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I-LITE LED DRIVER APPLICATION NOTE

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The following is a generic application note that applies to all ACI I-LITE LED drivers.

In the case of unique functions and/or performance for a given driver, the datasheet for that product should also be referenced.

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Datasheet symbol definitions

<i>V_f</i>	<i>Voltage forward</i>	The total forward voltage drop for a given series string of LEDs.
<i>I_{out}</i>	<i>Current output</i>	The current supplied by the LED driver into a given number of LEDs.
<i>OCV</i>	<i>Open circuit voltage</i>	The voltage that appears at the output of the LED driver with no LEDs connected.
<i>I_{cntl}</i>	<i>Current control</i>	The control voltage supplied by the user to control LED drive current

General circuit operation

ACI's I-LITE LED drivers operate as a true DC constant current source. The output current will remain constant for a given set-point provided that the total forward voltage (***V_f***) for a given series connected string of LEDs is within the recommended range as specified per the driver datasheet. The user has the ability to control the set-point or magnitude using the ***I_{cntl}*** input. The ***I_{cntl}*** input can support a wide variety of voltage control ranges with the most common being 0.25V to 3.0V which corresponds to a full dim to full bright range.

The I-LITE platform features a maximum intensity selector switch (S1) and this 4 position rotary switch allows the user to set the maximum output current when ***I_{cntl}*** is at full intensity. This allows the user to tailor the match when connected to various LED configurations. Typical maximum current settings per channel for a 6 channel driver *might* be:

- A = 32mA
- B = 24mA
- C = 16mA
- D = 8mA

For example, if setting B was chosen, varying ***I_{cntl}*** throughout its range would vary the output current from 0 to 24mA per channel. When no dimming is required, users should leave the ***I_{cntl}*** pin disconnected or tied to the +3.3V reference output pin (Pin 5 of CON 1) to allow the driver to operate at full output current (as dictated by the maximum output current setting A-D).

The input voltage of most ACI LED drivers is +12V +/-10%. Additionally, ACI can supply drivers capable of regulating over wide input voltage ranges of (+8V to +18V) or (+16V to +36V). The output drive current is under closed-loop control, and therefore remains stable despite changes of input voltage over the specified range.

The I-LITE driver is open circuit protected. However, shorting the outputs or referencing any of them to ground will potentially damage the unit and/or cause the on-board fuse to open. In most cases replacing the fuse (F1) will allow the unit to function again normally.

IMPORTANT: The cathode side (-) of I-LITE's output(s) is near ground potential (< 1.5V), but should **never** be connected directly to ground. As a consequence, the LED array **must** be free-floating to allow proper monitoring of the driven current. To date, many the LED backlit displays coming onto the market support this architecture.

Choosing the correct driver solution

Step 1 - LED configuration

Most of the LED equipped displays becoming available on the market are connected in one of three configurations, as defined in Figures 1, 2 and 3. ACI's I-LITE LED drivers can drive up to six (6) parallel channels of series-connected LEDs, and comes in two configurations. The first, common-cathode configuration, supports displays connected as shown in Figure 1. The second, common-anode configuration, supports displays that are connected as shown in Figure 2. In the case of each anode & cathode connection being brought out as shown in Figure 3, either I-LITE configuration will work.

The I-LITE series of LED drivers monitors the sum of all the currents flowing through the LEDs, so it is important to choose the driver that supports an equal number of channels as the LED backlight.

Step 2 - LED Drive Current

Within the LED backlight specification, the nominal LED drive current is typically defined for a single series channel. Similarly, all I-LITE products are specified the same way, on a per channel basis.

Step 3 - LED Forward Voltage Drop

The next step is to determine the nominal forward voltage drop per LED channel. Again, most LCD manufactures specify the total forward drop voltage per series channel. To maintain constant current under all operating conditions, it is important to refer to the "Recommended Operating Conditions" section of the I-LITE datasheet and to ensure that the series connected cumulative LED forward-drop voltage falls within the min/max range specified.

Control and Dimming

A standard I-LITE driver employs firmware that supports the following control signals:

- Enable (Active high, TTL compatible)
- Icntl (0.25V to 3.0V)
- +3.3Vref (use for high side of potentiometer or D/A reference)

The three control signals described above are configured by the on-board micro-controller. The I-LITE LED driver family supports two methods of dimming. The amplitude dimming method, or varying the output drive current, will typically produce ranges of over 3000:1 which are more than adequate for most applications. When more extreme dimming ranges are required (>5000:1), a combination of Amplitude and Pulse Width Modulation (or PWM) methods can be supported. This combination of dimming methods is called "mixed-mode" dimming. The standard dimming firmware approximates a logarithmic response as shown in Figure 4.

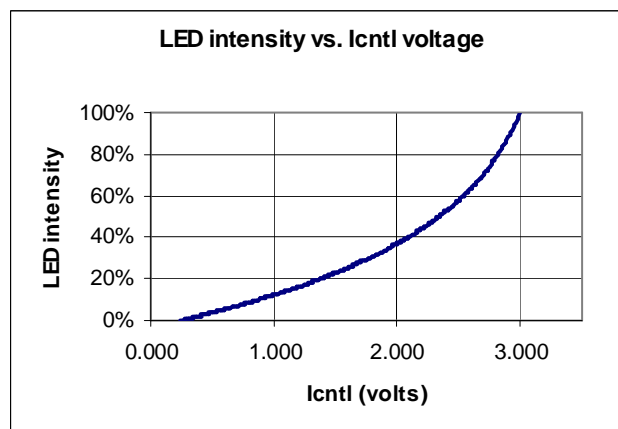


Figure 4 LED intensity vs. Icntl voltage

Connecting to the LEDs

The I-LITE family of LED drivers features two output connectors (CON2 & CON3). CON2 supplies up to six (6) channels of drive current with one return connection. Only this connector need be used when the LEDs are configured as shown in Figure 1 (common-cathode), or Figure 2 (common-anode). If the LED strings have independent anode & cathode connections as shown in Figure 3, then both CON2 & CON3 are used.

NOTE: If using an I-LITE common cathode LED driver, anodes go to CON2 & cathodes to CON3. If using an I-LITE common anode LED driver, cathodes go to CON2 & anodes to CON3. Refer to the example connection diagrams section for more information.

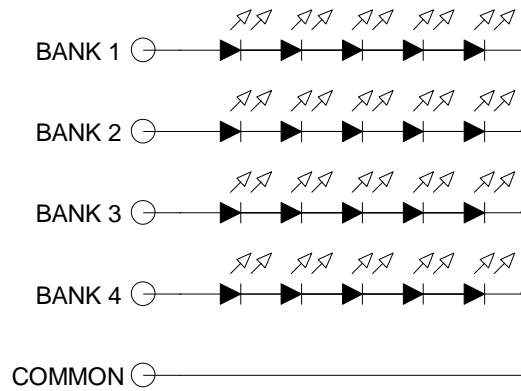


Figure 1 Common-cathode configuration

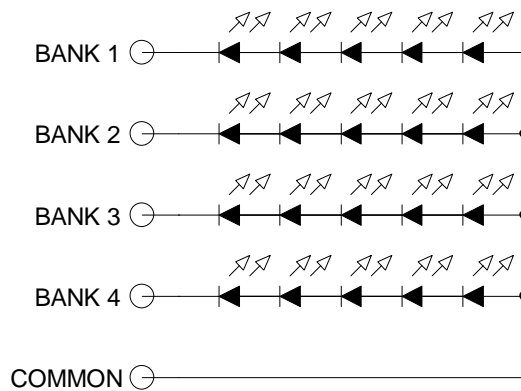


Figure 2 Common-anode configuration

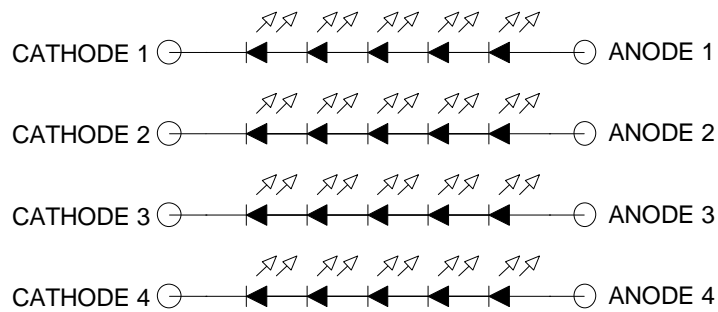


Figure 3 All independent connections

Selectable/Configurable output current levels

Generally, it is desirable to use a LED driver designed specifically for a given LED backlight for optimum performance. However, users may desire to experiment with I-LITE drivers for other panels or applications that may be configured with fewer LED channels (or strings) or that may require different current drive levels. Users may vary the number of LED channels (or strings) that are connected as well as the maximum intensity selector switch (S1) setting, keeping in mind the overall goal is to utilize as many channels as is practical, and to also provide output current balance to the connected channels.

Table 1 shows the resulting output current (ma), as a function of the maximum current switch setting (A-D) and the number of channels connected (1-6). The table is based upon using an I-LITE six-channel LED driver with nominal output current specifications as highlighted in green.

		# of LED channels utilized					
		1	2	3	4	5	6
On-board rotary switch setting	A	192	96	64	48	38.4	32
	B	144	72	48	36	28.8	24
	C	96	48	32	24	19.2	16
	D	48	24	16	12	9.6	8

Table 1

Although users may vary the number of LED channels (or strings) that are connected, care should be taken not to leave too many driver outputs open. When the target backlight consists of fewer LED channels than the number of channels supported by the I-LITE driver, the driver outputs should be connected in parallel with other outputs, and whenever practical, only in equal numbers.

For example, if the LED backlight is configured in three channels and a six channel driver is available, the user should connect all six channels in three groups of two. Channels 1 & 2 are connected in parallel to drive the 1st LED string, channels 3 & 4 are connected in parallel to drive the 2nd and channels 5 & 6 are connected in parallel to drive the 3rd channel.

In the case of a four channel LED backlight driven by a six channel driver, each channel should be connected independently, with the remaining two channels on the driver left open.

Refer to Table 2 for additional help in selecting the best configuration when the number of LED channels in the backlight does not match the number of channels connections on the driver.

Channels supported by I-LITE LED driver

	1	2	3	4	5	6
LED channels to be driven	1	1-2	1-3	1-4	1-5	1-6
1	1	1,2	1,2	1,2,3-4	1,2,3-4	1-3,4-6
2		1,2	1,2,3	1,2,3	1,2,3	1-2,3-4,5-6
3			1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
4				1,2,3,4,5	1,2,3,4,5	1,2,3,4,5
5					1,2,3,4,5,6	1,2,3,4,5,6
6						1,2,3,4,5,6

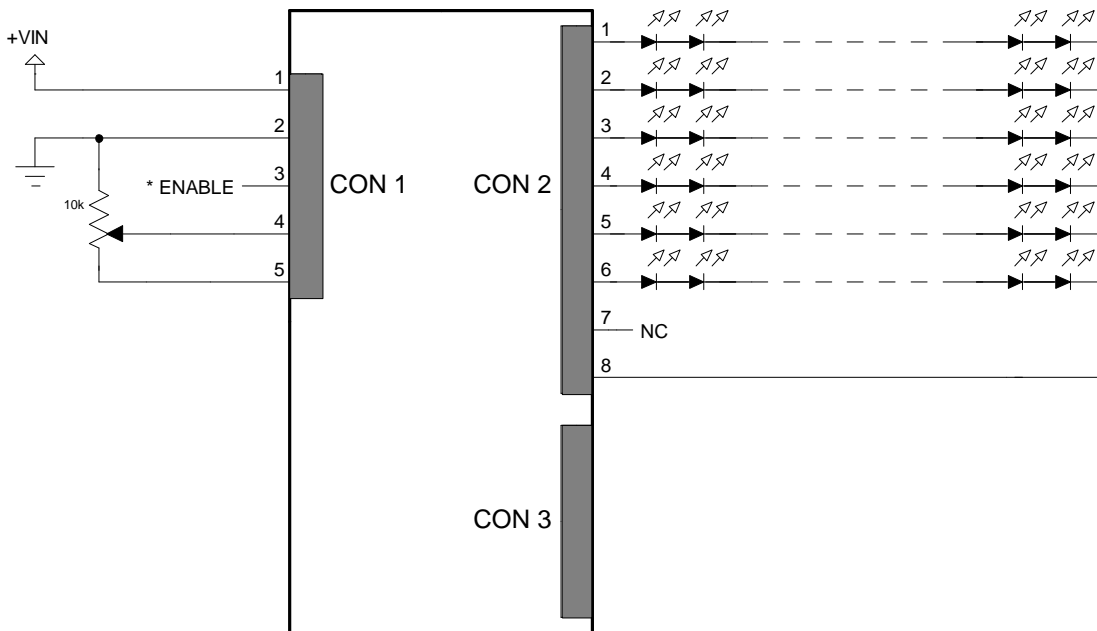
KEY:

- = Not applicable
- = Nominal configuration
- 1-2 = Paralleled channels
- 1,2 = Independent channels

Table 2

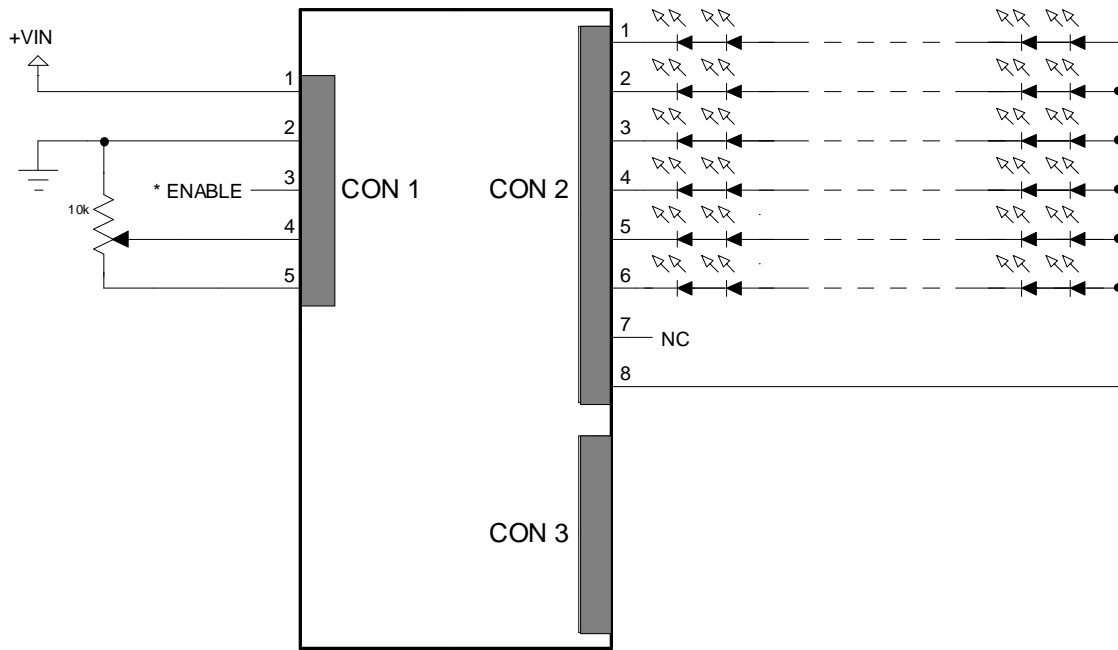
Example connection diagrams

I-LITE 6 CHANNEL COMMON CATHODE DRIVER WITH SINGLE RETURN



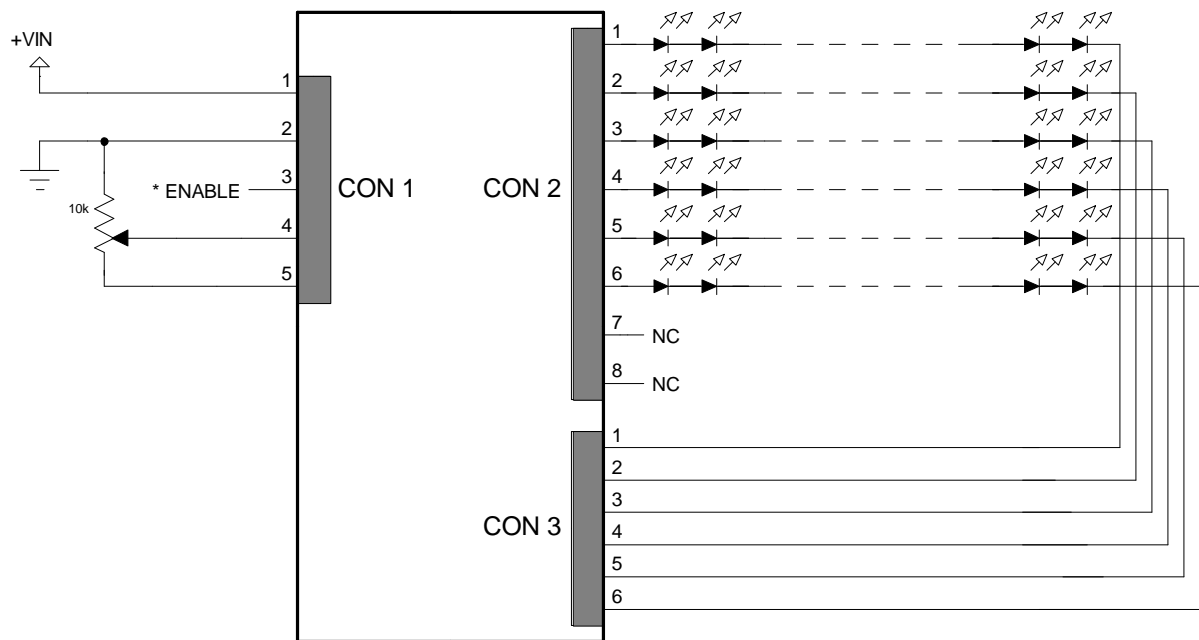
* Tie Enable (Pin 3) to +3.3V (Pin 5) if not used

I-LITE 6 CHANNEL COMMON ANODE DRIVER WITH SINGLE RETURN



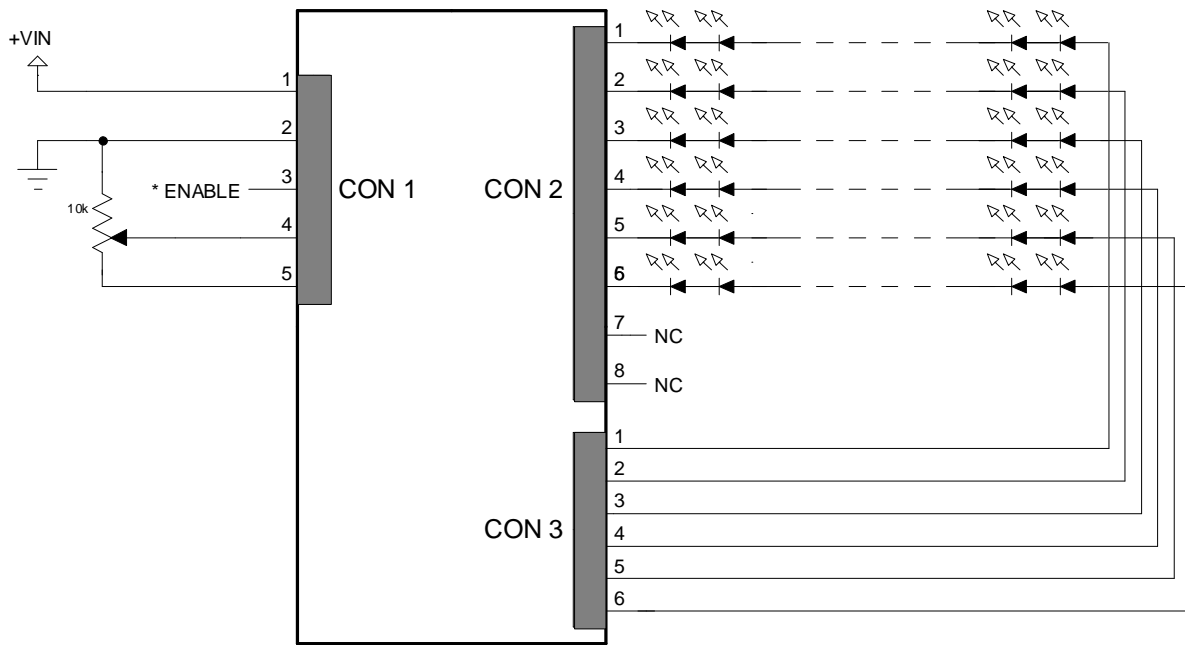
* Tie Enable (Pin 3) to +3.3V (Pin 5) if not used

I-LITE 6 CHANNEL COMMON CATHODE DRIVER WITH INDEPENDENT RETURNS



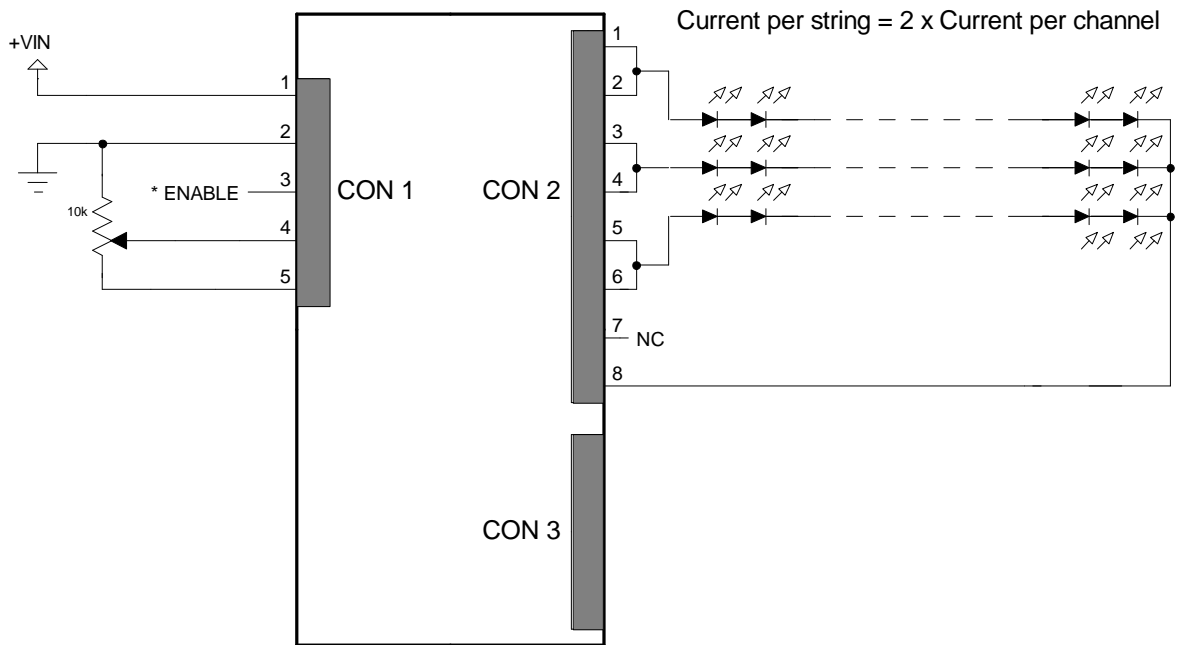
* Tie Enable (Pin 3) to +3.3V (Pin 5) if not used

I-LITE 6 CHANNEL COMMON ANODE DRIVER WITH INDEPENDENT RETURNS



* Tie Enable (Pin 3) to +3.3V (Pin 5) if not used

DRIVING 3 SERIES LED STRINGS WITH AN I-LITE 6 CHANNEL COMMON CATHODE DRIVER



* Tie Enable (Pin 3) to +3.3V (Pin 5) if not used