.25	V
	V_{REF}	*VSET = GND*, $V_{CC} \geq$ 11V	9.5	10.0	10.5	V
Trim Range	V_{R10}		4.5		V_{R10}	V
Current	I_{REF}		0.2		10.0	mA
V_{REF} vs. Temperature	dV_{REF}/dT	T_{amb} = – 40...+85°C		±90	±140	ppm/°C
Line Regulation	dV_{REF}/dV	V_{CC} = 6V...35V		30	80	ppm/V
	dV_{REF}/dV	V_{CC} = 6V...35V, $I_{REF} \approx$ 5mA		60	150	ppm/V
Load Regulation	dV_{REF}/dI			0.05	0.10	%/mA
	dV_{REF}/dI	$I_{REF} \approx$ 5mA		0.06	0.15	%/mA
Load Capacitance	C_L		1.9	2.2	5.0	µF
Current/Voltage Source						
Internal Reference	V_{BG}		1.20	1.27	1.35	V
V_{BG} vs. Temperature	dV_{BG}/dT	T_{amb} = – 40...+85°C		±60	±140	ppm/°C
Current Source: $I_{CV} = V_{BG}/R_{EXT}$						
Adjustable Current Range	I_{CV}		0		10	mA
Output Voltage	V_{CV}	V_{CC} < 18V	V_{BG}		V_{CC} – 5	V
	V_{CV}	$V_{CC} \geq$ 18V	V_{BG}		13	V
Voltage Source: $V_{CV} = V_{BG} (R_{EXT1} + R_{EXT2}) / R_{EXT2}$						
Adjustable Voltage Range	V_{CV}	V_{CC} < 18V	0.4		V_{CC} – 5	V
	V_{CV}	$V_{CC} \geq$ 18V	0.4		13	V
Output Current	I_{CV}	Source			10	mA
	I_{CV}	Sink			–100	µA
Load Capacitance	C_L	Source mode	0	1	10	nF
Instrumentation Amplifier						
Internal Gain	G_{IA}		4.9	5	5.1	
Differential Input Voltage Range	V_{IN}		0		±400	mV
Common Mode Input Range	*CMIR*	V_{CC} < 9V, I_{CV} < 2mA	1.5		V_{CC} – 3	V
	CMIR	$V_{CC} \geq$ 9V, I_{CV} < 2mA	1.5		6.0	V
Common Mode Rejection Ratio	*CMRR*		80	90		dB
Power Supply Rejection Ratio	*PSRR*		80	90		dB
Offset Voltage	V_{OS}			±1.5	±6	mV
V_{OS} vs. Temperature	dV_{OS}/dT			±5		µV/°C
Input Bias Current	I_B			–120	–300	nA
I_B vs. Temperature	dI_B/dT			–0.35	–0.8	nA/°C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Instrumentation Amplifier (cont.)						
Output Voltage Range	V_{OUTIA}	$V_{CC} < 9V$, $R_{LIA} \leq 10k\Omega$	0*		$V_{CC} - 3$	V
	V_{OUTIA}	$V_{CC} \geq 9V$, $R_{LIA} \leq 10k\Omega$	0*		6	V
Minimum Output Voltage	$V_{OUTIAmin}$	without external load resistance R_{LIA}		5	17	mV
Load Capacitance	C_L				250	pF
Zero Adjust Stage						
Internal Gain	G_{ZA}			1		
Input Voltage	V_{ZA}	$V_{ZA} \leq V_{OUTIA} - G_{IA} V_{IN}$	0		V_{OUTIA}	V
Offset Voltage	V_{OS}			±0.5	±2.0	mV
V_{OS} vs. Temperature	dV_{OS}/dT			±1.6	±5	µV/°C
Input Bias Current	I_B			38	100	nA
I_B vs. Temperature	dI_B/dT			24	75	pA/°C
Voltage Output Stage						
Adjustable Gain	G_{OP}		1			
Input Range	IR	$V_{CC} < 10V$	0		$V_{CC} - 5$	V
	IR	$V_{CC} \geq 10V$	0		5	V
Power Supply Rejection Ratio	$PSRR$		80	90		dB
Offset Voltage	V_{OS}			±0.5	±2	mV
V_{OS} vs. Temperature	dV_{OS}/dT			±3	±7	µV/°C
Input Bias Current	I_B			5	12	nA
I_B vs. Temperature	dI_B/dT			3.5	10	pA/°C
Output Voltage Range	V_{OUT}	$V_{CC} < 18V$	0		$V_{CC} - 5$	V
	V_{OUT}	$V_{CC} \geq 18V$	0		13	V
Output Current Limitation	I_{LIM}	$V_{OUT} \geq 10V$	5	7	10	mA
Output Current	I_{OUT}		0		I_{LIM}	mA
Load Resistance	R_L		2			kΩ
Load Capacitance	C_L				500	nF
Protection Functions						
Protection against reverse polarity		*Ground* vs. V_S vs. V_{OUT}			35	V
System Parameters						
Nonlinearity		ideal input		0.05	0.15	%FS

* Depending on external load resistance at output of IA ($R_{LIA} \leq 10k\Omega \Rightarrow V_{OUTIA} < 3mV$); internal load resistance is ≈ 100kΩ
Currents flowing into the IC are negative

BOUNDARY CONDITIONS

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Sum Gain Resistors	$R_1 + R_2$	only for sink mode of *CV* reference	90		200	kΩ
Sum Offset Resistors	$R_3 + R_4$		20		200	kΩ
V_{REF} Capacitance	C_1		1.9	2.2	5.0	µF
V_{IA} Capacitance	C_2		10		100	nF

FUNCTIONAL DIAGRAM

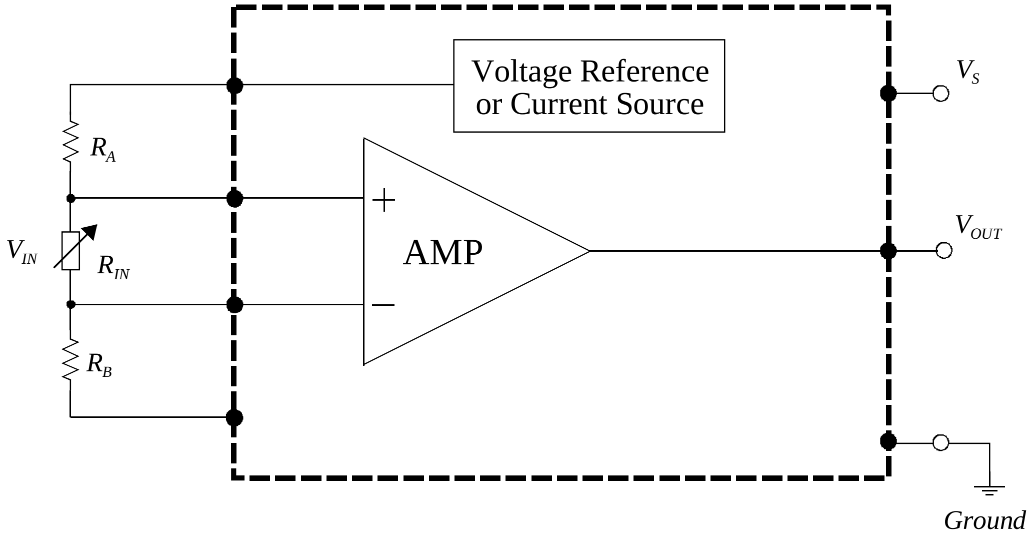

Figure 2

FUNCTIONAL DESCRIPTION

The IC AM401 is an integrated voltage transmitter for bridge input signals. With variations of a few external components the output voltage can be adjusted over a wide range. In addition to the resistors R_1 and R_2 the circuitry needs only two external capacitors C_1 and C_2 for a basic application. Using the input of the voltage output stage the AM401 can be used for single ended input signals as well. Typical values for the external components are listed in the *Application Notes*.

Basically the AM401 consists of 4 functional blocks as they are shown in Figure 1:

1. A high accuracy *instrumentation amplifier* with an internal gain G_{IA} and the possibility to adjust the bias voltage (pin *ZA*) for differential input signals.
2. An *operational amplifier output stage* used for voltage transmission and as the voltage output. The output stage has an output current limitation protecting the IC.
3. An *adjustable voltage reference* (*VSET = N.C.* or *VSET = GND*) can be used as an excitation for constant voltage sensors or as supply for other external devices.
4. An *auxiliary operational amplifier* which can used as a additional current/voltage source or as an adjustment for the bias offset voltage (see *Application Notes*).

The transfer function of the output voltage of the instrumentation amplifier is:

$$V_{OUTIA} = G_{IA} V_{IN} + V_{ZA}$$

with the an offset voltage V_{ZA} which can be adjusted on the zero adjust pin *ZA*. Using a circuitry with the additional operational amplifier like shown in figure 7, this offset voltage can be calculated by

$$V_{OFFSET} = V_{BG} - \frac{R_4}{R_3}\left(V_{REF} - V_{BG}\right)$$

For the entire output voltage V_{OUT} of the IC is valid

$$V_{OUT} = G_{OP} \cdot V_{INOP}$$

with the adjustable gain G_{OP}

$$G_{OP} = \frac{R_1}{R_2} + 1$$

The minimum supply voltage, which has to be adjusted, can be calculated by

$$V_S \geq V_{OUTmax} + 5\text{V}$$

Important: Non used blocks of the IC like the auxiliary OP in Application 1 have to be connected. The two capacitors C_1 and C_2 have to be connected in every case as well! Even if the voltage reference is not used.

PINOUT

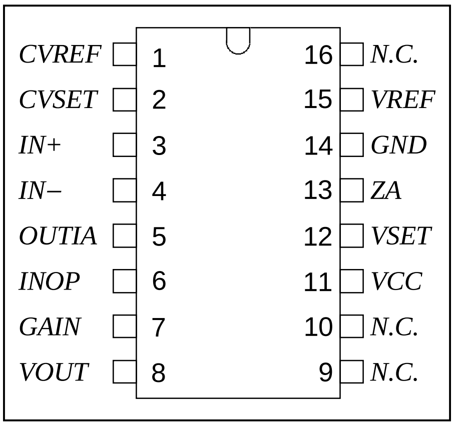

Figure 3

PIN	NAME	DESIGNATION
1	*CVREF*	Current/Voltage Reference
2	*CVSET*	Set Current/Voltage
3	*IN+*	Non Inverting Bridge Input
4	*IN–*	Inverting Bridge Input
5	*OUTIA*	Output Instrumentation Amplifier
6	*INOP*	Input Operational Amplifier
7	*GAIN*	Gain Adjustment
8	*VOUT*	Voltage Output
9	*N.C.*	Not Connected
10	*N.C.*	Not Connected
11	*VCC*	Supply Voltage
12	*VSET*	Voltage Select
13	*ZA*	Zero Adjust
14	*GND*	IC Ground
15	*VREF*	Reference Voltage
16	*N.C.*	Not Connected

DELIVERY

The AM401 is available in version:

- 16 pin DIL packages (samples)
- SO 16 (n) packages
- Dice on 5“ blue foil

PACKAGE DIMENSIONS SO16 (n)

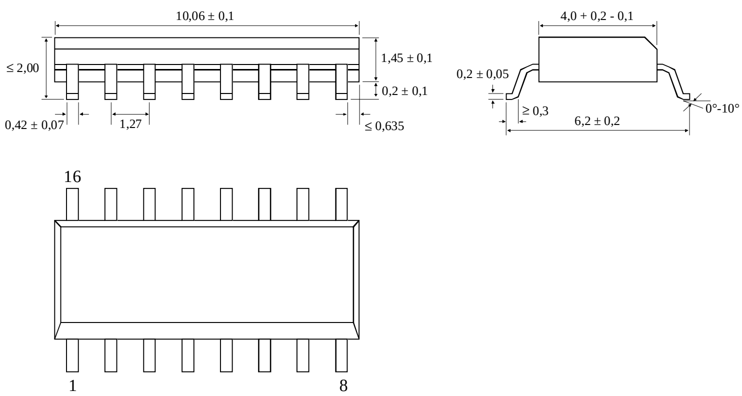

Figure 4

APPLICATION FOR OUTPUT VOLTAGE 0...10V

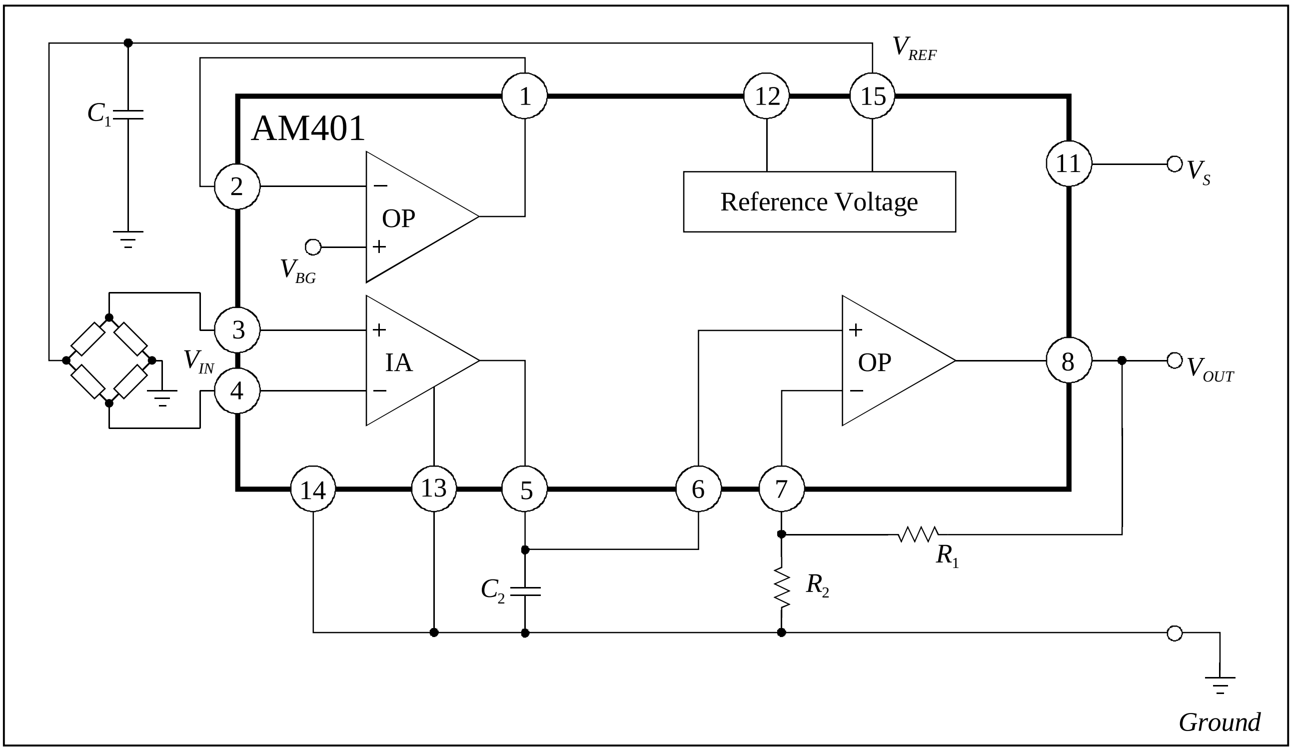

Figure 5

Used in a 0...10V output application zero adjust pin 13 (*ZA*) is connected to *Ground* (Figure 5). The Gain *G* is adjusted by external resistors R_1 and R_2 and can be calculated by

$$G = G_{IA} G_{OP} = G_{IA} (1 + R_1 / R_2)$$

The transfer function of the output voltage V_{OUT} becomes

$$V_{OUT} = G\, V_{IN}$$

With these equations the external resistors R_1 and R_2 can be adjusted

$$\frac{R_1}{R_2} = \frac{V_{OUT}}{G_{IA}\, V_{IN}} - 1$$

Example 1: Output voltage range 0...10V

In this case the values of the external devices (V_{IN} = 0...50mV, R_1/R_2 = 39) are as follows

$R_1 \approx 39k\Omega$ $R_2 \approx 1k\Omega$ $G_{IA} = 5$ $C_1 = 2.2\mu F$ $C_2 = 10nF$

Example 2: Output voltage range 0...5V

In this case the values of the external devices (V_{IN} = 0...100mV, R_1/R_2 = 9) are as follows

$R_1 \approx 90k\Omega$ $R_2 \approx 10k\Omega$ $G_{IA} = 5$ $C_1 = 2.2\mu F$ $C_2 = 10nF$

APPLICATION FOR CURRENT DRIVEN SENSORS

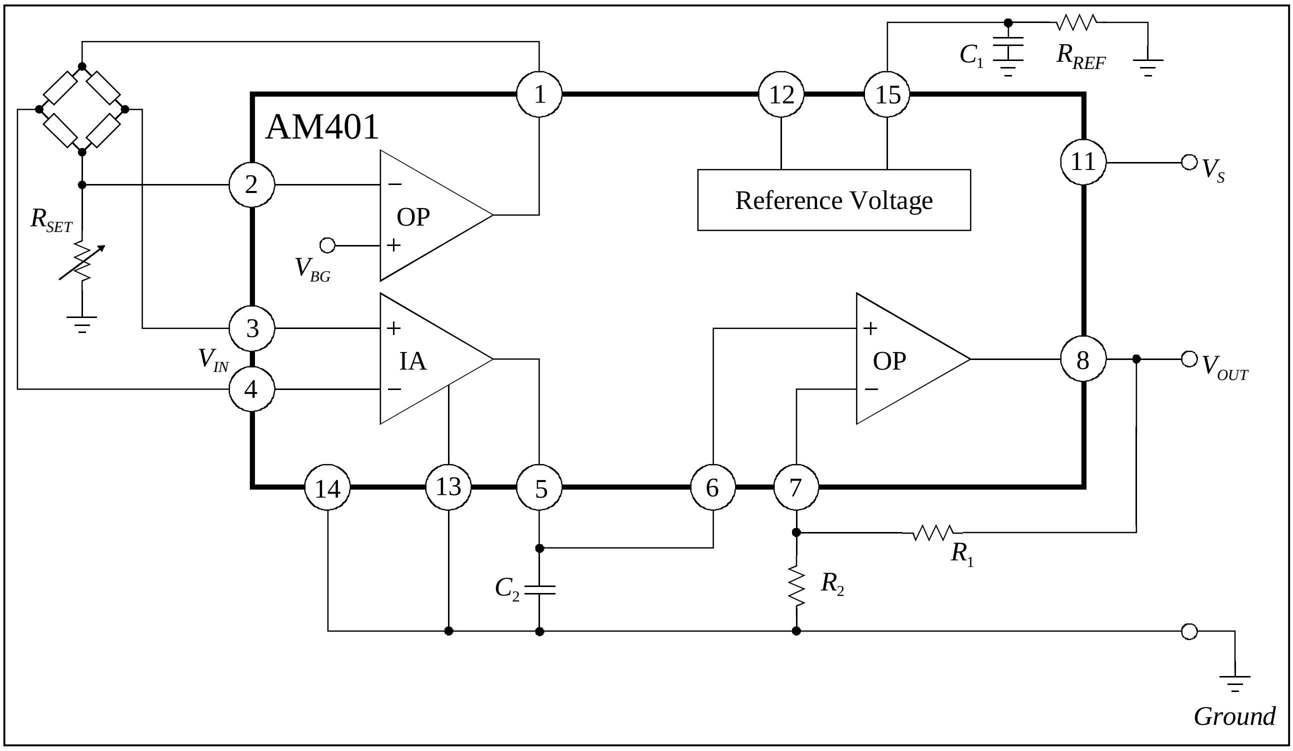

Figure 6

In this application the auxiliary operational amplifier is used as a current source. The values of the external components are calculated for an 0...5V output. For the application the zero adjust pin 13 (*ZA*) is connected to *Ground* (Figure 5). The Gain *G* is adjusted by external resistors R_1 and R_2 and can be calculated by

$$G = G_{IA} G_{OP} = G_{IA}\left(1 + R_1/R_2\right)$$

The transfer function of the output voltage V_{OUT} becomes

$$V_{OUT} = G\ V_{IN}$$

With these equations the external resistors R_1 and R_2 can be adjusted

$$\frac{R_1}{R_2} = \frac{V_{OUT}}{G_{IA}\ V_{IN}} - 1$$

The excitation current of for the sensor can be calculated over

$$I_S = \frac{V_{BG}}{R_{SET}}$$

Example 3: Output voltage range 0...5V
The values of the external devices (V_{IN} = 0...100mV, $R_1/R_2 = 9$, I_S = 1.5mA, V_{BG} = 1.27V) are

$R_1 \approx 90\text{k}\Omega$	$R_2 \approx 10\text{k}\Omega$	$G_{IA} = 5$	$C_1 = 2.2\mu\text{F}$	$C_2 = 10\text{nF}$
$R_{SET} \approx 846.7\Omega$	$R_{REF} \approx 22\text{k}\Omega$			

APPLICATION FOR OUTPUT VOLTAGE 0.5...4.5V

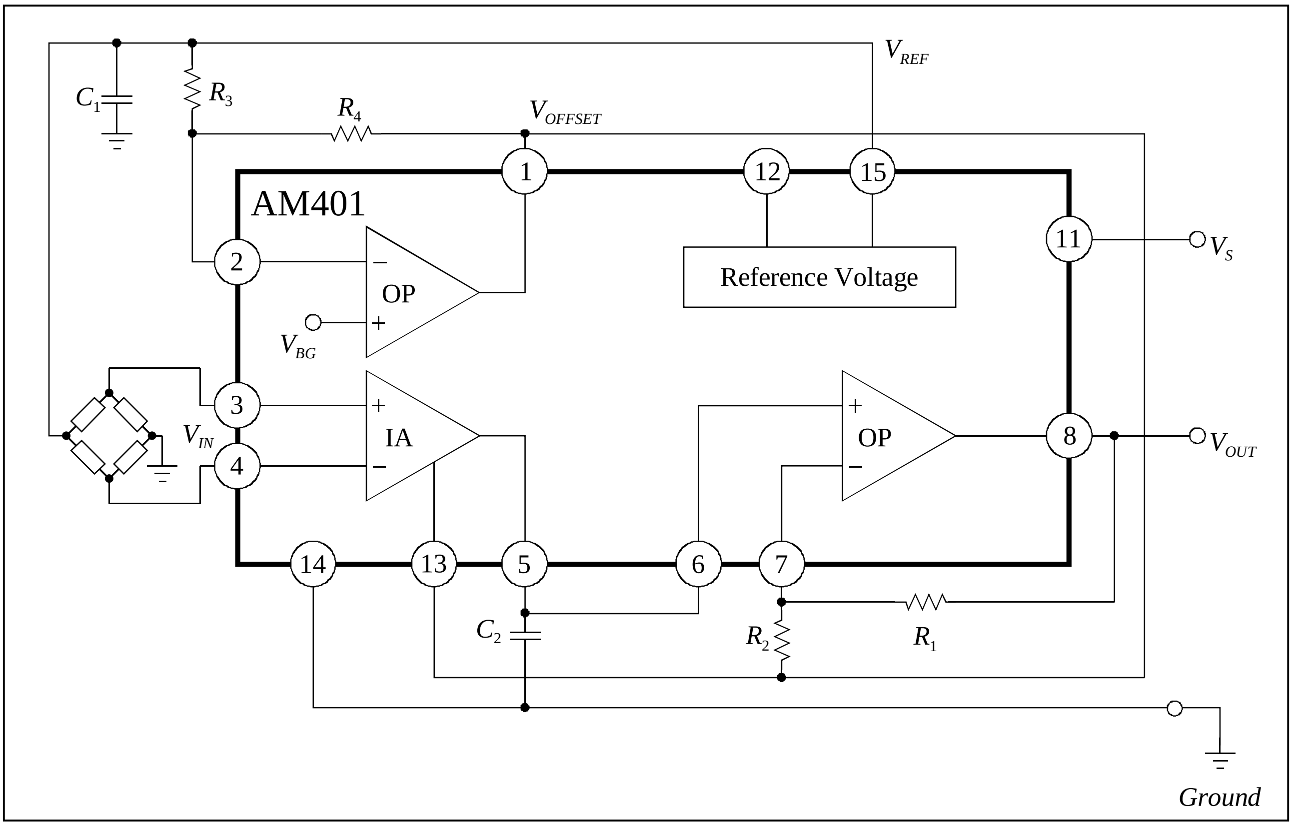

Figure 7

Used in a 0.5...4.5V output application zero adjust pin 13 (*ZA*) is connected to an offset voltage V_{OFFSET} (Figure 6). The Gain G is adjusted by external resistors R_1 and R_2 and can be calculated by

$$G = G_{IA} G_{OP} = G_{IA} \left(1 + R_1 / R_2\right)$$

The transfer function of the output voltage V_{OUT} becomes

$$V_{OUT} = G\ V_{IN} + V_{OFFSET}$$

The offset voltage can be calculated by

$$V_{OFFSET} = V_{BG} - \frac{R_4}{R_3}\left(V_{REF} - V_{BG}\right) \quad \Rightarrow \quad \frac{R_3}{R_4} = \frac{V_{REF} - V_{BG}}{V_{BG} - V_{OFFSET}}$$

With these equations the external resistors R_1 and R_2 can be adjusted

$$\frac{R_1}{R_2} = \frac{V_{OUT} - V_{OFFSET}}{G_{IA}\ V_{IN}} - 1$$

Example 4: Output voltage range 0.5...4.5V

In this case the values of the external devices (V_{IN} = 0...250mV, V_{REF} = 5V, R_1/R_2 = 2.2, R_3/R_4 = 5) are as follows

$R_1 \approx$ 100kΩ	$R_2 \approx$ 47kΩ	$R_3 \approx$ 75kΩ	$R_4 \approx$ 15kΩ
V_{OFFSET} = 0.5V	C_1 = 2.2µF	C_2 = 10nF	

TOPOLOGIE FOR THE 0...10V APPLICATION

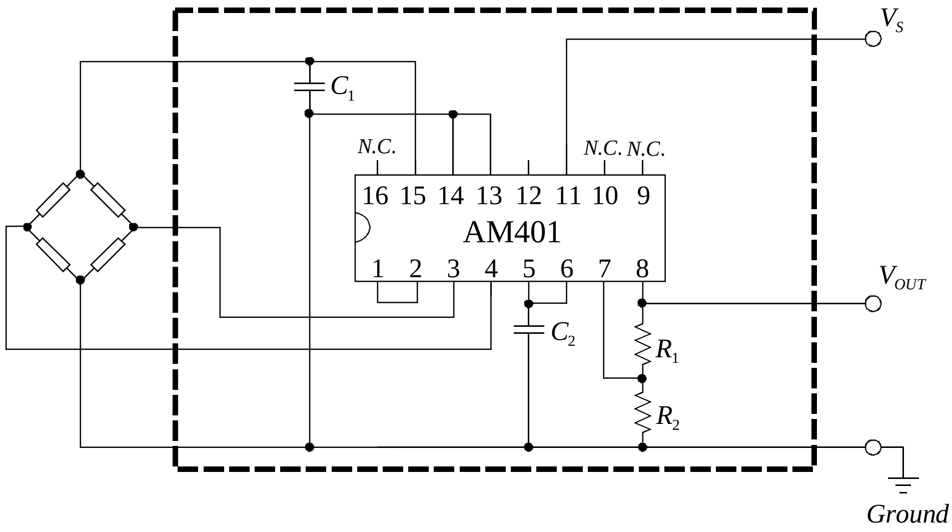

Figure 8

TOPOLOGIE FOR THE 0.5...4.5V APPLICATION

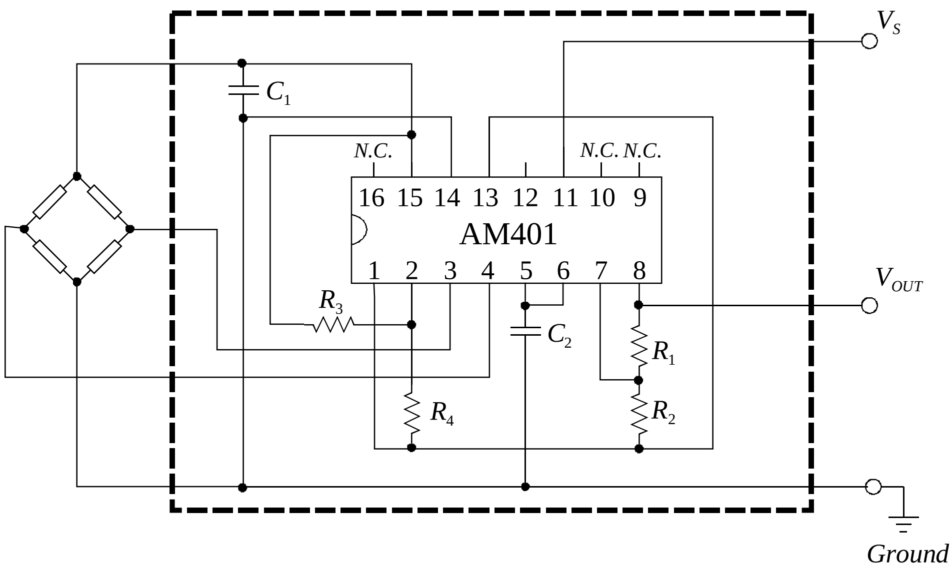

Figure 9