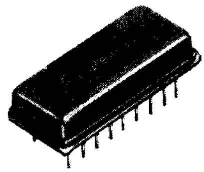
BURR-BROWN®

3630



Very High Accuracy INSTRUMENTATION AMPLIFIER

FEATURES

- ULTRA LOW VOLTAGE DRIFT - 0.25µV/°C
- LOW BIAS CURRENT - 20nA
- LOW NOISE - 1.2µV p-p
- HIGH INPUT IMPEDANCE - 10 x $10^9\Omega$
- HIGH CMR - 106dB @ 60Hz
- LOW OFFSET VOLTAGE - 25µV
- LOW NONLINEARITY - 0.002%

APPLICATIONS

- AMPLIFICATION OF SIGNALS FROM SOURCES SUCH AS:

  Strain Gages
  Thermocouples
  RTDs
- REMOTE TRANSDUCERS
- LOW LEVEL SIGNALS

DESCRIPTION

The 3630 is a high accuracy, multi-stage, integrated circuit instrumentation amplifier designed for signal conditioning requirements where very high performance is desired.

A multi-stage design is used to provide excellent specifications and maximum versatility at reasonable cost. The input stage uses Burr-Brown's ultra-low drift low noise monolithic operational amplifiers to provide outstanding input characteristics.

All resistors are on a single network of Nichrome deposited on silicon. This provides high initial accuracy low TCR (temperature coefficient of resistance) and TCR matching, and outstanding stability as a function of time.

State-of-the-art laser-trimming techniques are used for reduction of offset voltage, offset voltage drift versus temperature, and for maximizing common-mode rejection.

In addition to providing an outstanding set of specifications, the 3630 offers convenience and ease of use in providing the following features: single capacitor active low pass filtering; easy output biasing (zero suppression and elevation); common-mode voltage generation for active guard drive; conveniently increased output current capability.

The unit is packaged in an 18-pin metal hermetic dual-in-line package which provides shielding, ease of installation, and environmental ruggedness.

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DISCUSSION

INSTRUMENTATION AMPLIFIERS

Instrumentation amplifiers are closed loop gain blocks whose committed circuitry accurately amplifies the voltage applied to their inputs. They respond only to the difference between the two input signals and exhibit extremely high input impedance, both differentially and common-mode. Feedback networks are packaged within the amplifier module. Only one external gain setting resistor must be added. An operational amplifier, on the other hand, is an open loop, uncommitted device that requires external networks to close the loop. While op amps can be used to achieve the same basic function as instrumentation amplifiers, it is difficult to reach the same level of performance. Using op amps often leads to design trade-offs when it is necessary to amplify low-level signals in the presence of common-mode voltages while maintaining high input impedances.

THE 3630

A simplified schematic of the 3630 is shown in Figure 1. It is a three-stage device which provides all the desirable characteristics of a premium performance instrumentation amplifier. In addition, it has features not normally found on integrated circuit instrumentation amplifiers.

The input stage (A1 and A2) consists of two of Burr-Brown's premium grade high accuracy bipolar operational amplifiers. They are connected in the noninverting configuration to provide the high input impedance ($10 \times 10^9\Omega$) desirable in the instrumentation amplifier function. The inherent low offset voltage and low offset voltage drift versus temperature of these amplifiers is improved even further by the state-of-the-art laser-trimming techniques.

The second stage (A3) consists of a high quality operational amplifier connected in a unity gain difference amplifier configuration. A critical part of this stage is the matching of the four 10k ohm resistors which provide the difference function. These resistors must be initially well matched and the matching must be maintained over temperature and time in order to maintain excellent common-mode rejection. (The 106dB minimum at 60Hz for gains greater than 100V/V is a significant improvement compared to most other integrated circuit instrumentation amplifiers.)

All of the resistors shown in Figure 1 are part of a single thin-film network of Nichrome deposited on a passivated silicon substrate. The critical resistors are laser-trimmed to provide the desired high gain accuracy and common-mode rejection. The single network approach provides the excellent TCR (temperature coefficient of resistance) and TCR tracking desirable to provide gain accuracy and common-mode rejection when the 3630 is operated over wide temperature ranges.

The third stage (A4) of the 3630 adds a great deal of versatility and convenience to the amplifier. Its use allows easy implementation of active low pass filtering, output offsetting, and additional gain generation. The pin connections make the use of this stage optional but the effects are included in electrical specifications.

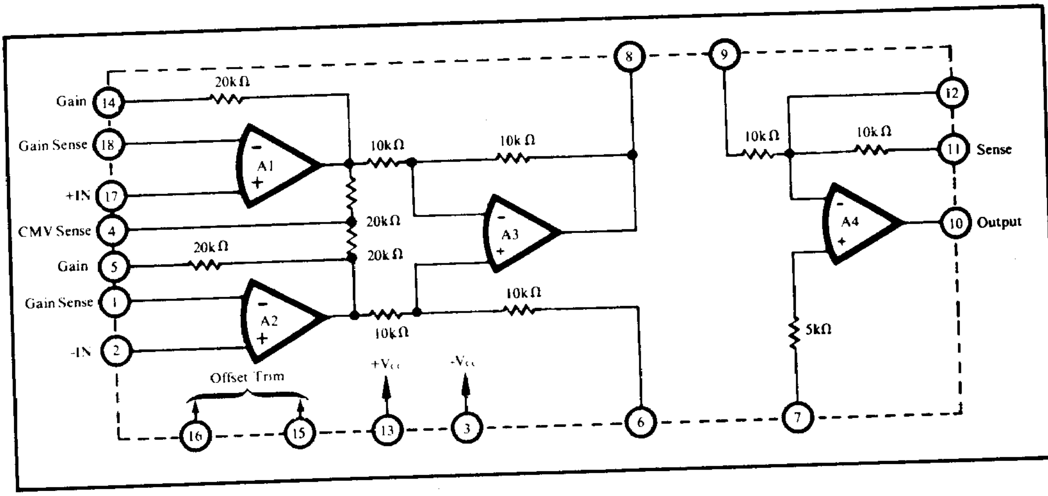


FIGURE 1. Simplified Schematic

USING THE 3630

Figure 2 shows the simplest configuration of the 3630. The gain is set by the external resistor R_G with a gain equation $G = 1 + 40k/R_G$. A low TCR resistor should be used for R_G since it contributes directly to the gain accuracy.

Pins 1, 5, 14 and 18 are accessible so that a four terminal connection can be made to R_G. (Pins 1 and 18 are the voltage sense terminals since no signal current flows into the operational amplifiers' inputs.) This may be useful at high gains where the value of R_G becomes small.

The optional offset null capability is shown in Figure 4. The adjustment affects only the input stage component of the offset voltage. Thus, the null condition will be disturbed when the gain is changed. Also, the input drift will be effected by approximately 0.33μV/°C per 100μV of input offset voltage nulled.

Output offsetting ("zero suppression" or "zero elevation") may be more easily accomplished with the 3630 than with most other IC instrumentation amplifiers.

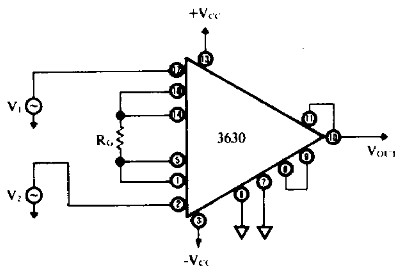


FIGURE 2. Basic Connections

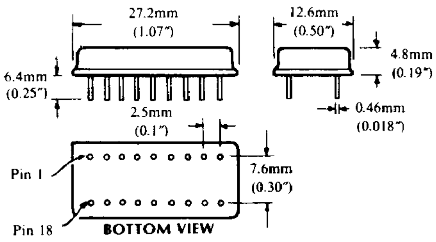
Figure 5 shows how this is done. The use of the noninverting input of the output stage means that CMR of the second stage is not disturbed and that any convenient value of variable resistor can be used.

The output stage also allows active low pass filtering to be implemented conveniently with a single capacitor. The effect this filtering has on noise reduction can be seen in the Typical Performance Curves.

The input stage contains extra resistors for the computation of input common-mode voltage. Figure 7 shows how this voltage, available at pin 4, can be used to drive the shield of the input cable. Since the cable is driven at the common-mode voltage the effects of distributed capacitance is reduced and the AC system common-mode rejection may be improved. Amplifier A1 is a buffer to supply larger currents than can be supplied by the 20kΩ resistors internally connected to pin 4.

Figure 8 shows how the output stage may be used to provide additional gain. If gains greater than 1000V/V are desired it is better to obtain them from the output stage than the input stage due to the low values of R_G required ($R_G < 40\Omega$ for $(1 + 40k/R_G) > 1000$).

MECHANICAL



Pin material and plating composition conform to Method 2003 (solderability) of Mil-Std-883 (except paragraph 3.2).

FIGURE 3. Mechanical Specifications

PIN DESIGNATIONS

1. Gain Sense
2. Inverting Input
3. Negative Supply
4. Common-mode Voltage Sense
5. Gain
6. Ground
7. Reference
8. Output of A_3
9. Input to A_4
10. Output
11. Sense
12. Summing Junction of A_4
13. Positive Supply
14. Gain
15. Offset Trim
16. Offset Trim
17. Noninverting Input
18. Gain Sense

ELECTRICAL SPECIFICATIONS

Specifications typical at 25°C with ±15VDC power supply and in circuit of Figure 2 unless otherwise noted.

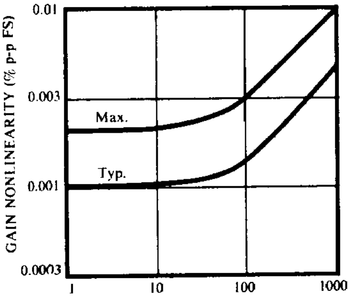
MODEL	3630AM			3630BM, 3630SM			3630CM			Units
	min	typ	max	min	typ	max	min	typ	max	
GAIN										
Range of Gain	1		1000	*		*	*		*	V/V
Gain Equation		$G = 1 + 40k/R_G$			*			*		V/V
Error From Equation, DC		(±0.05 ±0.0001G)	(±0.1 ±0.0002G)		(±0.02 ±0.00005G)	(±0.05 ±0.0001G)		(±0.02 ±0.00005G)	(±0.05 ±0.0001G)	%
Gain Temp. Coefficient[1]										
G = 1		8	20		*	*		*	*	ppm/°C
G = 10		45	115		*	*		*	*	ppm/°C
G = 100		50	125		*	*		*	*	ppm/°C
G = 1000		50	125		*	*		*	*	ppm/°C
Nonlinearity, DC		$\pm(0.002 + 10^{-5}G)$	$\pm(0.005 + 2 \times 10^{-5}G)$		$\pm(0.001 + 4 \times 10^{-6}G)$	$\pm(0.002 + 10^{-5}G)$		$\pm(0.001 + 4 \times 10^{-6}G)$	$\pm(0.002 + 10^{-5}G)$	% of p-p FS
RATED OUTPUT										
Voltage	±10	±12.5		*	*		*	*		V
Current	±5	±12.5		*	*		*	*		mA
Output Impedance		0.01			*			*		Ω
INPUT OFFSET VOLTAGE										
Initial Offset at 25°C[2]		±25 ±200/G	±50 ±400/G		±10 ±100/G	±25 ±200/G		±10 ±100/G	±25 ±200/G	µV
vs. Temperature			±2 ±20/G			±0.75 ±10/G			±0.25 ±10/G	µV/°C
vs. Supply		±(1 + 20/G)			*			*		µV/V
vs. Time		±(1 + 20/G)			*			*		µV/mo
INPUT BIAS CURRENT										
Initial Bias Current (each input)		±15	±50		±10	±30		±5	±20	nA
vs. Temperature		±0.3			*			*		nA/°C
vs. Supply		±0.1			*			*		nA/V
Initial Offset Current		±15	±50		±10	±30		±5	±20	nA
vs. Temperature		±0.5			*			*		nA/°C
INPUT IMPEDANCE										
Differential		$10 \times 10^9 \parallel 3$			*			*		Ω ‖ pF
Common-mode		$10 \times 10^9 \parallel 3$			*			*		Ω ‖ pF
INPUT VOLTAGE RANGE										
Range, Linear Response	±10	±12		*	*		*	*		V
CMR w/1kΩ Source Imbal.										
DC to 60Hz, G = 1	80	90		*	*		*	*		dB
DC to 60Hz, G = 10	96	106		*	*		*	*		dB
DC to 60Hz, G = 100 to 1000	106	110		*	*		*	*		dB
INPUT NOISE										
Voltage, p-p, 0.01Hz - 10Hz		1.2			*			*		µV p-p
rms, 10Hz - 1.0kHz		1.0			*			*		µV rms
Current, p-p, 0.01Hz - 10Hz		70			*			*		pA p-p
rms, 10Hz - 1.0kHz		20			*			*		pA rms
DYNAMIC RESPONSE										
Small Signal, ±3dB Flatness,										
G = 1		150			*			*		kHz
G = 10		90			*			*		kHz
G = 100		25			*			*		kHz
G = 1000		2.5			*			*		kHz
Small Signal, ±1% Flatness,										
G = 1		20			*			*		kHz
G = 10		10			*			*		kHz
G = 100		1			*			*		kHz
G = 1000		200			*			*		Hz
Full Power, G = 1 - 100		7.5			*			*		kHz
Slew Rate, G = 1 - 100	0.2	0.5		*	*		*	*		V/µsec
Settling Time (0.1%)										
G = 1		60			*			*		µsec
G = 100		100			*			*		µsec
G = 1000		500			*			*		µsec
Settling Time (.01%)										
G = 5		100			*			*		µsec
G = 100		150			*			*		µsec
G = 1000		1000			*			*		µsec
POWER SUPPLY										
Rated Voltage		±15			*			*		V
Voltage Range	±5		±20	*		*	*		*	V
Current, Quiescent		±8	±14		*	*		*	*	mA
TEMPERATURE RANGE										
Specification[3]	-25		+85	*		*	*		*	°C
Operation	-55		+125	*		*	*		*	°C
Storage	-65		+150	*		*	*		*	°C

NOTES:
1. With R_G, TCR = 0 ppm/°C
2. Trimmable to zero at any one gain.
3. -55°C to +125°C for 3630SM.

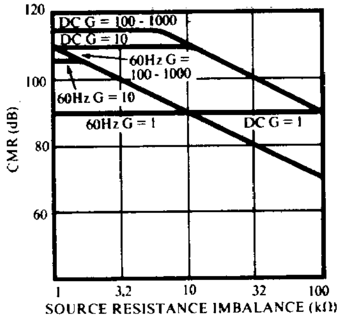
*Specifications same as for 3630AM

TYPICAL PERFORMANCE CURVES

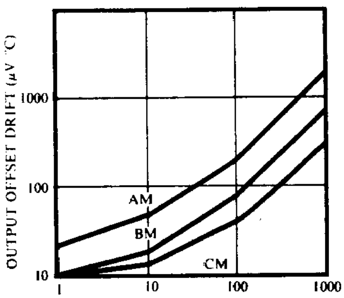
At 25°C and in circuit of Figure 2 unless otherwise noted.



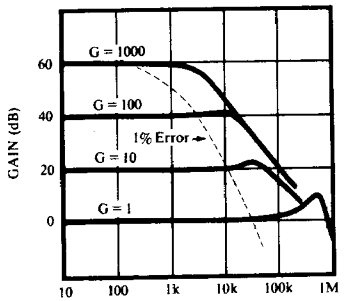
GAIN NONLINEARITY VS GAIN



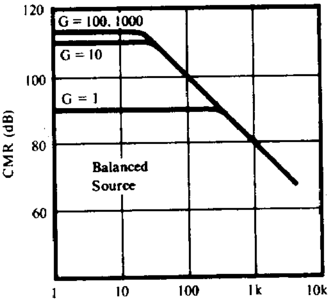
CMR VS SOURCE IMBLANCE



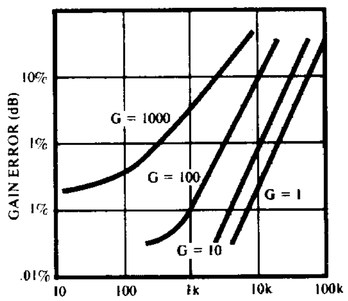
OUTPUT OFFSET DRIFT VS GAIN



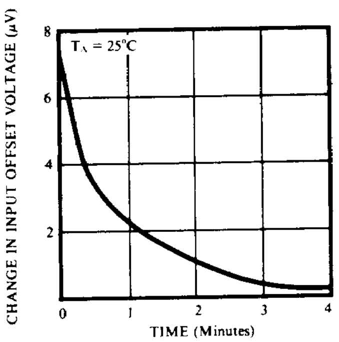
GAIN VS FREQUENCY



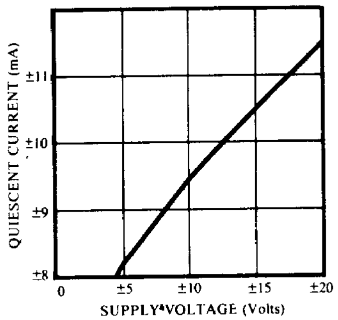
CMR VS FREQUENCY



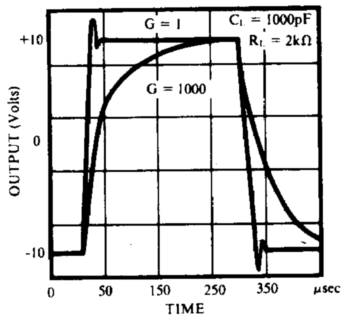
GAIN ERROR VS FREQUENCY



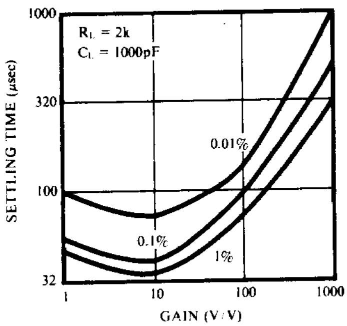
WARM-UP DRIFT VS TIME



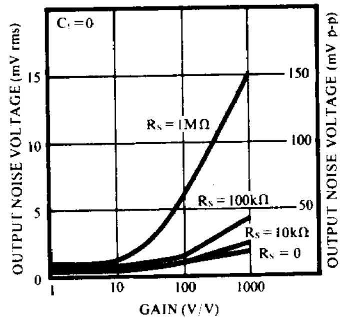
QUIESCENT CURRENT VS SUPPLY



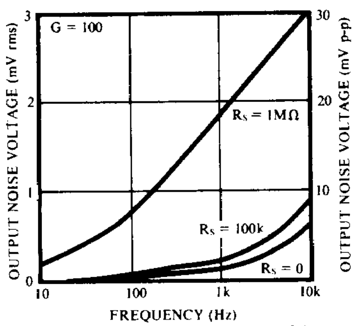
STEP RESPONSE



SETTLING TIME VS GAIN



OUTPUT NOISE VS GAIN



OUTPUT NOISE VS 3dB FREQUENCY

APPLICATIONS

3630

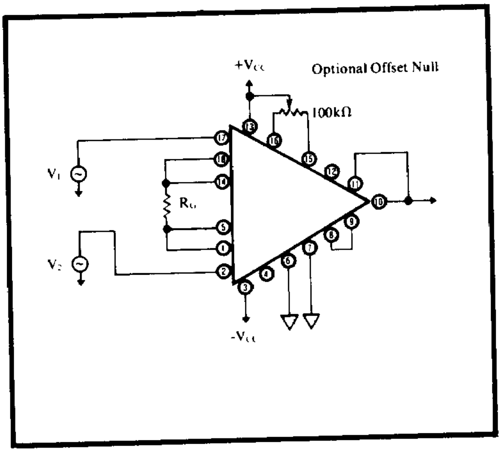


FIGURE 4. Optional Offset Null

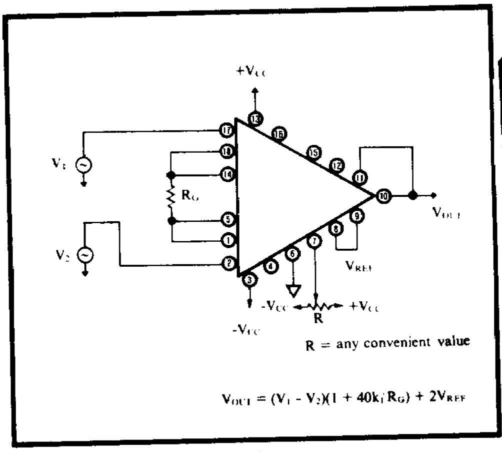


FIGURE 5. Output Offsetting

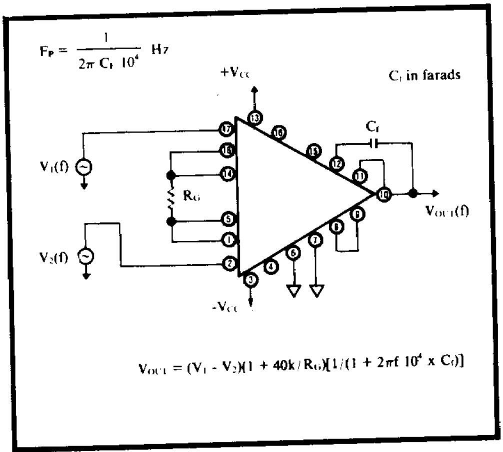


FIGURE 6. Active Low Pass Filtering

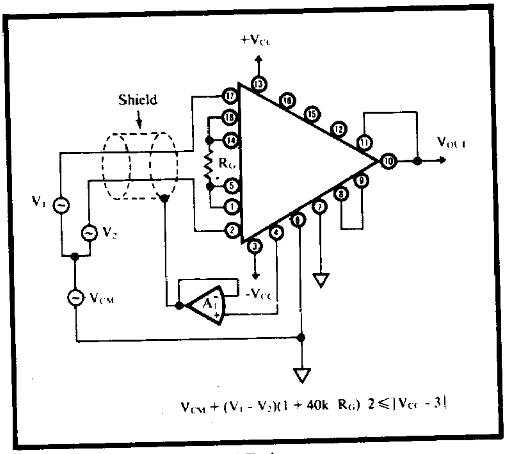


FIGURE 7. Use of Guard Drive

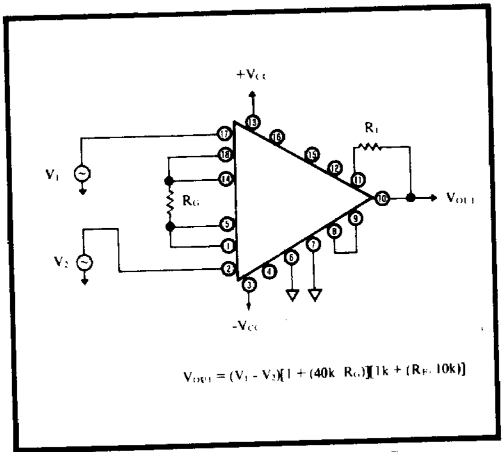


FIGURE 8. Additional Gain From Output Stage

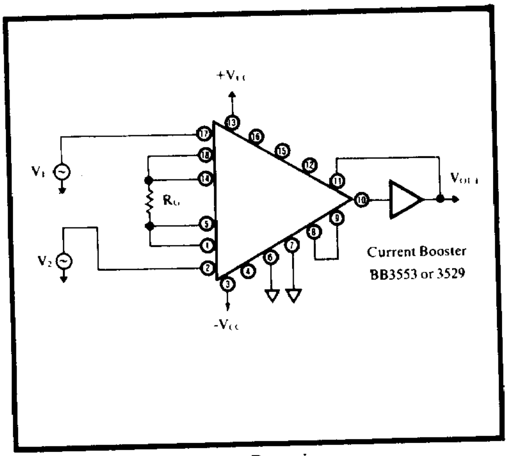


FIGURE 9. Output Power Boosting