Isolated, Loop-Powered Voltage-to-Current Converter

1B21

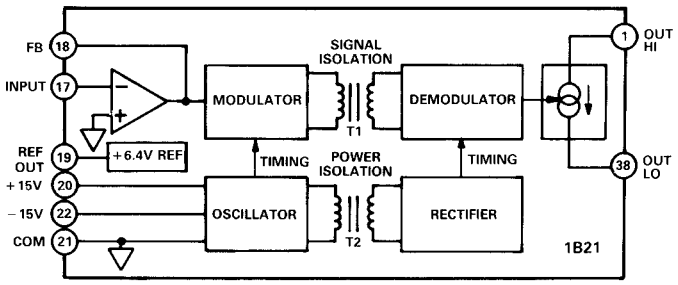
FEATURES

- **Wide Input Range: 0-1V to 0-10V**
- **High CMV Isolation: 1500V rms**
- **Programmable Output Ranges: 4mA to 20mA**
  0 to 20mA
- **Load Resistance Range: 0 to 1.35kΩ max**
- **High Accuracy**
  - **Low Offset Tempco: ±300nA/°C**
  - **Low Gain Tempco: ±50ppm/°C**
  - **Low Nonlinearity: ±0.02%**
  - **High CMR: 90dB min**
- **Small Package: 0.7″ × 2.1″ × 0.35″**
- **Meets IEEE Std. 472: Transient Protection (SWC)**

APPLICATIONS

- **Multichannel Process Control**
- **D/A Converter – Current Loop Interface**
- **Analog Transmitters and Controllers**
- **Remote Data Acquisition Systems**

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The 1B21 is an isolated voltage-to-current converter that incorporates a unique circuit design utilizing transformer based isolation and automated surface mount manufacturing technology. It provides an unbeatable combination of versatility and performance in a compact plastic package. Designed for industrial applications, it is especially suited for harsh environments with extremely high common-mode interference.

Functionally, the V/I converter consists of four basic sections: input conditioning, modulator, demodulator and current source (1B21 Functional Block Diagram). The input is a resistor programmable gain stage that accepts a 0-1V to 0-10V voltage input. This maps into a 0 to 20mA output or can be offset by 20% using the internal reference for 4mA to 20mA operation. The high level signal is modulated and passed across the barrier which provides complete input to output galvanic isolation of 1500V rms continuous by the use of transformer coupling techniques. Nonlinearity is an excellent ±0.05% max.

Designed for multichannel applications, the 1B21 requires an external loop supply and can accept up to 30V max. This would provide a loop compliance of 27V, which is sufficient to drive a 1.35kΩ load resistance.

The 1B21 is fully specified over −25°C to +85°C and operates over the industrial (−40°C to +85°C) temperature range.

DESIGN FEATURES AND USER BENEFITS

High CMV Isolation: The 1B21 features high input to output galvanic isolation to eliminate ground loops and offer protection against damage from transients and fault voltages. The isolation barrier will withstand continuous CMV of 1500V rms and meets the IEEE Standard for Transient Voltage Protection (Std. 472-SWC).

Small Size: The 1B21 package size (0.7″ × 2.1″ DIP) makes it an excellent choice in multichannel systems for maximum channel density. The 0.35″ height also facilitates applications with limited board clearance.

Ease of Use: Complete isolated voltage-to-current conversion with minimum external parts required to get a conditioned current signal. No external buffers or drivers are required.

REV. B

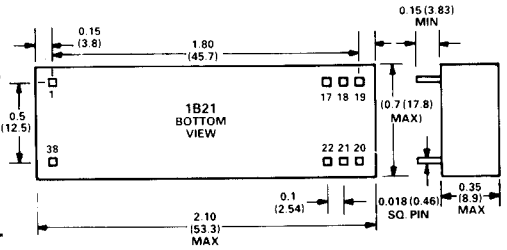
One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 617/329-4700 Fax: 617/326-8703 Twx: 710/394-6577
Telex: 924491 Cable: ANALOG NORWOODMASS

1B21—SPECIFICATIONS (typical at +25°C and V_S = ±15V unless otherwise noted)

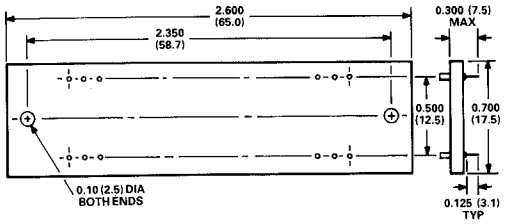
Model	1B21AN
INPUT SPECIFICATIONS	
Input Range	0 to + 10V
Full-Scale Input	+ 1V min to + 10V max
Input Bias Current	± 30pA (± 400pA max)
OUTPUT SPECIFICATIONS	
Current Output Range	4mA to 20mA, 0 to 20mA
Load Compliance at V_{LOOP} = 30V	27V min
Max Output Current @ Input Overload	25mA
Output Noise, 100Hz Bandwidth	1μA p-p
NONLINEARITY (% of Span)	± 0.02% (± 0.05% max)
ISOLATION	
CMV, Input to Output Continuous	1500V rms
CMR, @ 60Hz	90dB min
Transient Protection	IEEE-STD 472 (SWC)
ACCURACY	
Warm-Up Time to Rated Performance	5 min
Total Output Error @ + 25°C (Untrimmed)	
Offset (V_{IN} = 0V)[1]	± 100μA
Span (V_{IN} = + 10V)	± 0.6% FSR
vs. Temperature (− 25°C to + 85°C)	
Offset[2]	± 300nA/°C
Span	± 50ppm/°C
REFERENCE OUTPUT	
Voltage	+ 6.4V dc
Output Error	± 1.5% max
Temperature Coefficient	± 20ppm/°C max
DYNAMIC RESPONSE	
Settling Time to 0.1% of F.S. for 10V Step	9ms
Small Signal Bandwidth	100Hz
POWER SUPPLY	
Input Side	
Operating Voltage	± 15V ± 5%
Quiescent Current	
+ 15V Supply	10mA
− 15V Supply	5mA
Power Supply Rejection	± 0.01%/V
Loop Side	
Operating Voltage	+ 15V to + 30V
Maximum Current	25mA
ENVIRONMENTAL	
Temperature Range	
Rated Performance	− 25°C to + 85°C
Operating	− 40°C to + 85°C
Storage	− 40°C to + 85°C
Relative Humidity, Noncondensing	0 to 95% @ + 60°C
CASE SIZE	0.7" × 2.1" × 0.35" (17.8 × 53.3 × 8.9)mm

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



AC1060 MATING SOCKET



PIN DESIGNATIONS

PIN	FUNCTION
1	OUT HI
17	IN
18	FB
19	REF
20	+ 15V
21	COM
22	− 15V
38	OUT LOW

NOTES

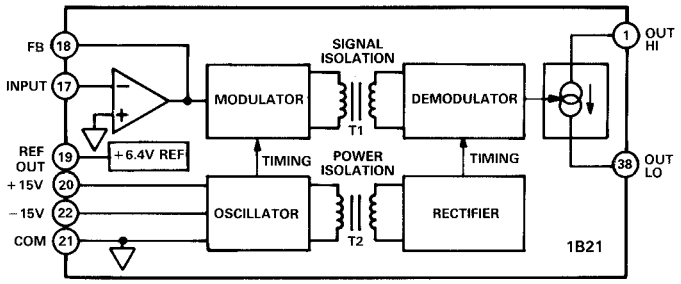
[1]For 0-20mA mode. For 4-20mA mode an additional 60μA is contributed by the ± 1.5% reference error on the 4mA output.

[2]For a complete discussion of the temperature effects of the offset resistor and reference refer to "Using the 1B21" section.

Specifications subject to change without notice.

INSIDE THE 1B21

Referring to the functional block diagram, the ±15V power inputs provide power to both the input side circuitry and the power oscillator. The 25kHz power oscillator provides both the timing information for the signal modulator and drives transformer T2 for the output side power supplies. The secondary winding of T2 is full wave rectified and filtered to create the output side power.



1B21 Functional Block Diagram

The input stage is configured as an inverting amplifier with three user supplied resistors for gain, offset and feedback. The conditioned signal is modulated to generate a square wave with a peak-to-peak amplitude proportional to V_{IN}. This signal drives the signal transformer T1. An internal reference with a nominal output voltage of +6.4V and tempco of ±20ppm/°C is provided to develop a 4mA offset for 4mA to 20mA current loop applications.

After passing through signal transformer T1, the amplitude modulated signal is demodulated and filtered by a single pole filter. Timing information for the output side is derived from the power transformer T2. The filtered output provides the control signal for the voltage-to-current converter stage. An external power supply is required in series with the load to complete the current loop.

USING THE 1B21

Input Configurations: The 1B21 has been designed with a flexible input stage for a variety of input and output ranges. The basic interconnection for setting gain and offset is shown in Figure 1. The output of the internal amplifier is constrained to 0 to −5V, which maps into 0 to 20mA across the isolation barrier. Thus to create a 4mA offset at the output, the input amplifier has to be offset by 1V.

For example, for 0 to 20mA operation the transfer function for the input stage is:

$$5/V_{IN} = R_F/R_I$$

and no offset resistor is needed. For 4mA to 20mA operation we get:

$$4/V_{IN} = R_F/R_I$$

which maps the input voltage into a 4V span. To create a 1V offset at the output of the internal amplifier (4mA at the output of the 1B21) a current derived from the reference can be fed into the summing node. The offset resistor (for a 1V output offset) will be given by the equation: $R_O = 6.4R_F$. For most applications it is recommended that R_F be in the 25kΩ ±20% range. Resistor values for typical input and output ranges are shown in Table I.

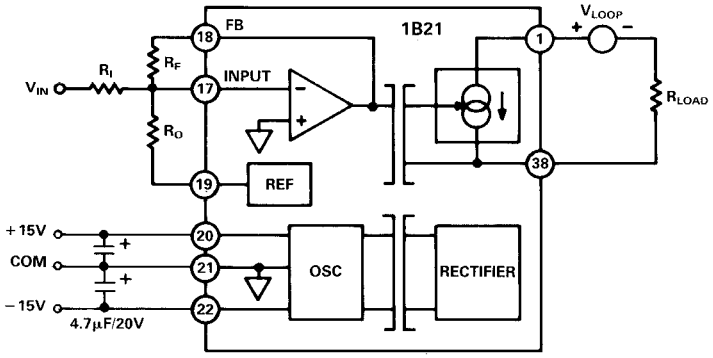


Figure 1. Basic Interconnections

Input Volts	Output mA	R_I kΩ	R_F kΩ	R_O kΩ
0-5	0-20	25	25	Open
0-10	0-20	50	25	Open
0-5	4-20	25	20	128
0-10	4-20	50	20	128
1-5	4-20	25	25	Open

Table I. Resistor Values for Typical Ranges

Adjustments: Figure 2 is an example of using potentiometers for trimming gain and offset for a 0-5V input and 0 to 20mA output. The network for offset adjustment keeps the resistors relatively small to minimize noise effects while giving a sensitivity of ±1% of span. For more adjustment range, resistors smaller than 274k can be used. Resistor values from Table I can be substituted for other input and output ranges.

In general, any bipolar voltage can be input to the 1B21 as long as it is offset to meet the 0 to −5V constraint of the modulator and the input signal range is 1V minimum.

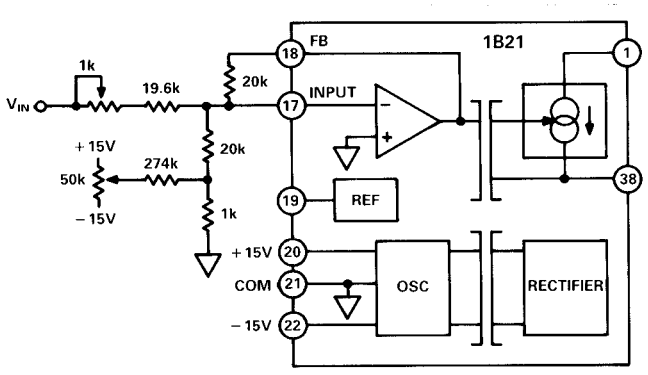


Figure 2. Offset and Span Adjustment

TC Considerations of External Resistors: The specifications for gain and offset temperature coefficient (TC) for the 1B21 exclude the effects of external components. The total gain TC for the circuit in Figure 1 is:

Gain TC = 1B21 Gain TC + (Tracking TC of R_F and R_I)

The offset TC is also affected by the thermal stability of the internal voltage reference and its contribution is:

Ref TC = $(V_{REF})(R_F/R_O)(4mA/V)$(TC of V_{REF} + Tracking TC of R_F and R_O)$/1\times10^6$

Total Offset TC = 1B21 Offset TC + Ref TC

Specifically using R_F, R_I and R_O from Case 3 in Table I, with absolute TCs of ±25ppm/°C we get:

Gain TC = 50 + (25+25) = 100ppm/°C

Offset TC = $300+(6.4V)(20k/128k)(4mA/V)(20+25+25)/1\times10^6$

= ±580nA/°C

Similarly, when using a resistor network with a tracking spec of ±5ppm/°C, the total gain TC would be ±55ppm/°C and the total offset TC would be ±400nA/°C.

APPLICATIONS

Output Protection: In many industrial applications it may be necessary to protect the current output from accidental shorts to ac line voltages in addition to high common-mode voltages and short circuits to ground. The circuit shown in Figure 3 can be used for this purpose. The maximum permissible load resistance will be lowered by the fuse resistance (typically 8Ω) when protection circuitry is utilized.

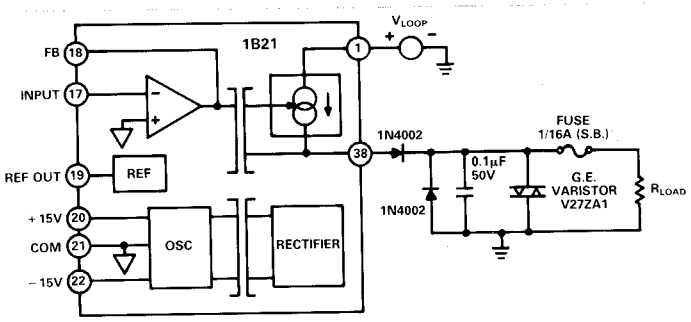


Figure 3. Output Protection Circuitry

Low Drift Input Network: Figure 4 shows a configuration suitable for applications where errors have to be minimized over a wide temperature range. A temperature tracking network such as a 50k Beckman (PN 698-3R50KD) can be used to implement both offset and gain for either 0 to 20mA or 4mA to 20mA current loops. For 0-10V signals either IN1 or IN2 can be used for input. For 0-5V signals, jumper IN1 to IN2. Similarly, for 4mA to 20mA operation the 4mA node should be jumpered to OFFSET, while for 0 to 20mA it should be tied to COM.

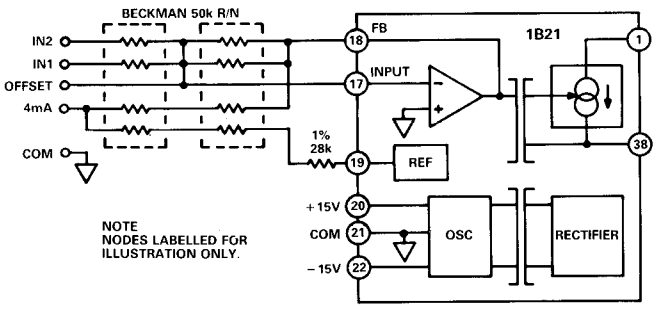


Figure 4. Low Tempco Resistor Network Configuration

Multiloop Isolation: Multiple 1B21s can be connected to a single loop supply in parallel as shown in Figure 5. The amperage of the loop supply should be sufficient to drive all the loops at full-scale output.

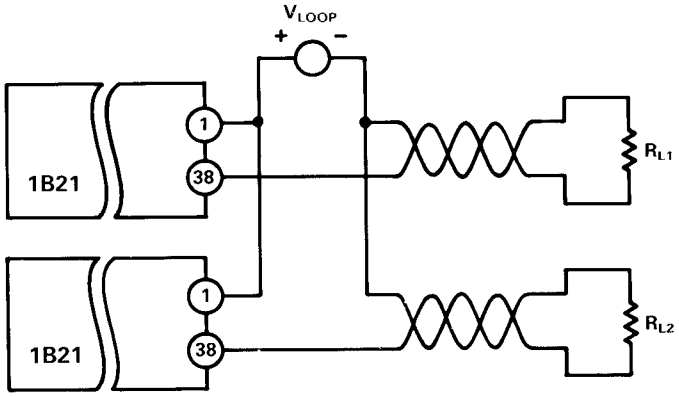


Figure 5. Multiple IB21s with Single Loop Supply

C1170a-5-6/91

PRINTED IN U.S.A.