

LED Backlight Driver Input Cable

April 26, 2014

1. Introduction

Nearly all the recent LCDs with LED backlight have the LED driver built-in. Thus, there is a connector (beside the LVDS connector) on the LCD PCB to provide the backlight power and the controls as shown below.

- A. Supply the power needed to operate the LED backlight.
- B. The backlight turn on and turn off control signal
- C. The backlight brightness adjustment signal

In general, for LCDs below 32" size, the voltage for the LED driver is at 12V DC. The power required depends on the LCD size. Typically, for a 15" LCD, the power is around 5 Watts. For larger size LCD such as the 27" LCD, the power required can be about 35 Watts.

The backlight on/off control is done with a DC voltage. The voltage turns on the backlight (V_{on}) is either 3.3V or 5V. The off voltage (V_{off}) is 0V.

For backlight brightness adjustment or dimming, nearly all the LCDs require a PWM (pulse width modulation) voltage waveform. When the PWM waveform is adjusted to 100% duty cycle, the backlight is run at its maximum brightness. As the duty cycle is adjusted down, the brightness reduces. Please refer to Section 3 on page 3 for details.

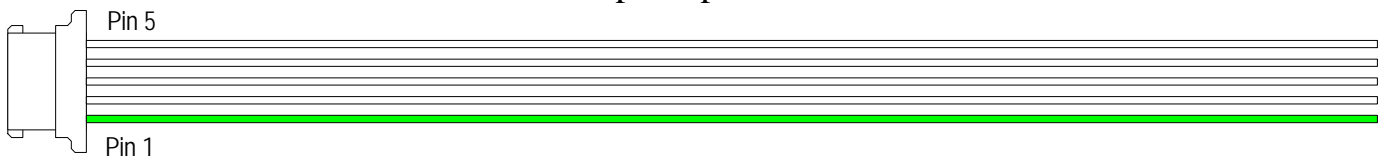
2. The LED Driver Input Cables

For industrial grade LCDs, there are 3 popular connectors for the LED driver input. Thus, we provide the following 3 input cables.

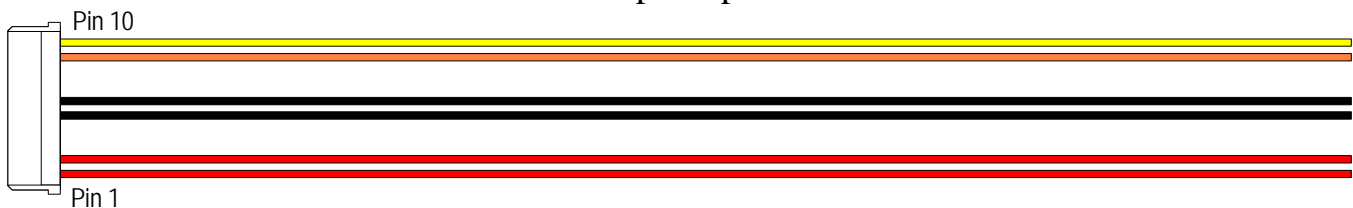
- A. E5 – A 5-pin input cable with 5 wires
- B. E6 – a 6-pin input cable with 6 wires
- C. A10 – a 10-pin input cable with 6 wires

The following figure shows the E5 and A10 input cables and the color of the wires.

E5: 5-pin input cable



A10: 10-pin input cable



The typical wire length is 250 mm. For A10 input cable, pins #3, 4 and #7, 8 do not have wires since the wires at pins #1, 2 and #5, 6 are good enough to provide the backlight power requirement.

For industrial LCDs, the E5 and A10 connector cables are the most popular ones. Besides providing the 12V and the Ground connections, there are two pins (wires) for the backlight on/off and dimming controls. In addition, for E5 connector cable, there are three different pin assignments. As a result, there are 3 different part numbers (E5A, E5B, E5C) for the E5 input cables as shown below:

Table 1 - E5 connector cable pin assignment

Pin #	Wire color	E5 A	E5 B	E5 C
1	Green	12V in	12V in	NC
2	White	12V in	Gnd	Dimming
3	White	Gnd	On/off	On/off
4	White	Dimming	Dimming	Gnd
5	White	On/off	NC	12V in

Caution – it is very critical to use the input cable correctly matching to the pin assignment of the LED driver connector on the LCD PCB. With the wrong cable, the 12V input will be connected to the pin with other function. This may damage the LED driver circuit and make the LCD not function any more. .

For the A10 LED backlight input cable, there is only 1 pin assignment as shown below. Thus, there is only 1 part number A10A.

Table 2 - A10 connector cable pin assignment

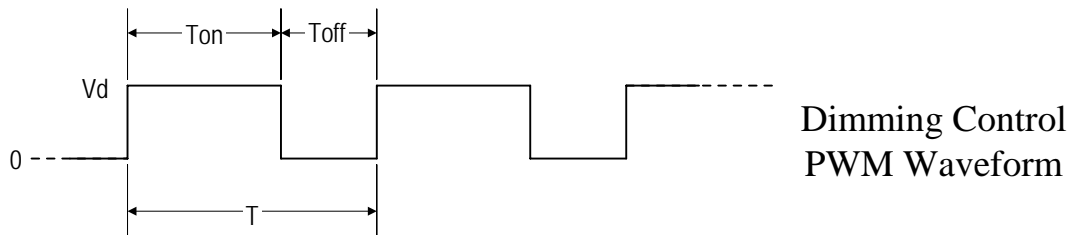
Pin #	Wire color	A10A
1	Red	12V in
2	Red	12V in
3	NC	12V in
4	NC	12V in
5	Black	Gnd
6	Black	Gnd
7	NC	Gnd
8	NC	Gnd
9	Orange	On/Off
10	Yellow	Dimming

For the A10A connector cable, there are 4 pins (1, 2, 3, 4) assigned for 12V input as well as 4 pins (5, 6, 7, 8) as Ground. Since two wires are good enough to carry the power needed, pins 3, 4, 7, and 8 are left open without wires.

3. The Backlight On/Off and Dimming Specifications

The backlight on/off control requires a DC voltage applied to the On/Off pin of the LED driver input connector. The voltage turns on the backlight (Von) is either 3.3V or 5V. The voltage turns off the backlight is 0V.

For backlight brightness adjustment or dimming, a PWM (pulse width modulation) voltage waveform as shown below is applied to the dimming pin of the LED driver input connector.



The waveform contains a square wave with the voltage at V_d for a time period of T_{on} followed by a voltage at $0V$ for a time period of T_{off} . The waveform repeats itself at a frequency of F_{pwm} which equals to $1/T$.

During the T_{on} time period, the backlight is turned on at maximum brightness (Y_{max}). When the voltage is at $0V$, the backlight is turned off ($Y = 0$). Thus, the brightness seen by the human eye is:

$$Y = (Y_{max} \times T_{on}) / T \quad \text{where } T = T_{on} + T_{off}.$$

T_{on} / T is call the duty cycle of the PWM waveform Thus, if $T_{on} = T$ ($T_{off} = 0$) the duty cycle is at 100% and the backlight is at the full brightness Y_{max} . As the duty cycle is adjusted down, the backlight brightness reduces accordingly. For example, adjusting the duty cycle to 50% by making $T_{on} = T_{off}$, the brightness is half of the maximum brightness.

The typical V_d value is 3.3V or 5V. The typical frequency of the PWM waveform (F_{pwm}) is about 200 Hz. On some LCDs, the F_{pwm} can be as high as 20 KHz.

In general, it is not good to have the duty cycle adjusted down to 0%. At this level, the backlight is off and the image on the LCD screen is no longer visible. So, the minimum duty cycle recommended in most of the LCD specifications is at about 10%.

In summary, the backlight On/Off control requires a DC voltage. The backlight brightness control requires a PWM (pulse width modulation) signal. On the voltage levels of these two controls, there are 3 difference specifications:

Table 3 - On/Off and PWM dimming voltage levels

Control	Symbol	Level 1	Level 2	Level 3	Backlight
On /Off	V_{on}	5 V	5 V	3.3 V	Turn on
	V_{off}	0 V	0 V	0 V	Turn off
PWM Dimming	V_d	5 V	3.3 V	3.3 V	Turn on
	0	0 V	0 V	0 V	Turn off

4. A Simple Way to Operate the Backlight of a Standard Brightness LCD

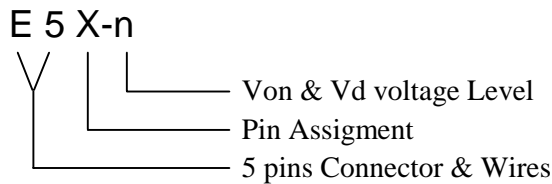
In general, a PWM waveform for dimming control is not easy to get. Also, the maximum screen brightness of standard brightness LCDs is typically around 300 nits. As a result, for most of the applications, the LCD screen brightness can be set at maximum (i.e. at 100% PWM duty cycle). In fact, at 100% duty cycle, the PWM waveform is actually a DC voltage V_d . Thus, we can set the dimming pin at a DC voltage V_d to run the LCD at maximum screen brightness. This way, there is no need to have a complicated PWM waveform for dimming control.

In case it is necessary to adjust the screen brightness down, most of the LCD controller can adjust the screen brightness down by reducing the LCD optical transmission. However, the brightness adjustment range is limited and the image quality displayed on the LCD may get degraded.

With this idea, Landmark designs the MG36 controller card BIOS to provide a dimming ratio about 3:1 with very little effect to the image quality displayed on the screen. Thus, with a 300 nits LCD, the screen brightness can be adjusted down to 100 nits. This is enough for most of the applications.

5. The 5-pin LED Driver Input Cable Part Number

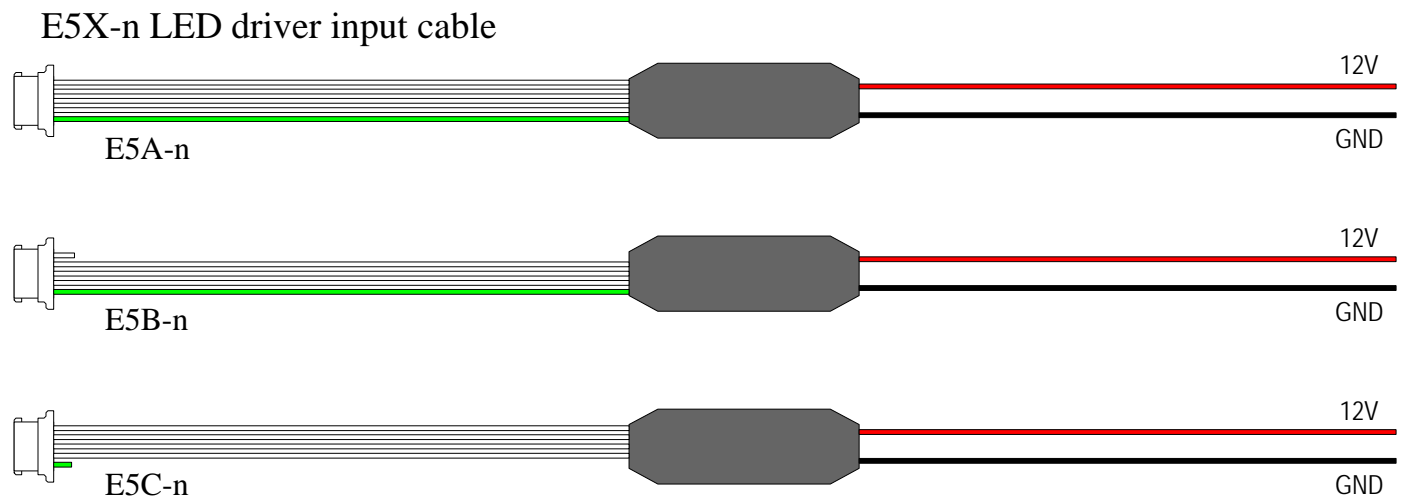
The 5-pin cable E5 currently supplied by Landmark Technology is the most popular one for running the LED backlights of industrial LCDs. Since there are 3 different pin assignments and 3 different Von & Vd voltage levels, it is necessary to use the following part number to identify the cable.



The character X specifies the 3 types of pin assignment (A, B, C) as shown in the table 1 on Page 2. The character n specifies the 3 voltage levels for the Von and Vd as shown in the table 3 on page 3. For example, a 5-pin cable harness with part number E5B-2 means:

1. Pin assignment is E5B as shown in Table 1.
2. Von is 5V and Vd is 3.3V (Level 2 as shown in table 3).

The following figure shows the 3 types of LED driver input cables provided by Landmark



Please note that there is a small PCB (inside the black shrink tubing) that can provide the correct Von and Vd to operate the backlight. On the right side of the cable, the red wire is for the 12V connection and the black wire is for the ground.

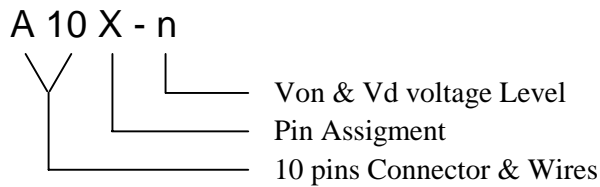
Also, please note that for E5C-n, the green wire at Pin #1 is cut off since this pin has no connection. For E5B-n, the white wire at Pin #5 is cut off for the same reason. With this arrangement, it is easy for the user to identify the cables among the part numbers E5A-n, E5B-n, and E5C-n.

Then with the value of n (1, 2, 3) on the cable part number, there will be very little chance to make a wrong connection and have the risk of damaging the LCD.

Caution: Before turning on the power to operate the backlight, it is necessary to compare the pin-assignment, the Von, and Vd levels provided by the cable with the LED driver specification on the LCD data sheet. Using a wrong cable may damage the LCD, in particular, if the 12V power is connected to the wrong pin.

6. The 10-pin LED Driver Input Cable Part Number

The 10-pin cable A10 is mainly used for CMI industrial LCDs. A similar part number A10X-n as shown below is used for this 10-pin LED driver input cable.



So far, there is only 1 pin assignment as shown in Table 2 on page 2. Also, for most of the CMI LCDs, both the Von and Vd voltage levels are at 3.3V. Thus, only one LED driver input cable, the A10A-3 is supplied.

The following figure shows this cable harness. Similar to the E5X-n cables, the small PCB supplies the 3.3V for Von and Vd.

A10A-3 LED driver input cable



7. The Other LED Driver Input Cables

Besides the A10 and E5 LED driver input cables, there are other connector/cables for some larger size industrial LCDs and the monitor LCDs. Among them, the 6-pin connector cable (E6X-n) is a popular one. The reason for using a 6-pin connector is due to the fact that the 12V current required to run the backlight in some larger size LCDs may be too high for just one pin to carry. Therefore, a 6-pin connector can provide 2 pins for the 12V and the Ground connections. The E6X-n cable will be introduced soon.

Besides the E6X-n cable, there are two 9-pin connectors are used for some LCDs. Also, a few LCDs have the LED driver input cable mixed together with the LVDS cable. For these special requirements, please contact Landmark Technology for more details.