IREL1/3 Series
Linear 4 to 20 mA Transmitter and Preamplifier for Miniature Infrared Gas Sensors

FEATURES

- IREL3 preamplifier mounts directly over IREL1 transmitter
- Configurable for the e2v range of infrared gas sensors, type IR1xxx, IR2xxx and IR3xxx (BD and BC variants only)
- Configurable ranges and gas types
- Simple calibration
- Linear output with concentration
- Selectable voltage and 4 - 20 mA outputs
- Wide input voltage supply range
- Low power
- Internal fault monitoring
- Small size
- Switchable temperature compensation

INTRODUCTION

e2v's IREL1 linear 4 - 20 mA transmitter and IREL3 preamplifier are obtainable separately (see Ordering Information), but are designed to be used as a pair for the IR1xxx, IR2xxx and IR3xxx (BD and BC variants only) range of miniature infrared gas sensors. The sensors plug directly into the 6-pin socket on the IREL3 board, which itself is located on and electrically connected to the IREL1. The reliability of the transmitter, preamplifier and associated sensors is enhanced by having no moving parts. The sensors contain active and reference wavelength detectors. These are monitored by the transmitter to substantially reduce drift caused by optical obscuration and changes in the sensor's infrared source intensity over time. This full referencing also provides more improved accuracy and stability than unreferenced sensors. All sensor driving is internal to the transmitter and full fault monitoring of the sensor and transmitter circuit is continuous.

OPERATION

The IREL3 is an interface circuit acting as a preamplifier that conditions the sensor signal before treatment by the IREL1 transmitter circuit. The sensor type is switch selectable. This in turn defines the linearity correction needed, the gas type and the sensitivity expected.

The sensor is monitored continuously for potential faults and the sensor signal is used to provide a linear output in voltage and 4 - 20 mA forms. Calibration is by means of zero and span potentiometers with the signal from the associated NDIR sensor internally linearised, without the need for user adjustment. An additional switch selectable sensitivity adjustment is provided to enable variable full scale ranges from a single gas calibration point, without compromising linearity over the selected sensor's standard concentration range. Connections are via screw terminals for the input power supply and the 4 - 20 mA source and voltage outputs.

Indicators are included for designating the transmitter status. They include: indication of sensor source pulsing; indication of the calibration mode; and fault diagnostics. A separate fault open collector output is also provided. The 4 - 20 mA output provides a fault indication by reducing the output to below 3 mA, with recovery from a fault condition being automatic. The visual fault indication and the open collector fault output latch on detecting a fault and require a reset to restore normal indications.

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GENERAL DATA

This information relates to the device operating continuously.

Electrical

Input supply voltage (polarity protected) . . 12 to 35 V dc
Maximum current consumption
(12 V dc supply, maximum output load) . . . . 250 mA
Voltage output:
range (switch selectable) . . . . . 0.2 to 1.0 V
1 to 5 V
maximum current draw . . . . . 5 mA
resolution . . . . . 0.15% of span
4 - 20 mA output (link selectable as source or sink):
maximum loop resistance in source mode . . . . 250 Ω
output resolution . . . . . 0.02 mA
maximum offset drift . . . . . ±20 μA
over-range output . . . . . 21.3 mA typical

Note: Observe antistatic precautions when handling.

Mechanical

Dimensions:
length . . . . . 105 mm
width . . . . . 85 mm
height . . . . . <20 mm
Weight (excluding associated sensors) . . . . . 75 g
Indicators:
green LED . . . . . system healthy indicator
three red LEDs . . . . . system fault indicators
fail output . . . open collector, normally switched to 0 V, released to float condition for fault indication

Environmental

Operating conditions
0 to 100% RH (non-condensing) . . . −10 to +50 °C
Storage conditions
0 to 100% RH (non-condensing) . . . −20 to +60 °C

Absolute Maximum Ratings

A voltage supply greater than the recommended 35 V dc must not be applied. The supply should be current limited at ⩽1 A. Do not apply more than +6 V or less than 0 V to the current output terminals.

ORDERING INFORMATION

Transmitters complete with buffer board and associated sensors should be ordered using the following part number sequence:

IREL1/x/yyzz

where:

x = 3 if preamplifier IREL3 is required, otherwise omit x/ from the part number sequence;

yy = the numeric part of the part number of the sensor fitted;

zz = the alpha part of the part number of the sensor fitted.

Examples:

IREL1 = transmitter only with no associated sensor or preamplifier.
IREL1/3 = transmitter and IREL3 with no associated sensor.
IREL1/3/11BD = transmitter and IREL3 with IR11BD miniature infrared sensor.

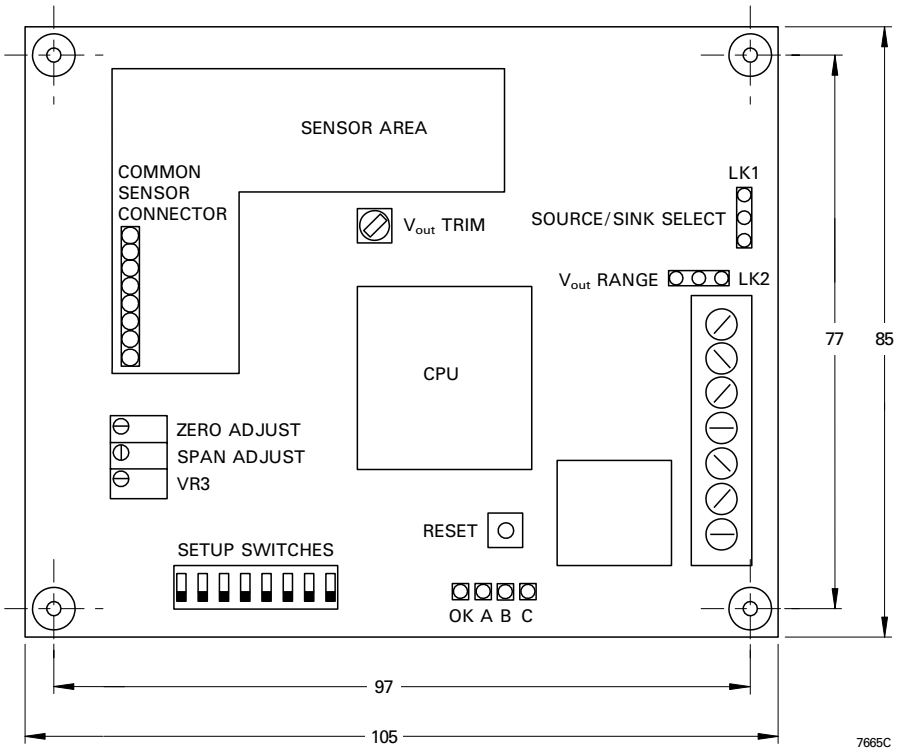
CIRCUIT DIAGRAMS

Customers are welcome to refer to circuit diagrams of IREL1 or IREL3. These are available on the e2v website at www.e2v.com or as hard copies or electronic files by contacting the Gas Sensors department at e2v.

IREL1 circuit diagram DAS547327AD
IREL3 circuit diagram DAS544943AD

TRANSMITTER BOARD OVERVIEW

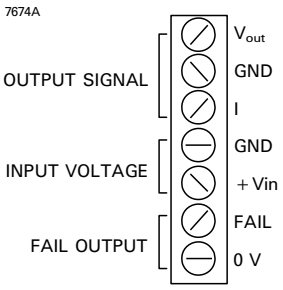
The general transmitter circuit layout is shown below. The transmitter board includes four fixing holes, one located at each corner.



All sensor types or preamplifiers connect to the common sensor connector, which locates the sensors within the designated sensor area. The ZERO and SPAN potentiometers are used in the calibration sequence; note that the non-linear algorithm is contained within the CPU software. The potentiometer VR3 is used to provide a variable full-scale range, if the default range is not appropriate. The setup switches are located below the potentiometers and are used to select the sensor type and range. The indicator LEDs are positioned to the right of the setup switches and a RESET push-button is located above the LEDs. This RESET push-button is used to clear any fault indications and reset the CPU for a full restart. The V_{out} TRIM potentiometer situated between the CPU and the sensor area is used to trim the full range output level. The output voltage range and 4 - 20 mA source or sink links are positioned above the external wiring connector. The automatic temperature compensation, when selected, uses the on-board temperature sensor located near the sensor area shown above.

WIRING AND SIGNALS

The transmitter circuit has a 4 - 20 mA source or sink output and a selectable voltage output. The external connections to the single terminal strip are as follows:



Terminal Connections

Terminal identification:

V_{out}	Voltage output
GND	Voltage output ground reference or 4 - 20 mA current return.
I	4 - 20 mA source or sink output, 5 V maximum source drive. **Do not apply more than +6 V or less than 0 V to this terminal.**
GND	Input ground.
$+V_{in}$	Input supply voltage.
FAIL	Fail signal open collector output.
0V	Fail signal ground reference.

Output Signal Selection

The IREL1 is provided with link selectors, adjacent to the output terminal strip, to accommodate current source or sink and voltage output selection in accordance with Table 1:

Required Output Signal	Links Required
4 – 20 mA Current Source	LK1 Common – Source
4 – 20 mA Current Sink	LK1 Common – Sink
0.2 – 1.0 V	LK2 Common – 1 V
1.0 – 5.0 V	LK2 Common – 5 V

Table 1 Signal selection links

LED INDICATOR DESCRIPTION

The green LED indicator, labelled OK, indicates the system condition as follows:

Green LED	Cause
OFF	Non-recoverable fault has occurred; system not functioning
SHORT ON PULSES	Fault detected; red LEDs ON to indicate cause
FLASHING @ 2 Hz	Initial start-up self-check procedure in progress
FLASHING @ 4 Hz	a) Indicates normal system function b) Indicates fault recovery in progress; red LEDs ON to indicate cause c) Indicates unit is in calibration mode if all red LEDs are ON

Table 2 Green LED indicator states

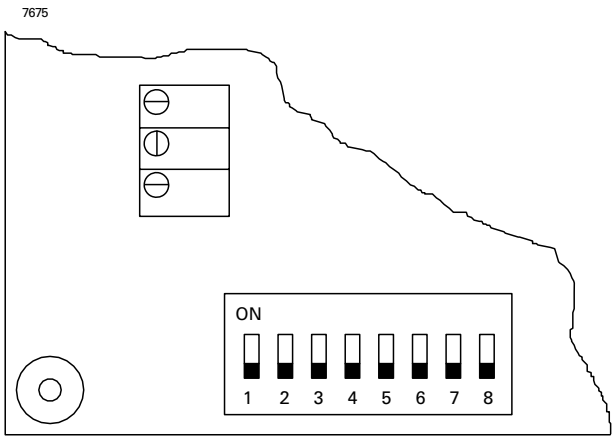
The red LED indicators are used to describe detectable fault conditions (see Table 3 below). If a red LED illuminates it can be cleared by pressing the RESET button. If the LED re-illuminates after the reset, refer to Table 3 to identify the fault. When all the red LEDs are OFF, this indicates normal operation.

LED A	LED B	LED C	Fault Mode	Action
ON	ON	ON	Hardware integrity failure detected during start-up	Non-recoverable. Return transmitter to e2v.
ON	ON	OFF	Undefined	Component failure. Return transmitter to e2v.
ON	OFF	ON	Mathematics routine error or under-range condition	Recoverable. Normal operation will resume when the fault has cleared.
ON	OFF	OFF	Input voltage is out of range	Check the power supply
OFF	ON	ON	Sensor source drive current failure	Replace the source unit on the sensor
OFF	ON	OFF	Output voltage is out of compliance	i) Check the correct voltage range is selected by the V_{out} switch ii) Check the load on the voltage output is within limits
OFF	OFF	ON	Undefined	Component failure. Return transmitter to e2v.
ON	ON	ON	Calibrate switch is set if green LED is flashing	Normal during output trim setting

Table 3 Red LED indicator states

CALIBRATION SETTINGS

The setup switches located beneath the potentiometers are used to select the infrared sensor type with associated gas type, range, span range selection and full-scale output trimming.



Setup Switches

Switch 1 selects the carbon dioxide sensor family or the hydrocarbon sensor family.

Switches 2 and 3 select the path length and/or associated range of the sensor.

Switch 4 is not used.

Switch 5 selects the default range when OFF; enables the variable range adjustment when ON.

Switch 6 enables automatic temperature compensation when ON; temperature compensation is disabled when OFF.

Switch 7 selects DC inputs when ON. Must be OFF for use with e2v sensors.

Switch 8 selects full-scale output for setting the output range when ON, and stores the default zero setting when returned to the OFF state.

EXTERNAL ELECTRICAL CONNECTIONS

Input Power

Connect a power source to the terminals designated GND and $+V_{in}$ on the terminal strip. The power source should be capable of delivering a voltage between +12 V dc and +35 V dc with a peak current capacity of 250 mA. The transmitter circuit is polarity protected and will not function with incorrect polarity.

Signal Outputs

A current loop and voltage output are available. Connections to both outputs are referred to the GND terminal situated between the I and V_{out} terminals. Connect the required output terminal (or terminals) and centre GND terminal to the required load and check continuity of the connections.

Note the maximum loop impedance for the current loop output is 250 Ω and the maximum load for the voltage output is 5 mA. Check that the state of the output selection links agrees with the output signal required.

Do not apply more than +6 V or less than 0 V to the I terminal.

Fault Indicator Output

If required, connect the FAIL and associated 0 V terminals to the appropriate load in order to make use of the fault indicator line.

CALIBRATION

Having made the required electrical connections and checked the status of the output links LK1 and LK2, apply input power to the transmitter and check that the green LED (OK) flashes slowly during the start-up period and then flashes at a faster rate to indicate normal system functioning. If any red LEDs illuminate after the start-up period refer to the failure mode indicator table above.

Sensor Select Check prior to Gas Calibration

Set the state of the setup switches SW1, SW2 and SW3 to the correct settings in order to select the sensor type attached to the common sensor connector, as detailed in Table 4.

For the first calibration, before proceeding with the set zero sequence, the following must be done:

- Enable automatic temperature compensation if required by setting switch SW6 ON.

If a general purpose Beer's law linearisation is selected (SW1 and SW3 ON), for using a hydrocarbon sensor with non-methane hydrocarbons:

- Turn potentiometer VR3 mid scale
- Set switch SW5 to the ON state.

If any other sensor type is selected (SW1 or SW3 OFF):

- Turn the SPAN potentiometer fully clockwise
- Set switch SW5 to the OFF state

Full-scale Output Calibration and Nominal Zero Set

This sequence sets the output to full-scale and monitors the sensor signals to set up a default zero level which is stored in on-chip EEPROM. It is important that this procedure is carried out with the sensor exposed to 100% nitrogen or zero grade air (devoid of any target gas). It is recommended that switch 8 be turned on with the sensor exposed to zero gas for at least 30 seconds.

Expose the sensor to 100% nitrogen or zero grade air.

Set switch 8 ON. The green LED indicator will flash and all three red LEDs will illuminate, designating the calibration sequence, and the output will be set to maximum range.

Adjust the V_{out} TRIM potentiometer to set full-scale current output at the I terminal to 20 mA or the voltage output at the V_{out} terminal to 1.00 V or 5.00 V, depending on the state of the voltage output link LK2.

When the output has been trimmed, return switch 8 to the OFF position. The default zero level is stored in EEPROM when switch 8 is returned to the OFF position.

Maintain the zero gas at the sensor and proceed with the Set Zero Sequence.

SW1	SW2	SW3	Gas	Sensor(s)	Defaults Range	Temp. Comp.
OFF	OFF	OFF	Not Specified			
ON	OFF	OFF	C_2H_2	IR14BD, IR34BC	2.5% vol.	ON
OFF	ON	OFF	CO_2	IR11BD, IR31BC	2% vol.	OFF
ON	ON	OFF	CH_4	IR12BD, IR13BD, IR32BC, IR33BC	5% vol.	ON
OFF	OFF	ON	CO_2	IR11BD, IR31BC	0.3% vol. (3000 ppm)	OFF
ON	OFF	ON	HC	IR12BD, IR13BD, IR32BC, IR33BC	100% LEL	ON
OFF	ON	ON	CO_2	IR11BD, IR31BC	5% vol.	OFF
ON	ON	ON	General purpose	Any (Beer's Law Linearisation)	Variable	-

Table 4 Setup switch details for sensor selection

Set Zero Sequence

Expose the sensor to 100% N_2 or zero grade air (devoid of any target gas) and adjust the ZERO potentiometer until the output is stable at the required output level.

When the zero level has been set, remove the source of N_2 or zero grade air.

Set Span Sequence

If a general purpose Beer's law linearisation is selected (SW1 and SW3 ON), do not adjust the SPAN potentiometer, but go to the Variable Scale Calibration (see below).

If any other sensor type is selected (SW1 or SW3 OFF) then set the span as follows:

Ensure that switch 5 is in the OFF position for the initial calibration, or if the default full scale ranges is required. If the transmitter has been previously calibrated with a variable scale and the variable scale is still valid then switch SW5 can be left in the ON position provided potentiometer VR3 has not been readjusted since the last calibration. If VR3 has been adjusted since the last calibration, turn switch 5 OFF and calibrate on the default scale before proceeding with the Variable Scale Calibration detailed below.

Expose the sensor to calibration gas and adjust the SPAN potentiometer until the output is stable at the appropriate signal level.

Note: The value of fsd is the default full-scale value listed in Table 4 if SW5 is OFF; or the rescaled value if SW5 is ON.

If the selected default scale, or a variable scale that had been previously calibrated, is used and VR3 has not been subsequently adjusted, then the transmitter is still calibrated. The calibration gas can be removed.

Variable Scale Calibration

This variable scale calibration replaces the span procedure if a general purpose Beer's law linearisation is selected (SW1 and SW3 ON).

If any other sensor type is selected (SW1 or SW3 OFF) the output must be set in accordance with the default range, before proceeding with the variable scale calibration. Only use this procedure if a full-scale range different to the default range is required.

Set switch SW5 to the ON position and expose the sensor to the calibration gas. With the calibration gas applied, adjust potentiometer VR3 until the output reaches the required value. The full-scale range is now adjusted without affecting the linearity. Do not adjust the SPAN potentiometer to achieve a different full-scale range, otherwise the linearity will be affected.

When set, the potentiometer VR3 can be locked in order to prevent the variable gain being readjusted. Subsequent span calibrations can be achieved by adjusting the span potentiometer only, provided VR3 is not readjusted.

The maximum increase in sensitivity available by adjusting potentiometer VR3 is 3.75 times the default sensitivity; the minimum sensitivity can be set to give a full-scale range of 100% gas. Note the linearity will be maintained up to the default range of the selected sensor. Deviations from linearity may be expected at gas concentrations significantly greater than the default range. Returning switch 5 to the OFF position disables the variable scale calibration.

After calibration, remove the calibration gas. The transmitter output is now calibrated.

Recovery

If the circuit develops a recurring fault or if there are other problems, the software can be reset by pressing the RESET push-button situated above the LED indicators. This forces a full software reset and re-initialises the transmitter. The calibration settings are unaffected by a reset.