◢ ANALOG DEVICES

High Performance, Isolated Voltage-to-Current Converter

MODEL 2B22

FEATURES
Wide Input Range: 0 to +1V to 0 to +10V
Standard Output Range: 4 to 20mA
High CMV Input/Output Isolation: 1500V dc Continuous
Low Nonlinearity: 0.05% max, 2B22L
Low Span Drift: 0.005%/°C max, 2B22L
Single Supply: +14V to +32V
Meets IEEE Std 472: Transient Protection (SWC)
Meets ISA Std 50.1: Isolated Current Loop Transmitters

APPLICATIONS
Industrial Instrumentation and Process Control
   Ground Loop Elimination
   High Voltage Transient Protection
D/A Converter — Current Loop Interface
Analog Transmitters and Controllers
Remote Data Acquisition Systems


GENERAL DESCRIPTION
Model 2B22 is a high performance, compact voltage-to-current converter offering 1500V dc input to output isolation in interfacing standard process signals. The input stage of the model 2B22 is single resistor programmable to accept voltage ranges from 0 to +1V to 0 to +10V. The isolated output current range is 4 to 20mA, and the 2B22 can be operated with 0 to 1000Ω grounded or floating loads.

Using modulation techniques with transformer isolation for reliable performance, the 2B22 is available in three accuracy selections offering guaranteed nonlinearity error (2B22L: ±0.05% max, 2B22K: ±0.1% max, and 2B22J: ±0.2% max) and guaranteed low span drift: ±0.005%/°C max, ±0.01%/°C max, and ±0.015%/°C max, respectively. The internally trimmed span and offset errors are ±0.1% max for the 2B22L and ±0.25% max for the 2B22J/2B22K. Both span and offset are adjustable by the optional external potentiometers.

Featuring a wide range, single supply operation (+14V to +32V), the 2B22 provides isolated +28V loop power and is capable of delivering rated current into an external 0 to 1000Ω load resistance. The unique output stage configuration also allows the user to utilize an optional external loop power supply to interface systems designed for a two-wire operation.

APPLICATIONS
Model 2B22 has been specifically designed for high accuracy applications in process control and monitoring systems to offer complete galvanic isolation and protection against damage from transients and fault voltages in transmitting information
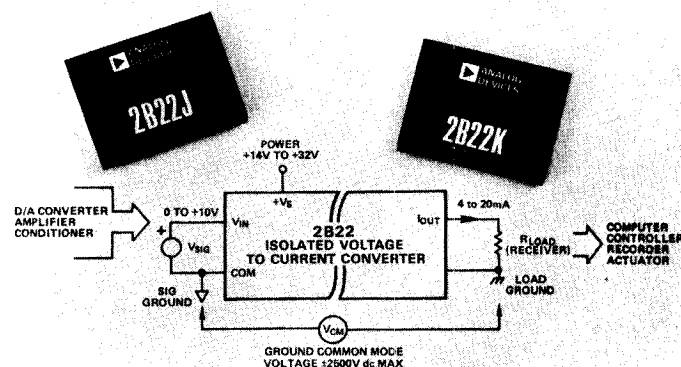
between subsystems or separated system elements. The 2B22 meets the requirements of the Instrument Society of America Std. 50.1 "Compatibility of Analog Signals for Electronic Industrial Process Instruments" for Type 4, Class U isolated current loop transmitters.

In the industrial environment, model 2B22 can serve as a transmission link between such system elements as transmitters, indicators, controllers, recorders, computers, actuators and signal conditioners. In data acquisition and control systems, the 2B22 may act as an isolated interface between the D/A converter output of a microcomputer and standard 4 to 20mA analog loops.

DESIGN FEATURES AND USER BENEFITS
High Reliability: Model 2B22 is a conservatively designed, compact, epoxy encapsulated module capable of reliable operation in harsh environments. To assure high reliability, the 2B22 has been designed to meet the IEEE Standard for Transient Voltage Protection (472-1974: Surge Withstand Capability).

Process Signal Compatibility: The versatile input stage design with a single resistor gain adjustment enables the 2B22 to accept any one of the standard inputs—0-1V, 0-10V, 1-5V; or 1-5mA, 4-20mA, 10-50mA; and provide standard, isolated 4-20mA output.

Isolated Loop Power: Internal 28V dc loop supply, completely isolated from the input power terminals (±1500V dc isolation), provides the capability to drive 0 to 1000Ω loads and eliminates the need for an external dc/dc converter.

SPECIFICATIONS (typical @ +25°C and V_S = +15V unless otherwise noted)

Model	2B22J	2B22K	2B22L
INPUT SPECIFICATIONS			
Voltage Signal Range, G = 1.6mA/V	0 to +10V	*	*
G = 16mA/V	0 to +1V	*	*
Gain Range	1.6 to 16mA/V	*	*
Maximum Safe Input	+15V	*	*
Input Impedance	10MΩ	*	*
OUTPUT SPECIFICATIONS			
Current Output Range	4 to 20mA	*	*
Load Resistance Range, V_S = +14V to +32V,			
Internal Loop Power	0 to 1000Ω max	*	*
Maximum Output Current,			
@ Input Overload	25mA	*	*
Output Ripple, 100Hz Bandwidth			
G = 1.6mA/V	60μA pk-pk	*	*
NONLINEARITY (% of Span)	±0.2% max	±0.1% max	±0.05% max
CMV, INPUT TO OUTPUT			
ac, 60Hz, 1 Minute Duration	1500V rms	*	*
Continuous, ac or dc	±1500V pk max	*	*
CMR, INPUT TO OUTPUT			
60Hz, 1kΩ Source Imbalance	90dB	*	*
ACCURACY[1]			
Warm Up Time to Rated Performance 5 Minutes			
Total Output Error @ +25°C[1,2]			
Offset (V_{IN} = 0V)	±0.25% max	±0.25% max	±0.1% max
Span (V_{IN} = +10V)	±0.25% max	±0.25% max	±0.1% max
vs. Temperature (0 to +70°C, G = 1.6mA/V)			
Offset (V_{IN} = 0V)	±0.01%/°C max	±0.005%/°C max	±0.0025%/°C max
Span (V_{IN} = +10V)	±0.015%/°C max	±0.01%/°C max	±0.005%/°C max
vs. Temperature (0 to +70°C)			
Offset (V_{IN} = 0V, G = 1.6mA/V to			
16mA/V)	±0.01%/°C	±0.005%/°C	±0.0025%/°C
Span (G = 1.6mA/V to 16mA/V)[3]	±0.015%/°C	±0.01%/°C	±0.005%/°C
DYNAMIC RESPONSE			
Settling Time – to 0.1% of F.S. for 10V Step	300μs	*	*
Slew Rate	0.06mA/μs	*	*
REFERENCE INPUT			
Voltage	+2.5V dc	*	*
Input Impedance	6kΩ	*	*
OSCILLATOR			
Frequency, Internal Oscillator	100kHz ± 10%	*	*
External Sync Input			
Frequency	100kHz ± 10% max	*	*
Waveform	Square wave,	*	*
	50% duty cycle		
Voltage	20V p-p	*	*
POWER SUPPLY			
Voltage, Rated Performance	+15V dc	*	*
Voltage, Operating	+14V to +32V dc	*	*
Supply Current (at Full Scale Output)			
Using Internal Loop Power	100mA	*	*
Using External Loop Power	50mA	*	*
Supply Change Effect (% of Span)			
on Offset (V_{IN} = 0V)	±0.0005%/V	*	*
on Span (V_{IN} = +10V)	±0.0005%/V	*	*
TEMPERATURE RANGE			
Rated Performance	0 to +70°C	*	*
Operating	-25°C to +75°C	*	*
Storage	-55°C to +85°C	*	*
CASE SIZE	2.2" X 3" X 0.6"	*	*

*Specifications same as 2B22J.

NOTES
[1] Accuracy is guaranteed at G = 1.6mA/V with no external trim
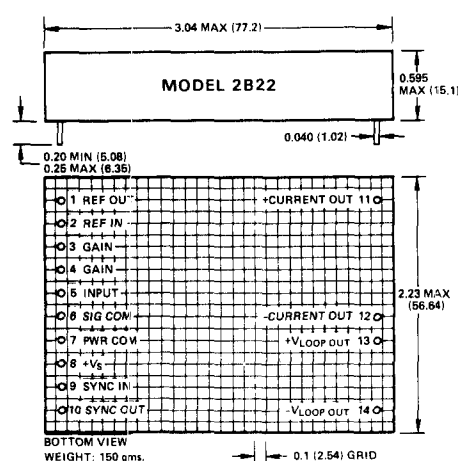adjustments when connected as shown in Figure 1.
[2] All accuracy is % of span where span is 16mA (±0.1% = ±0.016mA error).
[3] Span T.C. for gains higher than 1.6mA/V is R_G dependent – a low T.C.
(±10ppm/°C) R_G is recommended for best performance.

Specifications subject to change without notice.

OUTLINE DIMENSIONS
Dimensions shown in inches and (mm).

MATING SOCKET:
AC1579

INTERCONNECTION DIAGRAM
Model 2B22 can be applied directly to achieve rated performance as shown in Figure 1 below. The input stage gain of 1.6mA/V, to convert a 0 to +10V signal into a 4 to 20mA output current, is obtained with the values shown. A single polarity power supply (+14V to +32V dc) should be connected to pin 8. To eliminate ground loops, the user should insure that the signal return (common) lead does not carry the power supply current. Power common (pin 7) and signal common (pin 6) should be tied at the power supply common terminal. The voltage difference between pins 6 and 7 should not exceed 0.2V. An internal dc-dc converter provides isolated output loop power (pins 13 and 14), which is connected externally to the current output terminals (pins 11 and 12) and a load resistance. The standard 4 to 20mA current output signal is delivered into any external load between zero and 1000Ω.
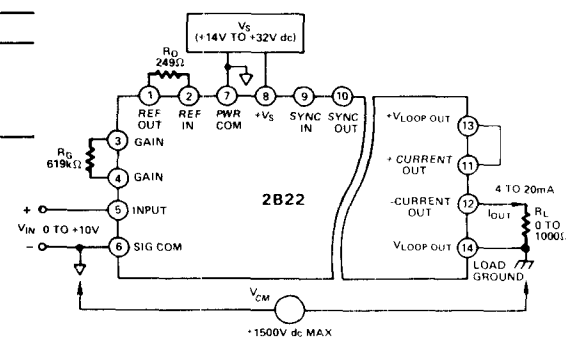
NOTE: Resistors R_O and R_G are 1%, 50ppm/°C Metal Film Type. Values shown are for G = 1.6mA/V. For G = 16mA/V, use 10ppm/°C R_G and 50ppm/°C R_O.

Figure 1. Basic Connections

FUNCTIONAL DESCRIPTION

The high performance of model 2B22 is derived from the carrier isolation technique which is used to transfer both signal and power between the V/I converter's input circuitry and the output stage. High CMV isolation is achieved by the transformer coupling between the input amplifier, modulator section and the current output circuitry. The block diagram for model 2B22 is shown in Figure 2 below.

The 2B22 produces an isolated 4 to 20mA output current which is proportional to the voltage input and independent of the load resistance. The input amplifier operates single-ended and accepts a positive voltage within 0 to +10V range. Gain can be set from 1.6mA/V to 16mA/V by changing the gain resistor R_G to accommodate input ranges from 0 to +1V (G = 16mA/V) to 0 to +10V (G = 1.6mA/V). The transfer function is $I_{OUT} = (4mA + G \times V_{IN})$.

An internal, high stability reference has nominal output voltage of +2.5V (REF OUT) and is used to develop a 4mA output current for a 0 volts input. The terminals REF OUT (pin 1) and REF IN (pin 2) should be connected via the offset setting resistor R_O. For ratiometric operation, an external reference voltage can be connected to the REF IN terminal.

The 2B22 is designed to operate from a single positive power supply over a wide range of +14V to +32V dc. An internal dc-dc converter provides isolated +28V loop power which is independent of +V_S. The maximum resistance of the load R_L (resistance of the receivers plus the resistance of the connecting wire) is 1000Ω. Since the loop power is derived from the input side, the current capability of the power supply (+V_S) must be 100mA min to supply full output signal current.
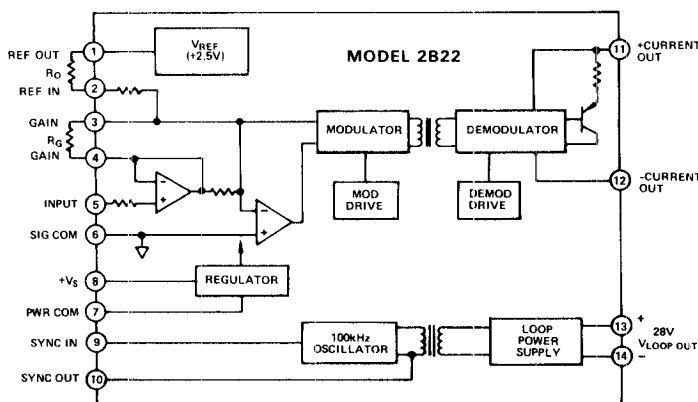

Figure 2. Block Diagram — Model 2B22

OPTIONAL TRIM ADJUSTMENTS

Model 2B22 is factory calibrated for a 0 to +10V input range (G = 1.6mA/V. As shipped, the 2B22 meets its listed specifications without use of any external trim potentiometers. Additional trim adjustment capability, to reduce span and offset errors to ±0.05% max, is easily provided as shown in Figure 3. The span and offset trim pots are adjusted while monitoring the voltage drop across a precision (or known) load resistor. The following trim procedure is recommended:

1. Connect model 2B22 as shown in Figure 3.
2. Apply V_{IN} = 0 volts and adjust R_O (Offset Adjust) for V_{OUT} = +2V ±4mV.

3. Apply V_{IN} = +10.00V and adjust R_G (Span Adjust) for V_{OUT} = +10V ±4mV.
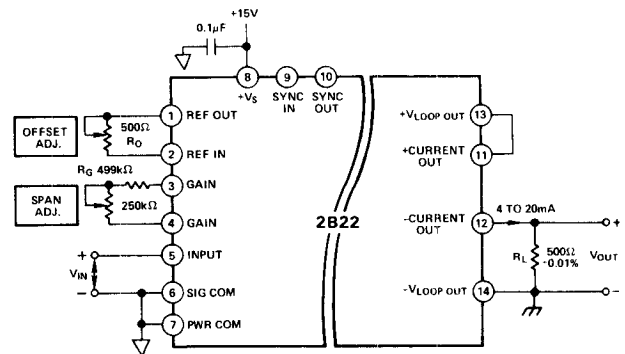

Figure 3. Optional Span and Offset Adjustment

GAIN AND OFFSET SETTING

The gain of the 2B22 is a scale factor setting that establishes the nominal conversion relationship to accommodate +1V to +10V full scale inputs (V_{IN}). The value of the gain setting resistor R_G is determined by: $R_G(k\Omega) = 6.314SF/(10.1 - SF)$ where SF is a scale factor equal to the value of V_{IN} F.S. Example: to convert a 0 to +1V input to the 4 to 20mA output, SF = 1 and R_G = 693Ω. Due to device tolerances, allowance should be made to vary R_G by ±5% using the potentiometer.

The value of the offset resistor R_O is independent from the gain setting and given by the relationship: $R_O(k\Omega) = 2.5$ (V_{REF} - 2.4) where V_{REF} is the reference voltage applied. For example, the reference provided by the 2B22 is +2.5V and therefore R_O = 250Ω. The accuracy of the R_O calculation from from the above formula is ±5%. When an external reference operation is desired (i.e. for ratiometric operation), connect the reference voltage via R_O to pin 2 and leave pin 1 open.

EXTERNAL LOOP POWER OPERATION

For maximum versatility, the 2B22's output stage is designed to operate from the optional, isolated external loop power supply. This feature allows the user to interface systems wired for a two-wire operation. As shown in Figure 4, the same wiring is used for loop power and output. The load resistance is connected in series with an external dc power supply (+6V to +32V), and the current drawn from the supply is the 4 to 20mA output signal. The input stage of the 2B22 still requires +V_S power, but the current drain from +V_S is limited to 50mA. Use of an external loop power may require gain and offset trimming to obtain specified accuracy. The maximum series load resistance depends on the loop supply voltage as shown in Figure 4.
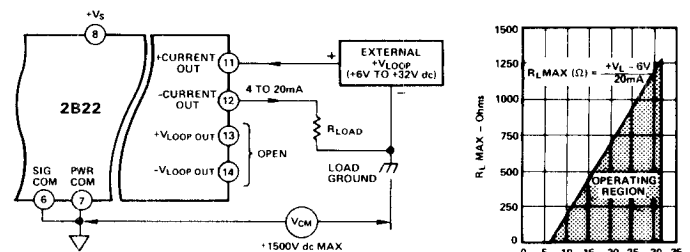

Figure 4. Optional External Loop Power Operation

SYNCHRONIZING MULTIPLE 2B22'S

In applications where multiple 2B22's are used in close proximity, radiated individual oscillator frequencies may cause "beat frequency" related output errors. These errors can be eliminated by synchronizing multiple units by connecting the SYNC OUT (pin 10) terminal to the SYNC IN (pin 9) terminal of the adjacent 2B22. The SYNC OUT terminal of this "slaved" unit can be used to drive another adjacent 2B22 (Figure 5). For best accuracy, each 2B22 should be retrimmed when synchronizing connections are used.
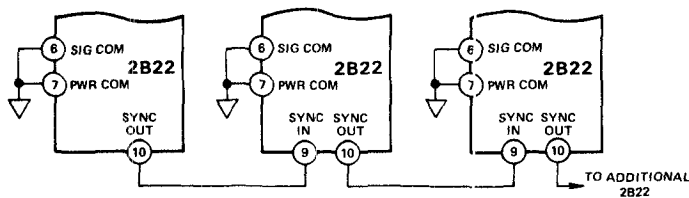

Figure 5. Multiple 2B22's Synchronization

OUTPUT PROTECTION

The current output terminals (pins 11 and 12) are protected from shorts up to +32V dc but in many industrial applications, it may be necessary to protect the 4 to 20mA output from accidental shorts to ac line voltages. The circuit shown in Figure 6 can be used for this purpose. The maximum permissible load resistance will be lowered by a fuse resistance value when protection circuitry is utilized.
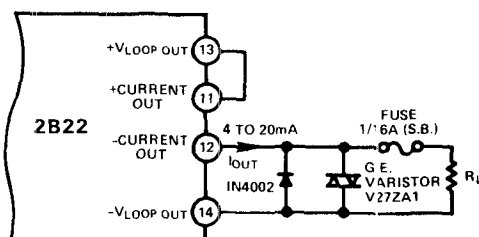

Figure 6. Output Protection Circuitry Connections

APPLICATIONS IN INDUSTRIAL MEASUREMENT AND CONTROL SYSTEMS

Process Signal Isolator: In process control applications, model 2B22 can be applied to interface standard process signals (e.g. 1 to 5mA, 4 to 20mA, 10 to 50mA, 1 to 5V) and convert them to isolated 4 to 20mA output. A typical hook-up of model 2B22 is illustrated in Figure 7, showing input resistor
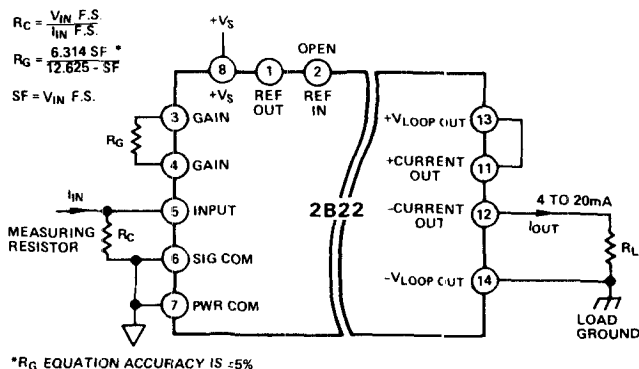

Figure 7. Process Signal Current Isolator

R_C converting the current from a remote loop to a voltage input, and a span adjustment resistor R_G. A value of R_C should be selected to develop a minimum of +1V signal with full scale input current applied. For example, a 50Ω resistor converts the 4 to 20mA current input to a 200mV to 1V voltage input, which the 2B22 isolates and converts to a 4 to 20mA output. The reference input (pin 2) is not connected since the process signal provides a desired offset.

Isolated D/A Converter: Model 2B22 offers total ground isolation and protection from high voltage transients in interfacing D/A converters to standard 4 to 20mA current loops. This requirement is common in a microcomputer-based control system. The voltage necessary to power the current loop can be derived from the same +15V supply that is used to power the D/A converter. The D/A converter, such as the 12-bit AD DAC80, should be connected for operation on the unipolar 0 to +10V output range. This is shown in Figure 8. After the load resistor connection has been made, the current loop can be calibrated using the offset and span adjustment potentiometers associated with the 2B22. First, a digital input code of all zeros is loaded into the D/A, and the offset adjustment potentiometer is adjusted for a current output of exactly 4mA. Then, a digital code of all one's is loaded into the D/A, and the span adjustment potentiometer is adjusted for a voltage across the load that corresponds to a current of 20mA less 1LSB (19.9961mA).
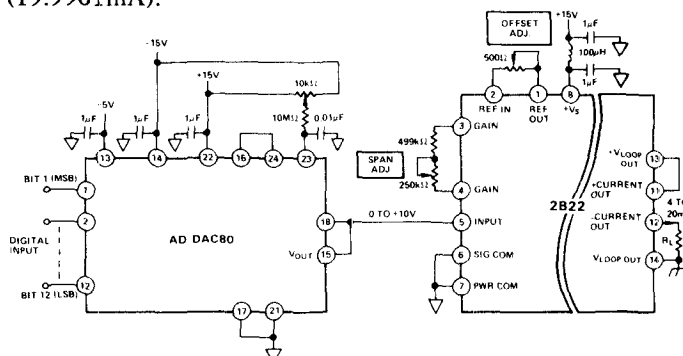

Figure 8. D/A Converter — Isolated 4 to 20mA Interface

Pressure Transmitter: In Figure 9, model 2B22 is used in a pressure transmitter application to provide complete input-output isolation and avoid signal errors due to ground loop currents. The process pressure is monitored with a strain gage type pressure transducer interfaced by the Analog Devices' model 2B30 transducer conditioner. The bridge excitation and system power is provided by the model 2B35 triple output power supply. The high level voltage output of the 2B30 is converted to the isolated 4 to 20mA current for transmission to a remote recorder or indicator.
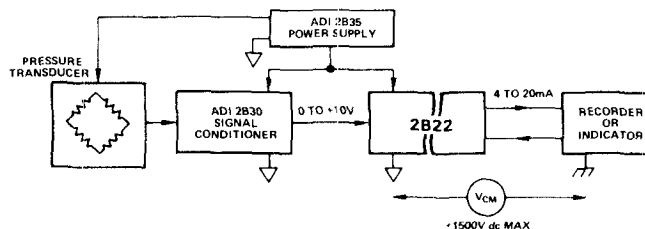

Figure 9. Isolated Pressure Transmitter