LS-C30
High Performance Sensor Interface with Switched Outputs

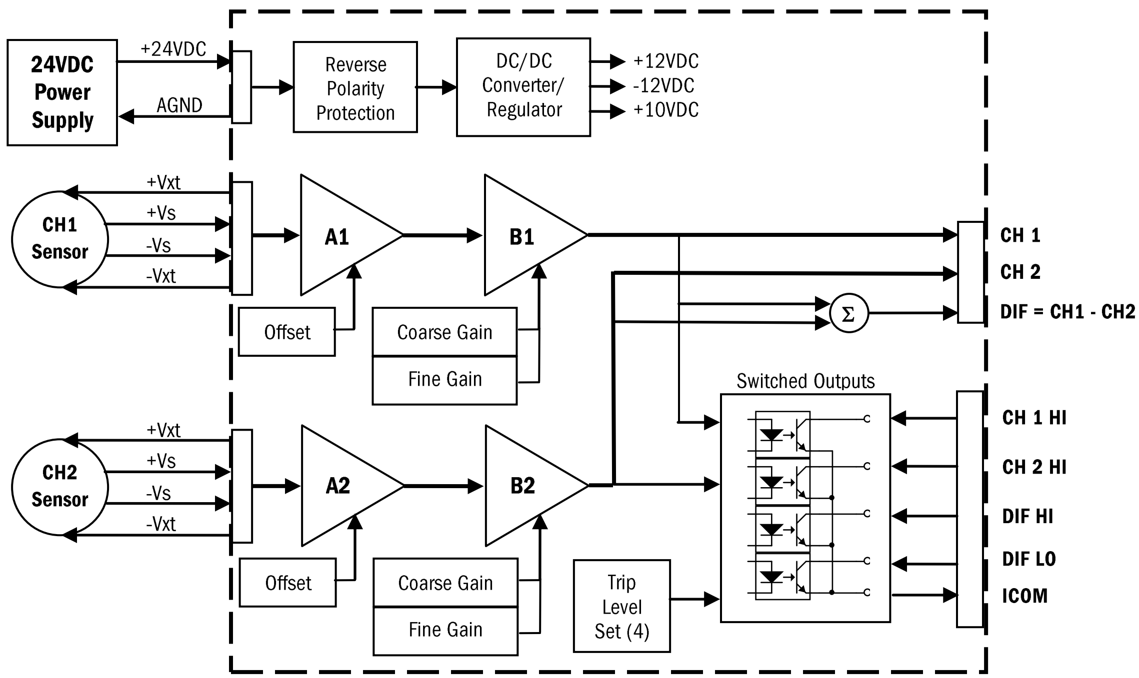
User's Guide

Overview

The High Performance Sensor Interface w/Switched Outputs is a dual channel small signal differential signal amplifier with 4 channels of optically isolated, switched outputs that function as trip level indications. The wide dynamic calibration range and low noise allow amplification of signals from very low level sensors (±12.5mV full scale) to medium range sensor outputs (±250mV full scale) to provide a full scale output of ±10VDC. The Signal Amplifier is intended to be used with bridge-type resistive sensors that provide a differential voltage output; although, it is designed to function with a variety of input configurations and signal levels.

Theory of Operation

The LS-C30 is a multi-functional high performance device that is very flexible. Shown below is a basic block diagram of the LS-C30.



Power Supply

The onboard power supply and control for the LS-C30 incorporates reverse polarity protection and indication. If the power input wires to the LS-C30 are inadvertently connected backwards, the reverse protection device will activate, thereby protecting the sensitive electronics of the LS-C30. A red LED will illuminate to identify to the user that a reverse polarity condition exists.

The LS-C30 also incorporates a DC/DC converter to generate the necessary voltages for the remaining electronics while maximizing efficiency and reducing heat production. Two versions of the LS-C30 are available based on the available power supply: 9-18VDC (12V nominal) and 18-36VDC (24V nominal).

Amplifier

Each sensor is excited by the locally supplied sensor excitation, $+V_{xt}$ (+10V) and $-V_{xt}$. $+V_{xt}$ is electrically identical for both channels and $-V_{xt}$ is electrically common with AGND for both channels. Each channel accepts the differential signal from a sensor or other small signal device and amplifies by the first stage gain (A1 for channel 1; A2 for channel 2). An offset value is incorporated into this pre-amplifier stage. A second amplification stage incorporates the final instrument gain setting (set by user). Gain A is a fixed gain pre-amp and has a gain of approximately 40. The dynamic range of adjustment for gain B is approximately 1-20 which results in a total dynamic gain range of 40-800. The amplifier is completely bi-polar to accommodate measurements in the positive *and* negative (i.e. pressure/vacuum or push/pull). The output of channel 1 may be described algebraically as follows:

$$V_{CH1} = [A1 * ({}^{+}V_S - {}^{-}V_S) + Offset] * B1$$
$$V_{CH2} = [A2 * ({}^{+}V_S - {}^{-}V_S) + Offset] * B2$$
$$V_{DIF} = V_{CH1} - V_{CH2}$$

Optically Isolated Switched Outputs

Four channels of optically isolated switched outputs have been provided for alarm or control function. All outputs are NPN type switches (current sink) with common emitters (ICOM). The optical isolation allows for connection to systems operating on differing voltage references with no risk of ground loop or ground noise problems. The output switches are reverse polarity such that when a switch condition is true (i.e. CH1 is higher than the set-point), the output voltage level from the switch will be a low voltage when the switches are configured in a typical arrangement (single pull-up resistor to supply, ICOM to low supply). Common uses for these switched outputs as well as a formula for calculation of a suitable resistor value may be found in the applications section at the end of this manual.

External Connections

Electrical connection to the LS-C30 is made by a selection of screw-type terminals. The terminals have been organized into functional groups as designated by the terminal board number (i.e. TB3). The terminal connections are identified by the terminal board number and terminal number (pin number within the terminal board). The terminals are numbered from left to right starting with #1 and will be identified throughout this document in the following format: **[Terminal Board #] – [Terminal #]** (i.e. TB1-1 or TB3-2). The tables below indicate the terminal designation, circuit board label, and function of each external connection of the LS-C30.

Inputs

Desig.	Label	Function
TB1-1	AGND	Analog Ground; low noise ground path from LS-C30 back to power supply
TB1-2	+Vpp	+24VDC Power; bulk power from 24VDC power supply referenced to AGND
TB2-1	CH1	Channel 1 Output; -10V to +10VDC referenced to AGND
TB2-2	CH2	Channel 2 Output; -10V to +10VDC referenced to AGND
TB2-3	DIF	Difference Output; -10V to +10VDC referenced to AGND where $V_{DIF} = V_{CH1} - V_{CH2}$
TB4-2	CH1 +Vs	Channel 1 Positive Sensor Input; based on bridge type sensor input, increase in physical parameter being measured should result in an increase in +Vs and a corresponding increase in CH1 and DIF
TB4-3	CH1 -Vs	Channel 1 Negative Sensor Input; based on bridge type sensor input, increase in physical parameter being measured should result in an decrease in –Vs and a corresponding decrease in CH1 and DIF
TB5-2	CH2 +Vs	Channel 2 Positive Sensor Input; same as CH1 +Vs
TB5-3	CH2 +Vs	Channel 2 Negative Sensor Input; same as CH1 -Vs

Outputs

Desig.	Label	Function
TB3-1*	CH1 HI	CH1 Level High Switched Output; active low connection, referenced to ICOM
TB3-2*	CH2 HI	CH2 Level High Switched Output; active low connection, referenced to ICOM
TB3-3*	DIF HI	Difference Level High Switched Output; active low connection, referenced to ICOM
TB3-4*	DIF LO	Difference Level Low Switched Output; active low connection, referenced to ICOM
TB3-5*	ICOM	Isolated Common; common reference for all isolated switched outputs
TB4-1	CH1 +Vxt	Channel 1 Positive Sensor Excitation Voltage; positive sensor excitation power for channel 1 sensor, referenced to CH1 -Vxt
TB4-4	CH1 -Vxt	Channel 1 Negative Sensor Excitation Voltage; negative sensor excitation power for channel 1 sensor, electrically common to AGND
TB5-1	CH2 +Vxt	Channel 2 Positive Sensor Excitation Voltage; positive sensor excitation power for channel 2 sensor, referenced to CH2 -Vxt
TB5-4	CH2 -Vxt	Channel 2 Negative Sensor Excitation Voltage; negative sensor excitation power for channel 2 sensor, electrically common to AGND

*Isolated switched outputs have independent current sinks (NPN), but share a current return; ICOM.

Controls, Indications, and Adjustments

Indications

There are several indications on the LS-C30. The table to the right lists the various available indications, color, circuit board label, and the function of the indication when illuminated.

Power Status Indicators – Five power status Light Emitting Diodes (LED's) are provided for DC power status and minor troubleshooting.

LED	Color	Label	Indicates
LD1	Green	OK	+24V Applied Correctly
LD2	Red	Rev	+24V Applied in Reverse
LD3	Green	+12V	+12V Regulator OK
LD4	Green	-12V	-12V Regulator OK
LD5	Green	+10V	+10V Excitatin OK
LD6	Orange	CH1 HI	CH1 O/P above trip point
LD7	Orange	CH2 HI	CH2 O/P above trip point
LD8	Orange	DIF HI	DIF O/P above trip point
LD9	Orange	DIF LO	DIF O/P below trip point

LD1 thru LD4 indicate the status of various voltages from external and internal sources.

Switched Output Indicators – LD5 thru LD8 indicate the status of the optically isolated output. These LED's will indicate reverse polarity when the output switch is configured in a typical NPN arrangement (LED 'ON' indicates a *LOW* output; i.e. transistor is sinking current).

Adjustments

The table below provides a listing of all adjustments available to the end user by component designation, circuit board label, and function.

Desig.	Label	Function
RP1	CH1 Offset	Compensates for input offset of sensor
RP2	CH1 Gain (C)	Coarse gain adjustment for Channel 1
RP3	CH1 Gain (F)	Fine gain adjustment for Channel 2
RP4	CH2 Offset	Compensates for input offset of sensor
RP5	CH2 Gain (C)	Coarse gain adjustment for Channel 1
RP6	CH2 Gain (F)	Fine gain adjustment for Channel 2
RP7	CH1 HI	Sets high trip level for CH1
RP8	CH2 HI	Sets high trip level for CH2
RP9	DIF HI	Sets high trip level for DIF
RP10	DIF LO	Sets low trip level for DIF

*All adjustments will tend to increase the parameter value when rotated in the CW direction

Offset and Gain - Each channel of the LS-C30 provides for offset and gain adjustments via 11 turn potentiometers to accommodate a wide range of sensor inputs. The offset adjustment is labeled 'Offset' for each channel ('CH1' for channel 1 and 'CH2' for channel 2). The gain adjustments are labeled 'Gain' but incorporate two adjustments for each channel; a coarse adjustment labeled 'C', and a fine adjustment labeled 'F'. The purpose of a course and fine adjustment for the gain setting is to allow for a wider gain range while maintaining adjustment precision (the coarse adjustment is approximately 50 times more sensitive than the fine adjustment).

Adjustable Switched Output Trip Points – The output of Channels 1, 2, and DIF may have a valid output anywhere within the range of -10V to +10V depending on system calibration by end user. The switched output trip level is controlled by adjusting 11 turn potentiometers (RP7 thru RP10). The output trip level may be adjusted over a range of approx +12V to -12V. The trip voltage may be monitored via TP1 thru TP4 (TP5 is a local AGND and is provided for convenience). The output switch will sink current when the test condition is true (i.e. the 'CH1 HI' output will conduct current when the voltage from CH1 is greater than the voltage at CH1 Hi test point; TP1). A true condition will actuate the appropriate switch at TB3 and illuminate the appropriate LED.

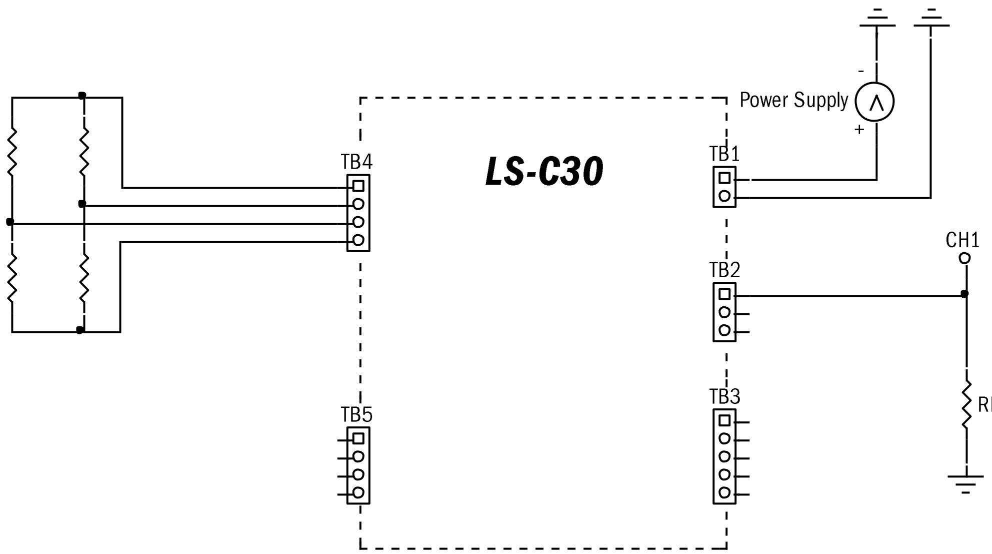
Application Examples

The LS-C30 is an extremely flexible device. There are many ways to configure the external connections to provide the functionality the user desires. In this section are several means of connecting and using the LS-C30, however, this set of examples is not exhaustive and other means may be valid.

General Notes

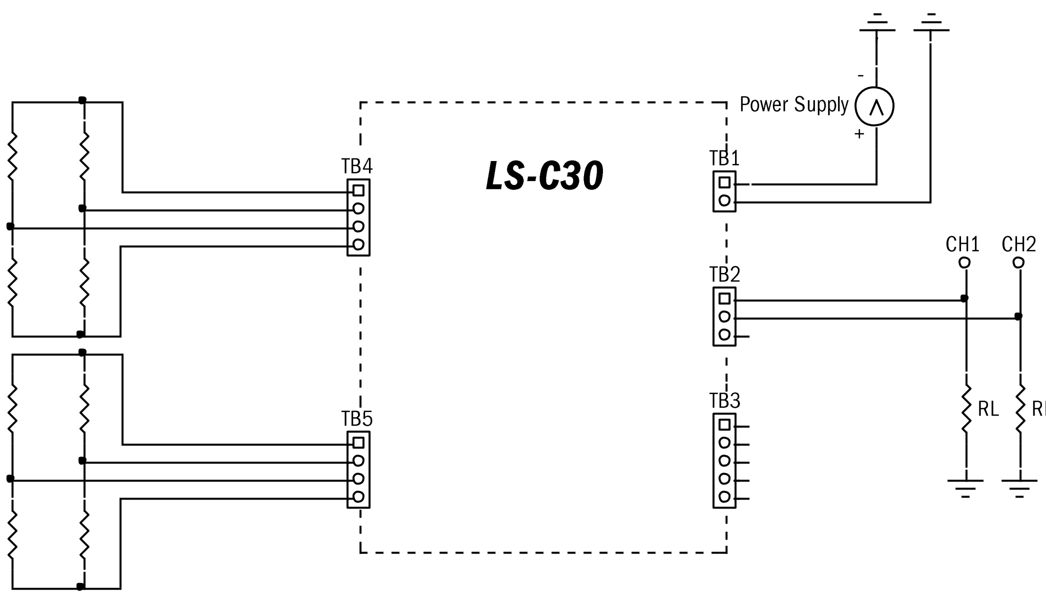
- Observe sensor manufacturer's limits for excitation voltage
- Observe CH1 and CH2 output minimum impedance at R_L (see LS-C30 Datasheet)
- Power supply voltage required will depend on LS-C30 model selected

Single Channel Bridge Sensor Amplifier



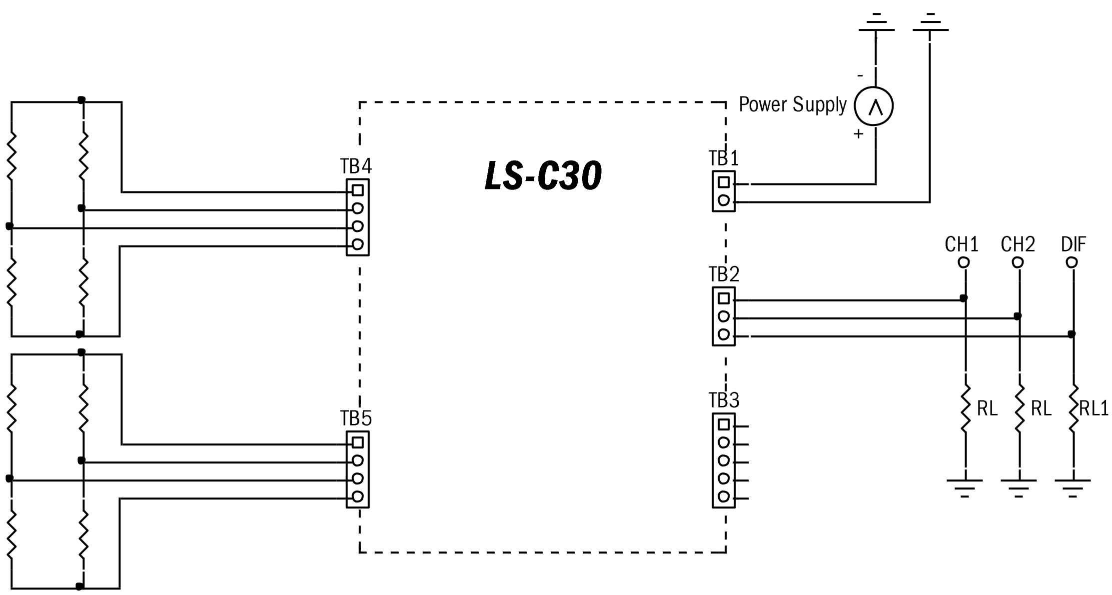
**Channel 2 and Difference Output remains un-used and unconnected*

Dual Channel Bridge Sensor Amplifier



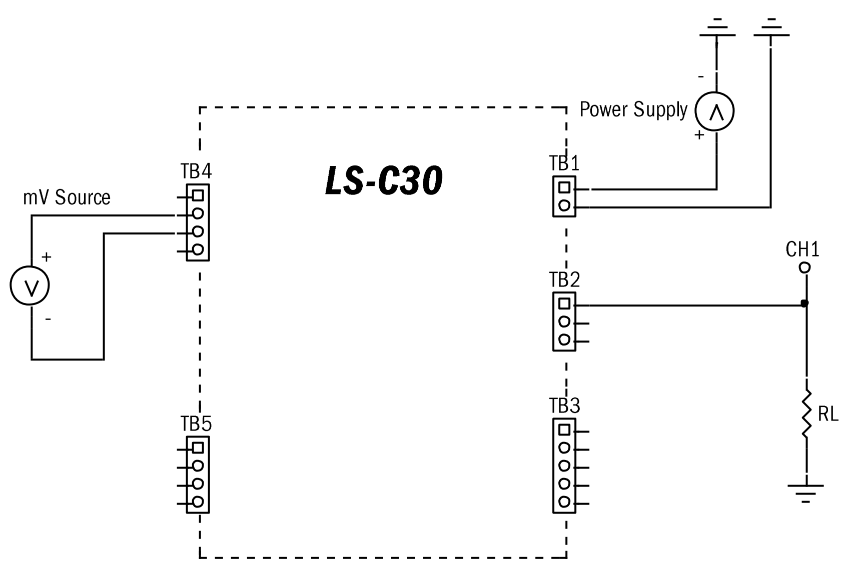
**Difference output is not used*

Dual Channel Bridge Sensor Amplifier w/ Difference Output



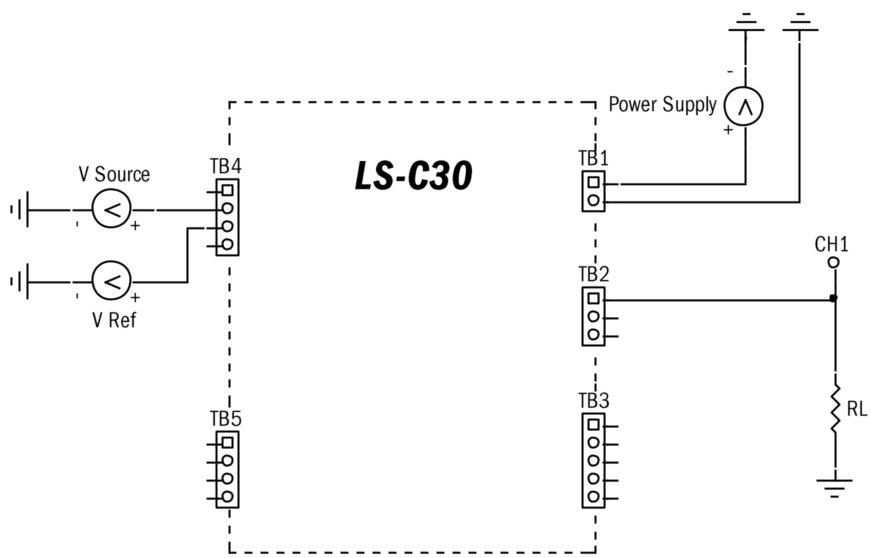
**DIF = CH1 - CH2*
**Switched outputs are not-used*

Isolated mV Differential Voltage Source (Channel 1 and/or Channel 2)



**Channel 2 shown not used, but may be bridge input or other mV source*
**Switched outputs shown not used*

Small Signal Amplifier with Large Offset (Reference)



**The signal source (V Source) is a small mV signal 'riding' on a large DC reference (V Ref)*
**Channel 2 shown not used, but may be bridge input or other mV source*
**Switched outputs shown not used*

Use of Optically Isolated Switched Outputs (NPN/Current Sinking)

The switched outputs are optically isolated from the amplifier and power supply sections of the LS-C30 and require external connections to a current source to provide a useful output. The outputs are inverted logic (i.e. CH1 HI output will be high impedance with the CH1 HI LED is lit). Typically, the switched outputs are implemented using only a single load resistor and suitable power supply. This power supply need not be the same supply that powers the LS-C30 (although, one configuration uses the same supply). If an isolated supply is used, ensure the limits of the LS-C30 datasheet are not exceeded.

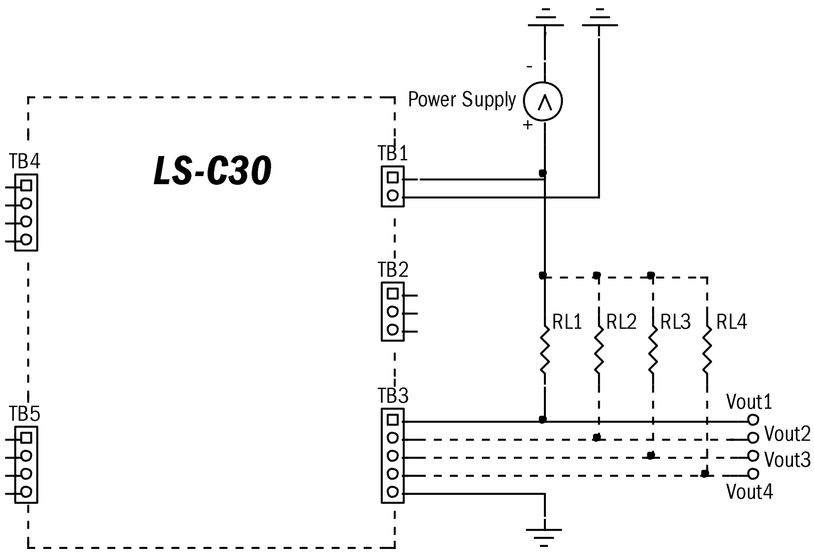
To calculate the minimum switched output load resistance, perform the following:

1. Determine the maximum allowable switch current ($I_{SW\ MAX}$) for the application; not to exceed the maximum current from the LS-C30 datasheet
2. Determine the maximum voltage from the isolated power supply (i.e. $V_{SW\ MAX} = V^+ - V^-$)
3. Calculate the minimum load resistance by: $R_{SW\ MIN} = V_{SW\ MAX} / I_{SW\ MAX}$
4. Calculate the required power rating of the chosen resistor by: $P_{RESISTOR} = V_{SW\ MAX} * I_{SW\ MAX}$

<u>Example</u> –

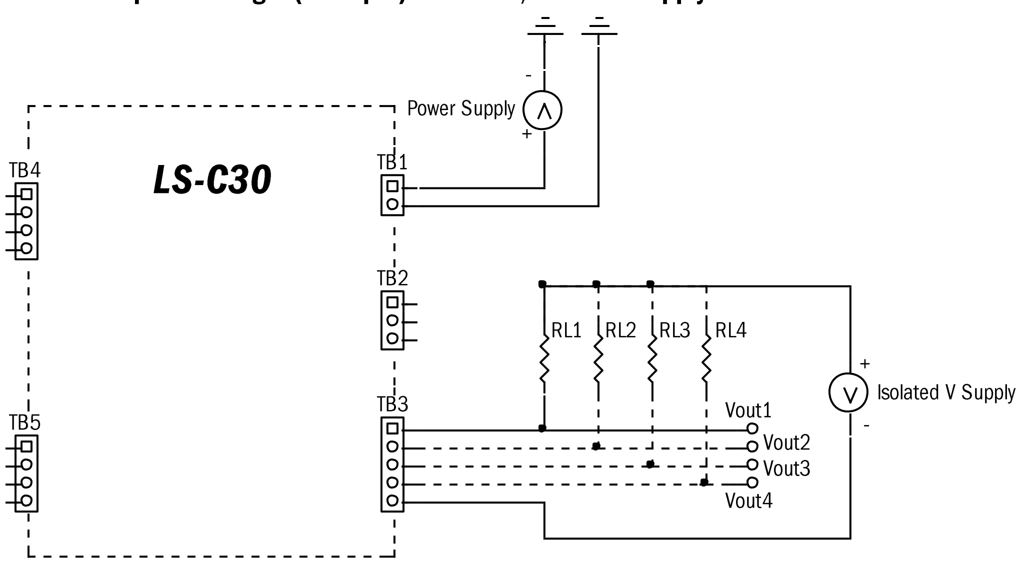
- We determine that the maximum current desired is 5mA
- We choose to use a 24V supply on a separate circuit from the LS-C30
- The minimum load resistance is $R_{SW\ MIN}$ = 24V / 5mA = 4.8kΩ
- We choose the next available 5% resistor value of 5.1kΩ
- The resistor power rating must be in excess of: $P_{RESISTOR}$ = 24V * 5mA = 0.12W; we may use a resistor with a power rating ≥1/8W

Typical Application – Switched Output for Single (Multiple) Channels; Non-Isolated Supply



Channel 1 and Channel 2 shown not-connected for simplicity
All values for R_L calculated as stated above
RL1 through RL4 and associated wiring may be connected in any combination as shown to provide V_{OUT1}, V_{OUT2}, V_{OUT3}, and/or V_{OUT4}
V_{OUT} will be 0V when the associated LED is lit, and V_{SUPPLY} when LED is extinguished (inverted logic)

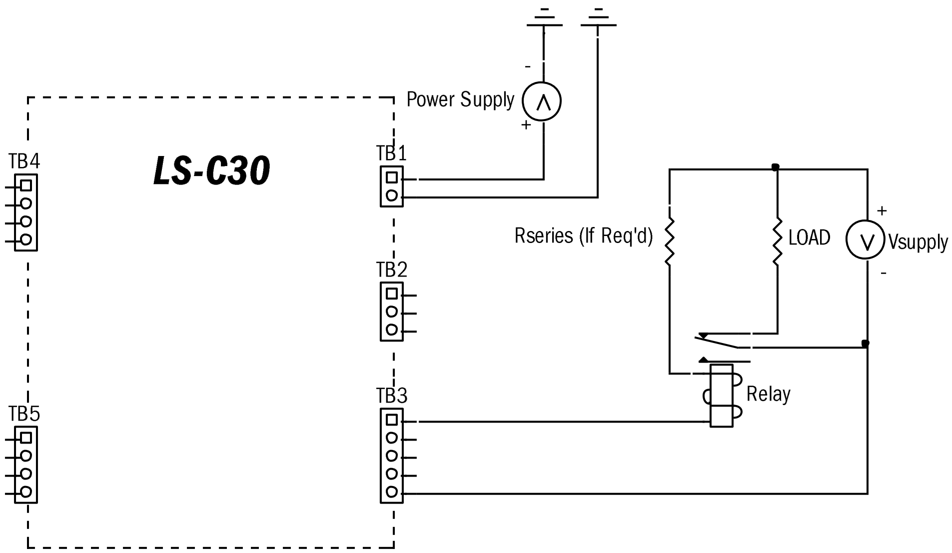
Switched Output for Single (Multiple) Channels; Isolated Supply



Channel 1 and Channel 2 shown not-connected for simplicity
All values for R_L calculated as stated above
RL1 through RL4 and associated wiring may be connected in any combination as shown to provide V_{OUT1}, V_{OUT2}, V_{OUT3}, and/or V_{OUT4}
V_{OUT} will be 0V when the associated LED is lit, and V_{SUPPLY} when LED is extinguished (inverted logic)

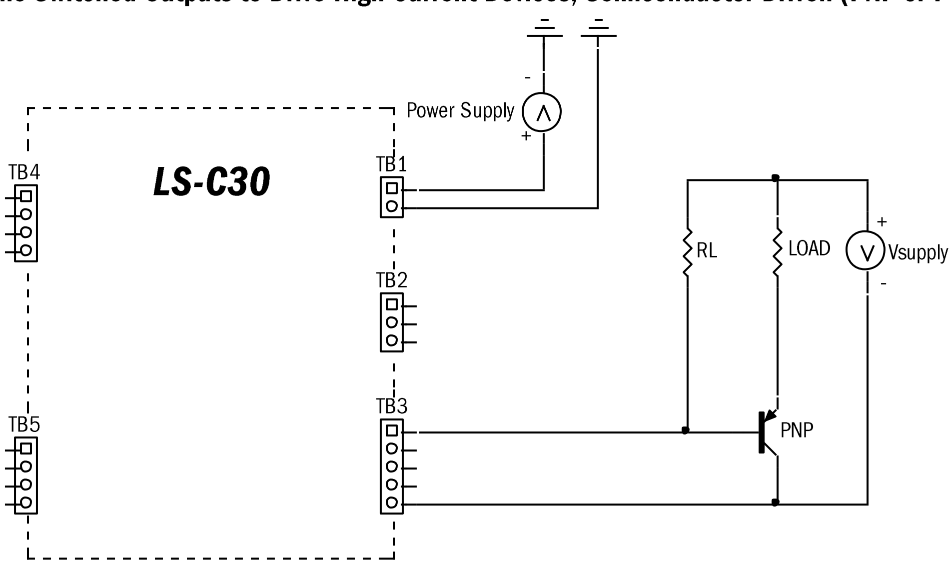
**ICOM must be connected to Power Supply common or V*

Using the Switched Outputs to Drive High Current Devices (i.e Valves, Sirens, etc.); [Relay Driven]



**Channel 1 and Channel 2 shown not-connected for simplicity*
**R_{SERIES} is selected as required to ensure switch current remains below maximum limit (see LS-C30 datasheet)*
**"LOAD" may be any high current device the user wishes to power*
**Only a single switched output is shown connected here, however, any or all of the switched outputs may be used in a similar manner*

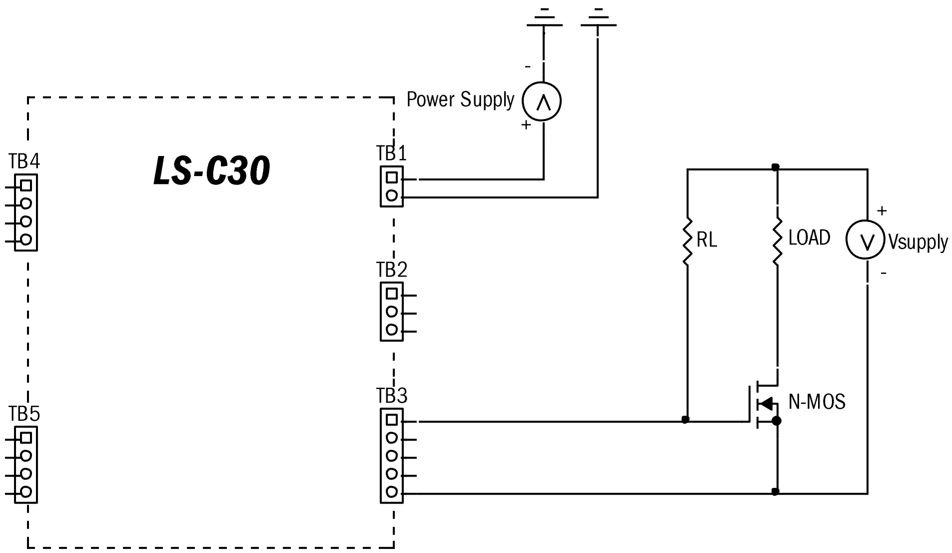
Using the Switched Outputs to Drive High Current Devices; Semiconductor Driven (PNP or P-Type)



**Channel 1 and Channel 2 shown not-connected for simplicity*
**R_L value calculated as described previously*
**"LOAD" may be any high current device the user wishes to power*
**Switch transistor may be BJT, MOSFET, or other suitable device*

**Only a single switched output is shown connected here, however, any or all of the switched outputs may be used in a similar manner*

Using the Switched Outputs to Drive High Current Devices; Semiconductor Driven (NPN or N-Type)



**Channel 1 and Channel 2 shown not-connected for simplicity*
**R_L value calculated as described previously*
**"LOAD" may be any high current device the user wishes to power*
**Switch transistor may be BJT, MOSFET, or other suitable device*
**Only a single switched output is shown connected here, however, any or all of the switched outputs may be used in a similar manner*

Operating Instructions

Calibration Procedure

This calibration procedure is provided *as a guide* to help the end user set up the LS-C30 successfully. An intrinsic understanding of the signal source, the signal characteristics, the physical system being measured, as well as the overall signal scheme chosen is critical to incorporating the LS-C30 successfully into any system.

> *This procedure is intended to be complete but adequately vague so as to cover most applications; however, it would not be feasible to represent every possible combination of inputs and outputs. Other configurations may be perfectly valid and adequate despite not being mentioned here.*
>
> *For simplicity, this procedure is written as if setting up Channel 1. Channel 2 would be set up in a similar manner.*

1. Connect the signal source to the Channel 1 input as shown in the application examples. If using a third party sensor, the wire color designations are typical (refer to the sensor manufacturer's documentation):
   - Red = $+V_{XT}$ (TB4-1)
   - Black = $-V_{XT}$ (TB4-4)
   - Green = $+V_{SENSE}$ (TB4-2)
   - White = $-V_{SENSE}$ (TB4-3)
2. Connect appropriate electrical power to the LS-C30 via TB1-1 (AGND) and TB1-2 ($+V_{PP}$); verify proper supply polarity and voltage depending on the LS-C30 power supply option ordered (9-18VDC or 18-36VDC)
3. Establish a *physical* input of 'Zero' or minimum to the sensor or input device (i.e. 0 psig for a pressure sensor, 0 lbf for a force sensor, 0mV for a mV source, etc.).

   NOTE: DEPENDING ON THE SIGNAL/CONTROL SCHEME, ZERO VOLTS MAY NOT REPRESENT PHYSICAL ZERO (I.E. THE USER MAY WANT 0 VOLTS TO REPRESENT 10 PSIG AND 10 VOLTS TO REPRESENT 75 PSIG). FOR THIS PROCEDURE, THIS MINIMUM PHYSICAL INPUT VALUE WILL BE REFERRED TO AS 'ZERO'.
4. While monitoring the output at CH1 (TB2-1), adjust the Channel 1 Zero (RP1) until the output is approximately 0V.
5. Establish a physical input of maximum to the sensor (i.e. 100 psig for a 0 – 100 psig sensor, 250 lbf for a 0 – 250 lbf load cell, etc.).
6. Adjust the coarse gain (RP 2) to achieve approximately 10V.
7. Repeat steps 3 and 4 to fine tune the zero for an output of 0.00V.
8. Repeat steps 5 and 6 adjusting the fine gain (RP3) instead of the coarse gain (RP2) to achieve an output at Channel 1 of 10.00V.
9. Vary the physical input to the sensor over the range of operation to verify the linearity of the system (i.e. vary the pressure between 0 psig and 100 psig in 10 psig increments and monitor output voltage; 10 psig should correspond to 1.00V).