High Precision Instrumentation Amplifier AM447

FEATURES

- **Very Low Offset Voltage: < 25µV**
- **Low Input Bias Current: ≤ 5nA**
- **High Input Sensitivity**
- **High CMRR: > 90dB min**
- **Wide Operating Temperature Range: –40°C...+140°C**
- **Adjustable Rail–to–Rail Voltage Output Stage: 0.5...4.5V**
- **Single Supply Device (ratiometric)**
- **Integrated Source and Sink Capability: ±2mA**
- **Low Noise Behaviour**

APPLICATIONS

- Small Signal (Bridge) Amplifier
  - Low Pressure Sensors
  - Automotive Applications
  - DMS Interface
  - Interface for Ceramic Sensors
- High Precision Amplifier
  - Medical Instrumentation
  - Data Acquisition

GENERAL DESCRIPTION

The AM447 is a high precision amplifier, designed for amplification of sensor bridge signals up to 35mV full scale. The single supply circuit consists of a high precision instrumentation amplifier (IA) and an integrated ratiometric output stage. Input offset voltages less than ±25µV (±1µV/°C) are adjustable by only two externally trimmable resistors. The monitoring of the amplified signal is possible at the output of the IA and makes the adjustment easier. With the externally adjustable gain of the output stage, the AM447 can be used for different signal sources. The 2mA sink and source capability makes it ideal for high precision applications specially in the field of automotive sensors.

DELIVERY

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

BLOCK DIAGRAM

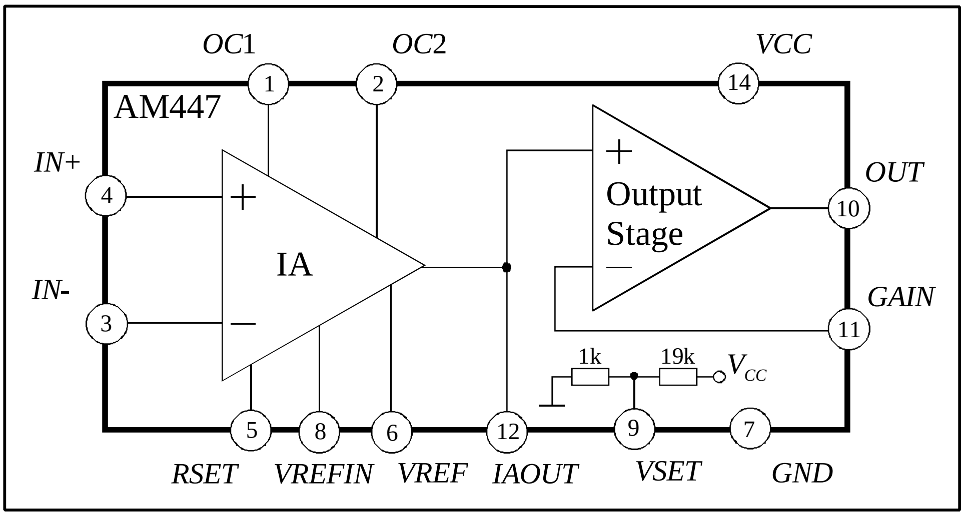

Figure 1

Analog Microelectronics GmbH
An der Fahrt 13, D – 55124 Mainz
Internet: www.analogmicro.de

Phone: +49 (0)6131/91 073 – 0
Fax: +49 (0)6131/91 073 – 30
E–Mail: info@analogmicro.de

ELECTRICAL SPECIFICATIONS

V_{CC} = 5V, T_{amb} = 25°C (unless otherwise noted)

Parameter	Symbol	Conditions	RM	Min.	Typ.	Max.	Unit
Supply Voltage Range	V_{CC}		yes	4.75	5	5.25	V
Maximum Supply Voltage	V_{CCmax}					7	V
Quiescent Current	I_{CC}	$V_{IN} = 0$		2.2	3.3	4.6	mA
Temperature Specifications							
Life Time	LT			2500/10			h/a
Operating	T_{amb}	$T_{85\%}$ = 100°C for 85% of LT $T_{15\%}$ = 120°C for 15% of LT T_{max} = 140°C for t ≤ 50h		–40		140	°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
Instrumentation Amplifier							
Internal Gain	G_{INT}			100	102	104	
Gain Drift(1)	dGI_{INT}/dT				30		ppm/°C
Differential Input Voltage	V_{IN}	$V_{IN} = V_{IN+} - V_{IN-}$		7		35	mV
Common Mode Input Range	$CMIR$			2.1	2.5	2.9	V
Common Mode Rejection Ratio	$CMRR$	DC, R_G = 0, V_{IN} = 5mV		90	≥ 105		dB
Power Supply Rejection Ratio	$PSRR$	DC, R_G = 0, V_{IN} = 5mV		96	≥ 105		dB
Input Offset Voltage	V_{OS}	R_G = 0, compensated			± 25		µV
	V_{OS}	R_G = 0, uncompensated			± 500		µV
V_{OS} vs. Temperature(1)	dV_{OS}/dT	R_G = 0, compensated			± 1		µV/°C
	dV_{OS}/dT	R_G = 0, uncompensated			± 5		µV/°C
Input Offset Current	I_{OS}		yes		± 1	± 5	nA
I_{OS} vs. Temperature	dI_{OS}/dT		yes		± 5	± 20	pA/°C
Input Bias Current	I_B		yes		± 15	± 25	nA
I_B vs. Temperature	dI_B/dT		yes		± 50		pA/°C
Input-Referred Voltage Noise	e_n	10Hz			25	60	nV/√Hz
		0.1 ... 10Hz			1		μV_{PP}
Input-Referred Current Noise		10Hz			1.6		pA/√Hz
		0.1 ... 10Hz			70		pA_{PP}
Output Voltage Range	V_{IAOUT}			0.15		V_{CC} – 1.25	V
Output Current	I_{IAOUT}	Sourcing, V_{IAOUT} = max.		50			µA
		Sinking, V_{IAOUT} = min		20			µA
Capacitive Load Stability	C_{IAOUT}				100		pF
Nonlinearity		End-point Method			20	40	ppm FS
Reference Voltage							
Adjustable Voltage Range	V_{REF}		yes	0.15	0.25	1.00	V
Output Current	I_{REF}	Sourcing		80			µA
		Sinking		80			µA

Note: (1) No statistic measurements
RM: Ratiometrical
R_G: Generator Source Resistance
FS: Full Scale

Parameter	Symbol	Conditions	RM	Min.	Typ.	Max.	Unit
Output Stage							
Adjustable Gain	G_{ADJ}			1.2	1.65	4	
Gain Drift	dG_{ADJ}/dT					5	ppm/°C
Common Mode Input Range	$CMIR$			0.05		$V_{CC} - 1$	V
Common Mode Rejection Ratio	$CMRR$	DC		80	90		dB
Power Supply Rejection Ratio	$PSRR$			70	80		dB
Input Offset Voltage	V_{OS}	$R_G = 0$			± 0.6	± 2.8	mV
V_{OS} vs. Temperature	dV_{OS}/dT	$R_G = 0$			± 15	± 25	µV/°C
Input Bias Current	I_B		yes	–5	–10	–30	nA
I_B vs. Temperature	dI_B/dT		yes	5	10	25	pA/°C
Output Voltage Range	$V_{OUT,min}$	Sinking, $I_{OUT} = 2mA$			100	200	mV
	$V_{OUT,max}$	Sourcing, $I_{OUT} = 2mA$		$V_{CC} - 0.2$			V
Output Resistance	R_{OUT}					1	Ω
Capacitive Load Stability	C_{LOAD}			0		47	nF
Slew Rate	SR	$C_{LOAD} = 5nF$	yes	0.027			V/µs
Sink Capability	I_{Sink}	$V_{OUT} = 2.5V$, $G_{ADJ} = 1$				2	mA
Source Capability	I_{Source}	$V_{OUT} = 2.5V$, $G_{ADJ} = 1$				2	mA

ESD: This integrated circuit can be damaged by ESD. Analog Microelectronics recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

BOUNDARY CONDITIONS

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Offset Compensation Resistor (IA) 1 [1)]	R_{OC1}		27		33	kΩ
Offset Compensation Resistor (IA) 2 [1)]	R_{OC2}		27		33	kΩ
Gain Resistor 1	R_{G1}		67.3		68.7	kΩ
Gain Resistor 2	R_{G2}		14		210	kΩ
Offset Compensation Resistor (Bridge) 1	R_{O1}			19		kΩ
Offset Compensation Resistor (Bridge) 2	R_{O2}			1		kΩ
Set Resistor [2)]	R_{SET}		75.0	76.8	78.7	kΩ
Sensor Bridge Resistor [3)]	R_{BRIDGE}		7		13	kΩ
Differential Input Voltage	V_{IN}	$V_{CC} = 5V$	7		35	mV

Notes: [1)] The offset adjustment is described in the *Functional Description*. An offset compensation over temperature can only be achieved by choosing the resistors R_{OC1} and R_{OC2} with the same temperature coefficient and a very close placement of them in the circuit.
[2)] A good matching of the resistor R_{SET} with the bridge resistors is forced.
[3)] The symmetry of the two resistor half bridges has to be better than 2%.

FUNCTIONAL DIAGRAM

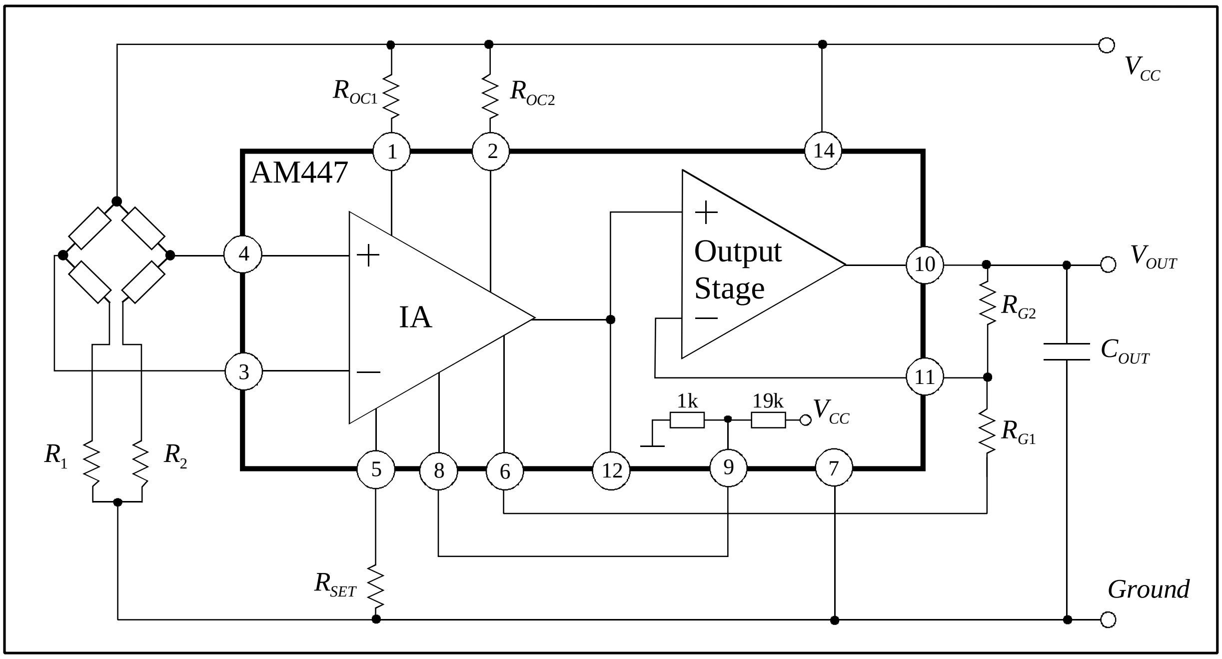

Figure 2: Application for non-compensated and non-calibrated transducers

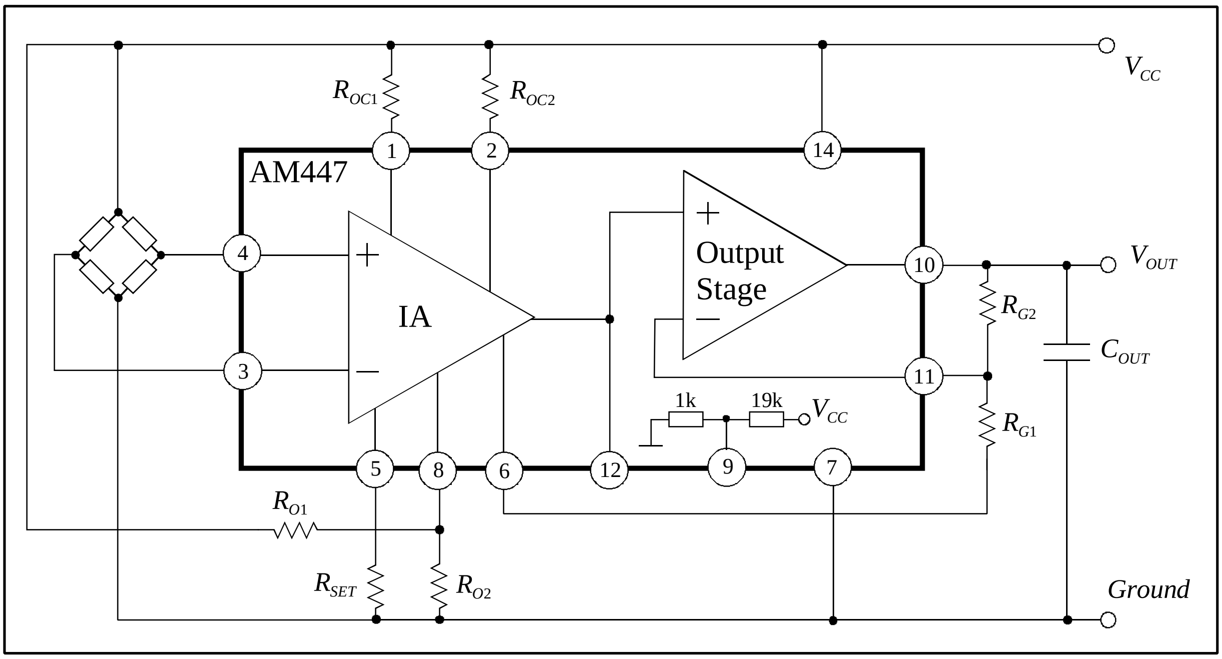

Figure 3: Application for compensated and calibrated transducers

FUNCTIONAL DESCRIPTION

The IC AM447 is an integrated high precision amplifier for low bridge output signals. Basically the AM447 is composed of 2 functional sections as shown in Figure 1:

1. A high accuracy *instrumentation amplifier (IA)* allows amplification with a high signal-to-noise ratio. The two offset compensation resistors R_{OC1} and R_{OC2} offer the possibility to make the input offset voltage of the instrumentation amplifier to nearly zero. But offset compensation over temperature is only given if the resistors R_{OC1} and R_{OC2} have the same temperature coefficients. Furthermore, these resistors have to be placed together very close. It is also necessary to use similar metals for the connection of the sensor bridge and the AM447 to avoid thermocouple effects. The internal gain of the IA is fixed to the value $G_{INT} = 102$. The output voltage V_{IAOUT} (pin 10) of the IA is given by the following equation:

$$V_{IAOUT} = G_{INT} \cdot \left(V_{IN+} - V_{IN-}\right) + V_{VREF}$$

2. An *output stage* de–couples the IA and thus improves the performance of the AM447. The gain factor G is fixed by the two external resistors R_{G1} and R_{G2}. The gain factor of the output stage is defined by

$$G_{ADJ} = 1 + \frac{R_{G2}}{R_{G1}}$$

The output signal V_{OUT} (pin 10) can be calculated with

$$V_{OUT} = G\left(V_{IN+} - V_{IN-}\right) + V_{VREF} = \underbrace{G_{INT} \cdot G_{ADJ}\left(V_{IN+} - V_{IN-}\right)}_{\text{Span adjustment}} + \underbrace{V_{VREF}}_{\substack{\text{Offset adjustment for}\\ \text{kalibrated transducers}}}$$

The AM447 is suited for two types of transducers. The IC is designed for usage with non-compensated and non-calibrated sensors using resistors R_1 and R_2 for offset calibration as well as for sensor systems with calibrated transducers. The remaining offset of the transducers can be calibrated by variation of V_{VREF}. The adjustment of the offset is then:

$$V_{VREF} = \frac{R_{O2}}{R_{O1} + R_{O2}} V_{CC}$$

The entire sensor systems realised with the different types of AM447 and only a few external components are shown in Figures 2 and 3.

Offset calibration of the instrumentation amplifier

The offset compensation has to be handled with care because the entire system performance depends on it. Please note, that this offset adjustment doesn't include the bridge offset.

The offset compensation has to be done in the following order:

- $T = 25°\text{C}$ and $V_{CC} = 5\text{V}$
- $V_{IN+} = V_{IN-} = V_{REF} = 2.5\text{V}$
- The voltage between V_{IAOUT} (pin 12) and V_{REF} (pin 6) has to be adjusted to zero Volt.
- V_{IAOUT} is increased by increasing R_{OC1} and is decreased by increasing R_{OC2}.

PINOUT

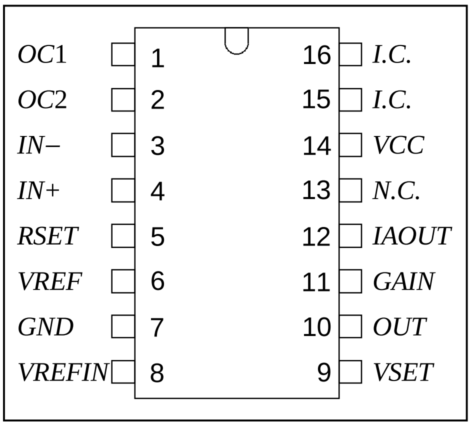

Figure 4

PIN	NAME	DESIGNATION
1	*OC*1	Offset Compensation Resistor 1
2	*OC*2	Offset Compensation Resistor 2
3	*IN–*	Inverting Input (IA)
4	*IN+*	Non–inverting Input (IA)
5	*RSET*	Set Resistor
6	*VREF*	Reference Voltage
7	*GND*	Ground
8	*VREFIN*	Reference Voltage Input
9	*VSET*	Choice of Application
10	*OUT*	Output
11	*GAIN*	Gain Adjustment
12	*IAOUT*	Output (IA)
13	*N.C.*	Not Connected
14	*VCC*	Supply Voltage
15	*I.C.*	Internally Connected
16	*I.C.*	Internally Connected

DELIVERY

The AM447 is available in version:

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

PINOUT

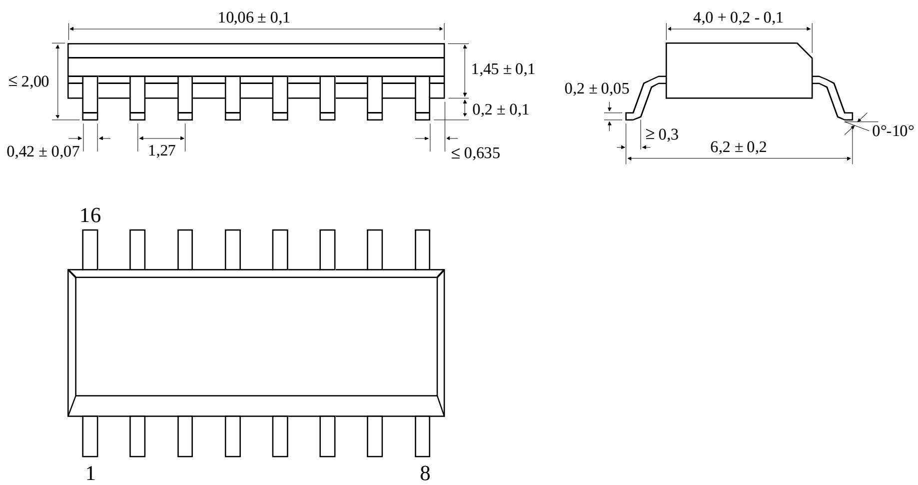

Figure 5