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Application Note

Managing LVDS Interfaces

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INTRODUCTION

The popularity of LVDS interfaces continues to grow, underlining its value in Industrial Applications. LVDS offers several advantages and only a few drawbacks as a means of interfacing.

This Application Note will cover some LVDS basics, review these concerns and show some practical applications using Sharp displays.

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BASICS

LVDS stands for Low Voltage Differential Signalling, a form of signal transmission using two conductors carrying complementary signals. It differs from single-ended signalling in an important way: the two conductors carry the same, but opposite polarity, signals. The conductors are driven using a differential signal driver, with a complementary signal receiver on the other end. The result is a signal that is highly immune to noise and crosstalk. See Figure 1.

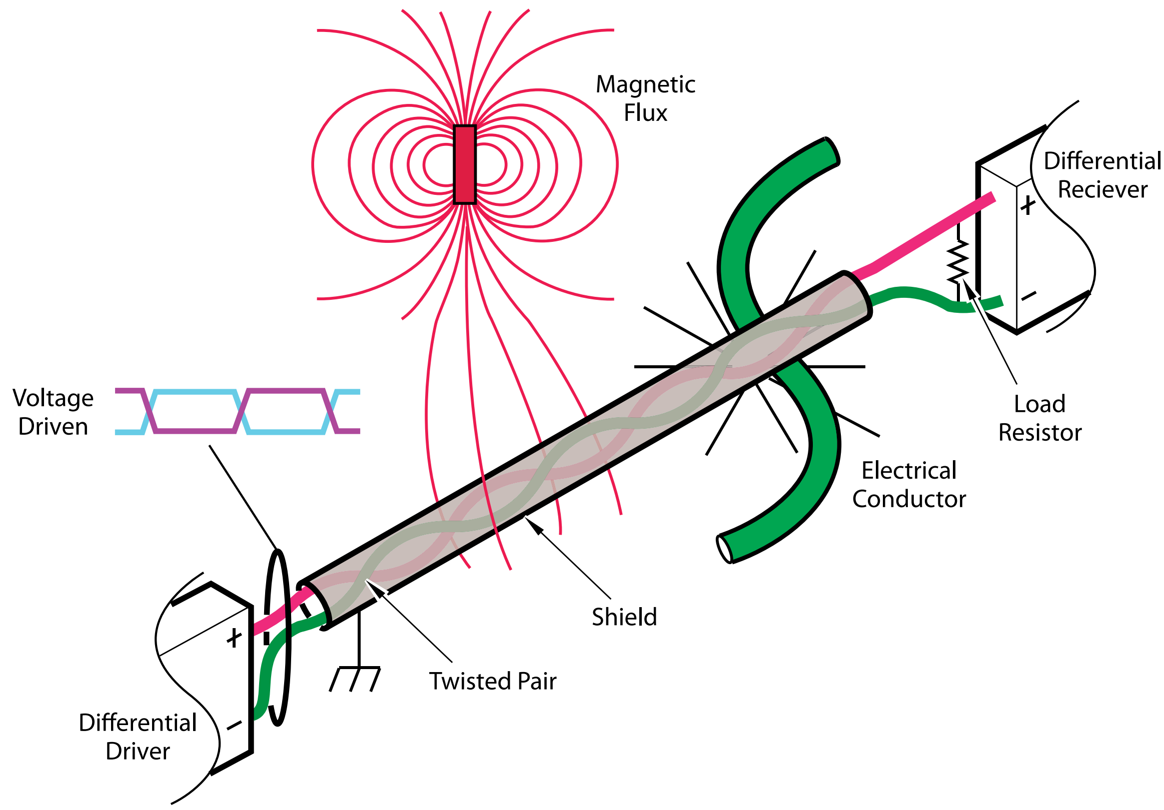

Figure 1. Differential Resistance to Noise

DIFFERENTIAL RESISTANCE TO NOISE

Differential signalling has been in use for many decades; the most common uses are in terrestrial telephony and professional audio applications. The ability to drive low-level signals for long distances with a minimum of noise and crosstalk is the main reason differential signalling is used. The other is that differential signalling uses very little net power. In all these applications, a constant-current drive feeds both the positive and negative sides of the differential pair. Because of the constant-current nature of the drive, signal transitions typically require minimum voltages. In the case of telephony, this drive is constant-current, typically at about 10 V, due to the typical distance being driven. For professional audio, the microphone is the source of the differential voltage, typically 1 V across 600 W in the receiver. The voltage swing from an LVDS transmitter for good symbol recognition in the receiver is typically about 350 mV. See Figure 2.

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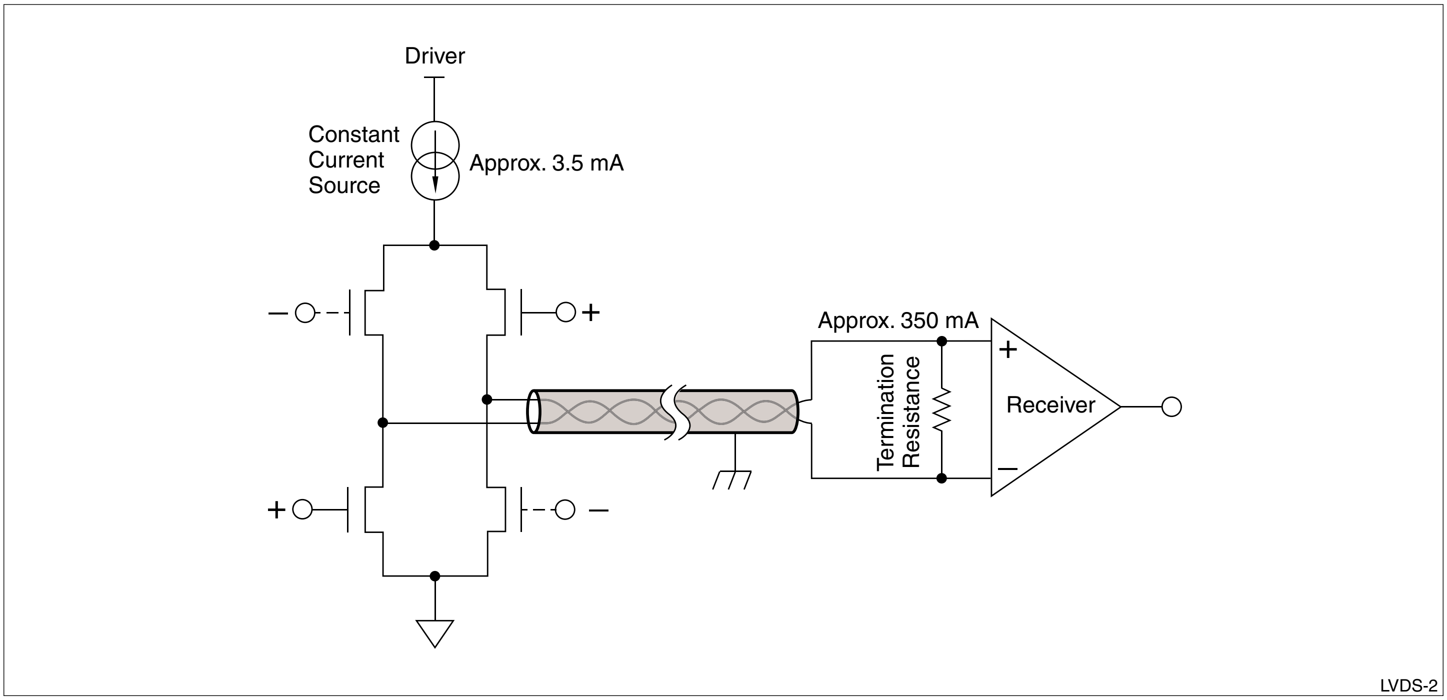

Figure 2. Constant-current Drive

CONSTANT-CURRENT DRIVE

Single-ended signals can only be driven a certain distance before they begin to pick up noise from their environment. (How far depends entirely upon the signal environment.) This method also requires a hefty power driver on the transmitter end to handle the maximum speed of all signal transitions. Furthermore, this transmitter has to have enough power output to create enough voltage swing on the receiving end for the circuitry to decipher the symbols being sent. Because the voltage at the receiver has to be driven through a far greater range than with LVDS (3 V or more versus 350 mV), the power requirements for single-ended operation can be much greater.

LVDS AND LCDs

As it applies to LCD-based signals, LVDS interfacing has several advantages: it is much less susceptible to electrical noise and therefore EMI, allowing the transmitting device to be located farther from the display, and LVDS generally consumes less power. Pin counts are lower and there are far fewer worries about signal skew with LVDS.

LVDS is not without disadvantages: It can be more expensive to implement on the transmitter side because it is more complex, requiring more board-based components.

However, from the receiver side, an LCD module with an LVDS interface often has no price difference.

NOISE RESISTANCE

LVDS is less susceptible to induced magnetic and electrical interference because it is a differential, or 'balanced' system. See Figure 1. Mirror-image voltages are driven through a twisted-pair (and shielded, if much distance is involved) cable. Because the cable contains a differential or balanced signal, all EMI or magnetically induced voltages appear across both conductors simultaneously. At the receiving end, these signals are common in mode with each other but reversed in phase; this makes the noise signals self-cancelling, leaving the original signal unchanged.

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DISTANCE

Because of the differential nature of the signal, LVDS signals can be driven much farther than simple parallel data. Commercial applications of this balanced signal arrangement can drive signals literally for any distance until I^2R losses overwhelm the signals.

POWER CONSUMPTION

LVDS consumes less power because it utilizes a small constant-current output source. It is always on, and the pairs of output FETs just switch from one set to another to generate ones and zeroes. Again, see Figure 2. Therefore the voltages also remain constant, and any switching transients tend to be self-cancelling. Generated EMI is minimized because the conducting twisted-pairs in the cable are carrying the same current but in opposite directions.

Functioning systems typically use pre-emphasis circuits to sharpen up the transitions for better symbol interpretation on the far end of the cable.

PIN COUNT

Much lower interface pin counts are also a trademark of LVDS, due to inherent signal multiplexing. Table 1 shows the pin count for LQ070Y3DG3B, a typical 24-bit digital panel. It features the same color depth as LQ150X1LG91, but the 15-inch panel has an LVDS interface. In this case, diagonal size of the module doesn't matter, as all other parameters are the same.

When looking at the list for the LQ150X1LG91, you begin to notice the large number of grounds. This is to insure low cross-talk within the connection cable and to help absorb stray noise in unshielded connection cables.

Table 1. Interface Comparison

PIN NUMBER	LQ070Y3DG3B INTERFACE		LQ150X1LG91 INTERFACE	
	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
1	GND		VCC	+3.3 V Power supply
2	GND		VCC	+3.3 V Power supply
3	VCC	+3.3 V Power Supply	GND	GND
4	VCC	+3.3 V Power Supply	GND	GND
5	R0	RED data signal (LSB)	RxIN0-	LVDS receiver signal CH0 (-)
6	R1	RED data signal	RxIN0+	LVDS receiver signal CH0 (+)
7	R2	RED data signal	GND	GND
8	R3	RED data signal	RxIN1-	LVDS receiver signal CH1 (-)
9	R4	RED data signal	RxIN1+	LVDS receiver signal CH1 (+)
10	R5	RED data signal	GND	GND
11	R6	RED data signal	RxIN2-	LVDS receiver signal CH2 (-)
12	R7	RED data signal (MSB)	RxIN2+	LVDS receiver signal CH2 (+)
13	G0	GREEN data signal (LSB)	GND	GND
14	G1	GREEN data signal	CK IN-	LVDS receiver signal CK (-)
15	G2	GREEN data signal	CK IN+	LVDS receiver signal CK (+)
16	G3	GREEN data signal	GND	GND
17	G4	GREEN data signal	RxIN3-	LVDS receiver signal CH3 (-)
18	G5	GREEN data signal	RxIN3+	LVDS receiver signal CH3 (+)
19	G6	GREEN data signal	RL/UD	Horizontal/Vertical display mode select
20	G7	GREEN data signal (MSB)	SEL_LVDS	LVDS Data Mode Select
21	B0	BLUE data signal (LSB)	—	—
22	B1	BLUE data signal	—	—
23	B2	BLUE data signal	—	—

Table 1. Interface Comparison, cont'd.

PIN NUMBER	LQ070Y3DG3B INTERFACE		LQ150X1LG91 INTERFACE	
	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
24	B3	BLUE data signal	—	—
25	B4	BLUE data signal	—	—
26	B4	BLUE data signal	—	—
27	B6	BLUE data signal	—	—
28	B7	BLUE data signal (MSB)	—	—
29	GND		—	—
30	DOTCLK	Dot-clock signal	—	—
31	NC		—	—
32	HSYNC	Line sync signal	—	—
33	VSYNC	Frame sync signal	—	—
34	DEN	Display enable signal	—	—
35	NC		—	—
36	NC		—	—
37	GND		—	—
38	GND		—	—
39	NC		—	—
40	NC		—	—

PUTTING LVDS TO WORK

Figure 3 presents a simplified block diagram of an LVDS interface implementation.

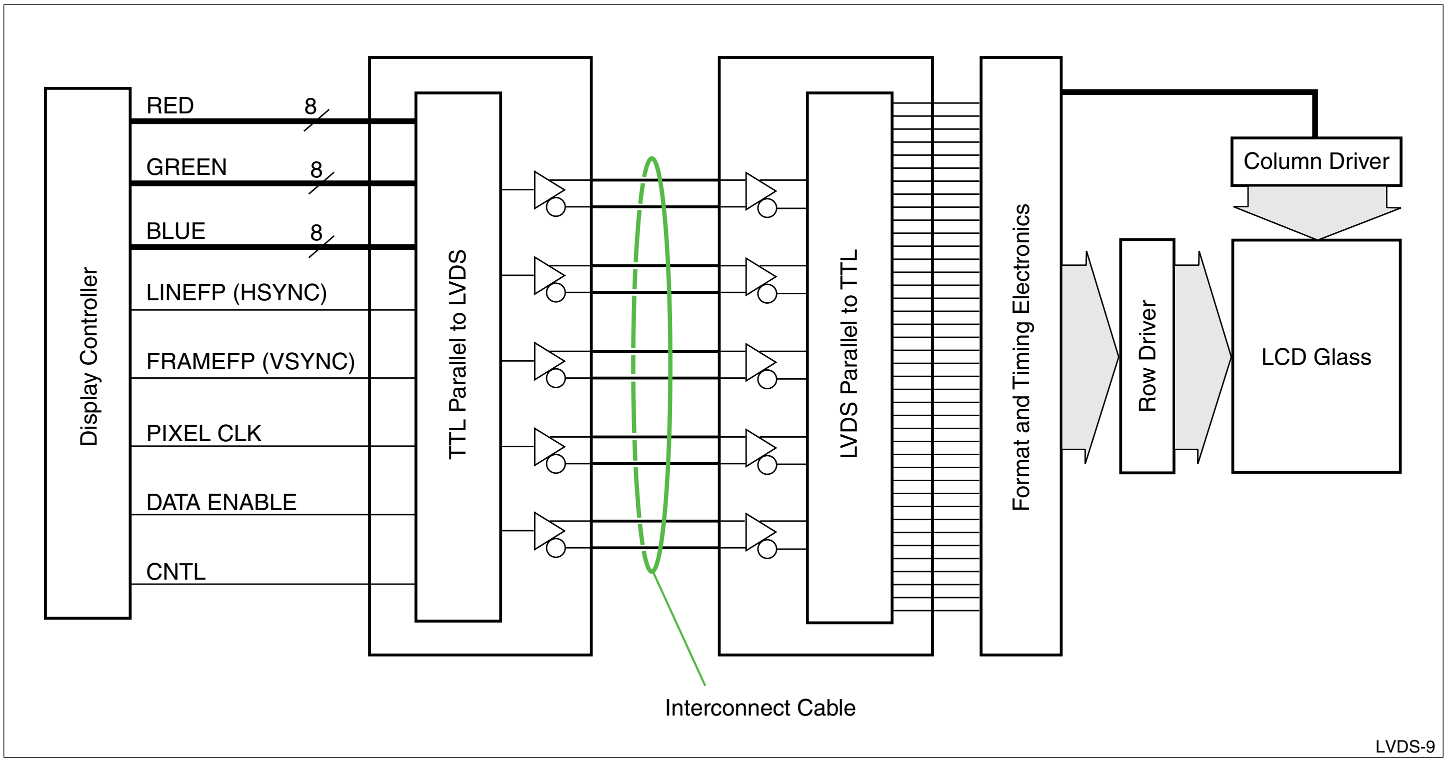

Figure 3. Simplified LVDS Implementation

The Display Controller outputs RGB pixel values in the normal manner, but instead of the signals being coupled directly to the LCD module, they pass through the LVDS interface where they are serialized, transmitted, then recieved and de-serialized in the module for distribution to the module's display system.

LVDS TRANSMITTER

Figure 4 presents a simplified LVDS transmitter; normally the transmitter is chosen to match the target LCD module's interface.

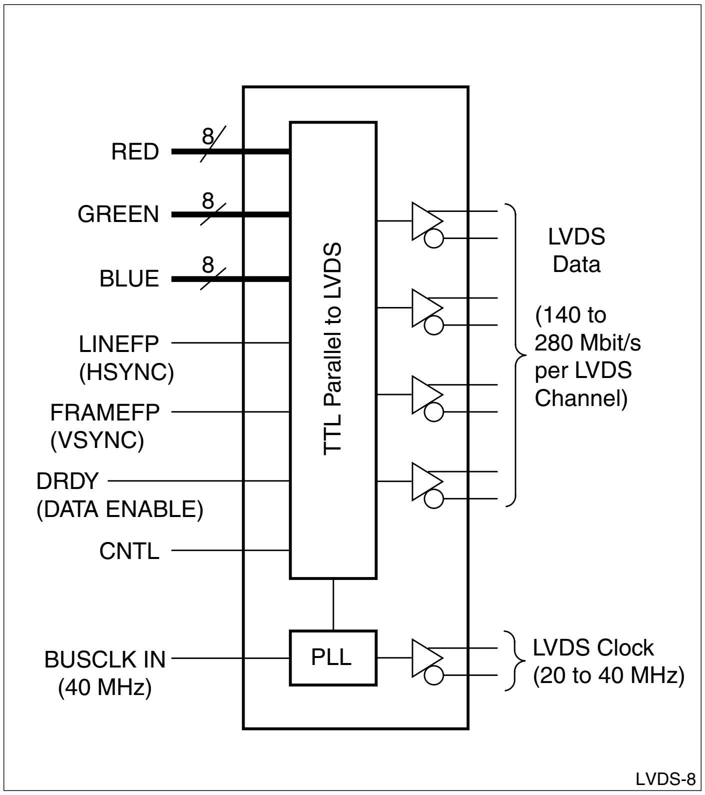

Figure 4. Simplified LVDS Transmitter

At the transmitter, panel data (24-bit, in this case) is presented by the graphics controller along with a clock to latch the pixel data.

The transmitter reformats the data into serial form, then drives the result onto its output lines. The serial data rate will be much higher than the parallel input rate, since we are now driving the serial representation of the input parallel data within the same period of time.

The transmitter is able to switch output states at a very high rate, as it is only switching the output of its constant current source and does not have to drive a voltage to a certain threshold.

Here again is where the advantage of a balanced transmission line comes into play. Because there is a high common-mode rejection of electrical noise, the transmitter does not have to overwhelm any induced voltages with its output.

Designers need to pay attention to the endian-ness of the data as it is being transmitted. As shown in the next paragraphs, some but not all LCD modules can accept MSB data on either the RxIN0 or RxIN3 inputs.

One other caution for designers is that some transmitters do not have specific data lines labeled as clearly as those in Figure 4. For instance, the THine TH63LVDM83R, the compatible transmitter for our example LQ150X1LG91, has a different labeling scheme; see Figure 5.

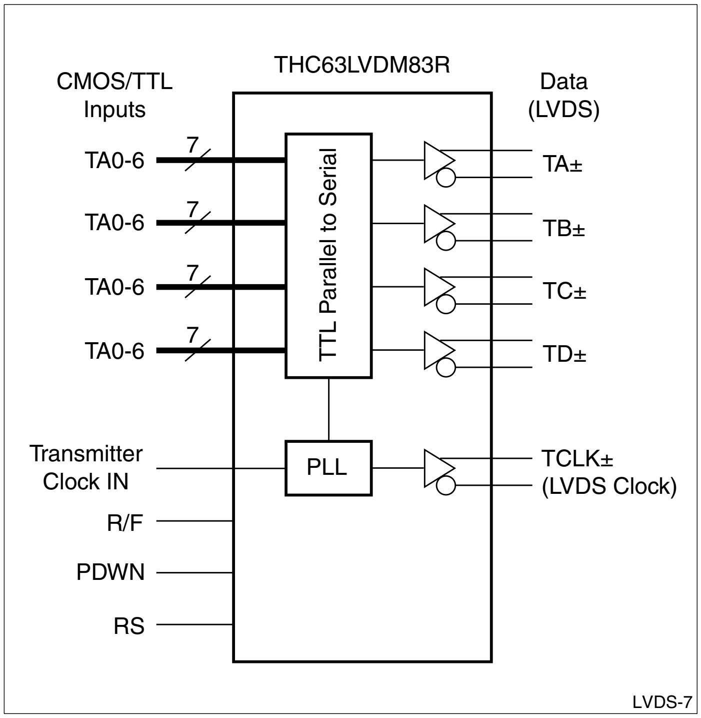

Figure 5. THine Electronics TH63LVDM83R

INTERFACE MODES

Most LCD modules using the LVDS interface use the Single Pixel mode and have a flexible interface structure - they can accept the most significant bits (MSBs) of the data on RxIN3 or RxIN0, with the default being RxIN3. The LQ150X1LG91 above is an example of this. Figure 6 and Figure 7 show how the module expects the MSBs to exist on RxIN0 (with SEL_LVDS LOW) or RxIN3 (with SEL_LVDS HIGH or floating).

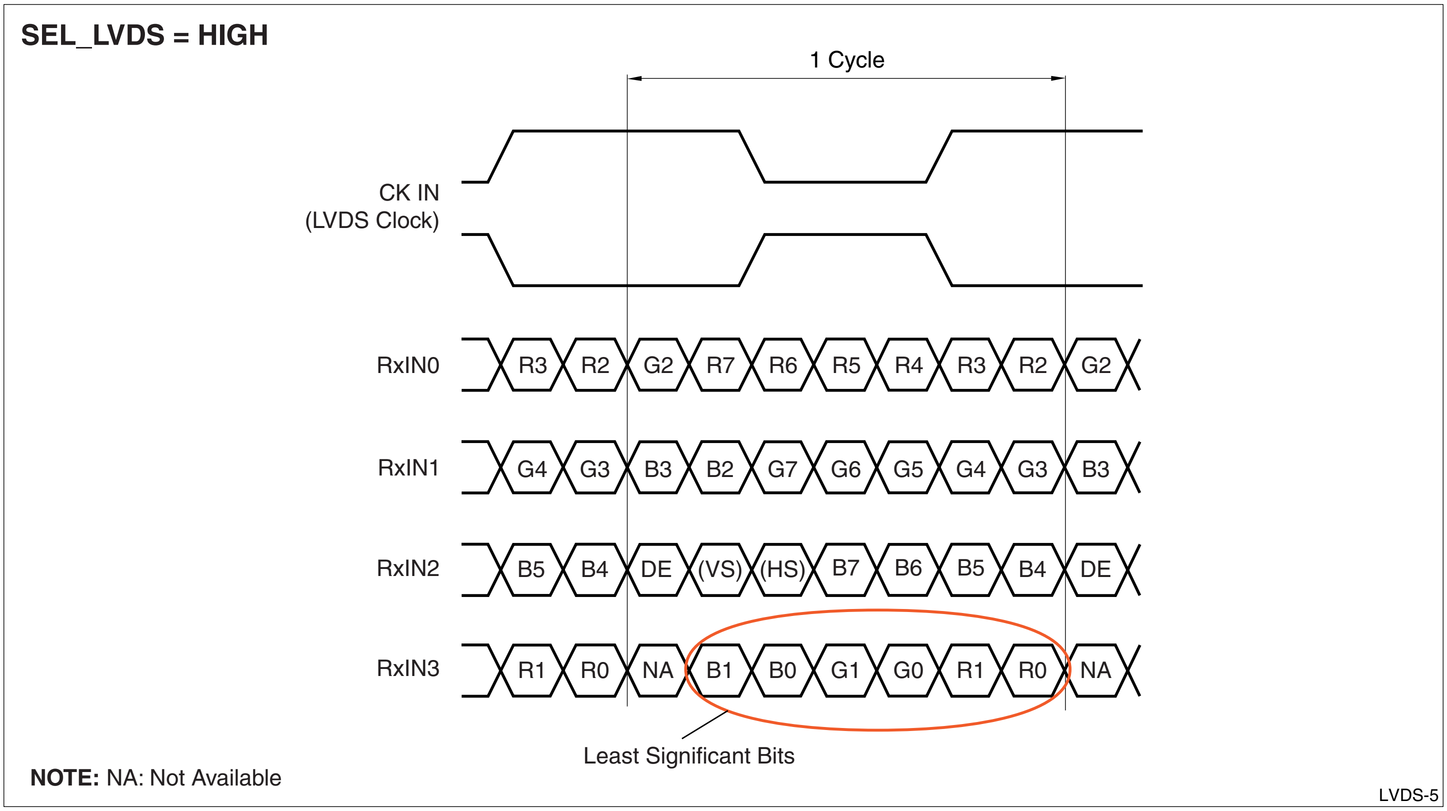

Figure 6. Most Significant Bits on RxIN3 (SEL_LVDS is HIGH or floating)

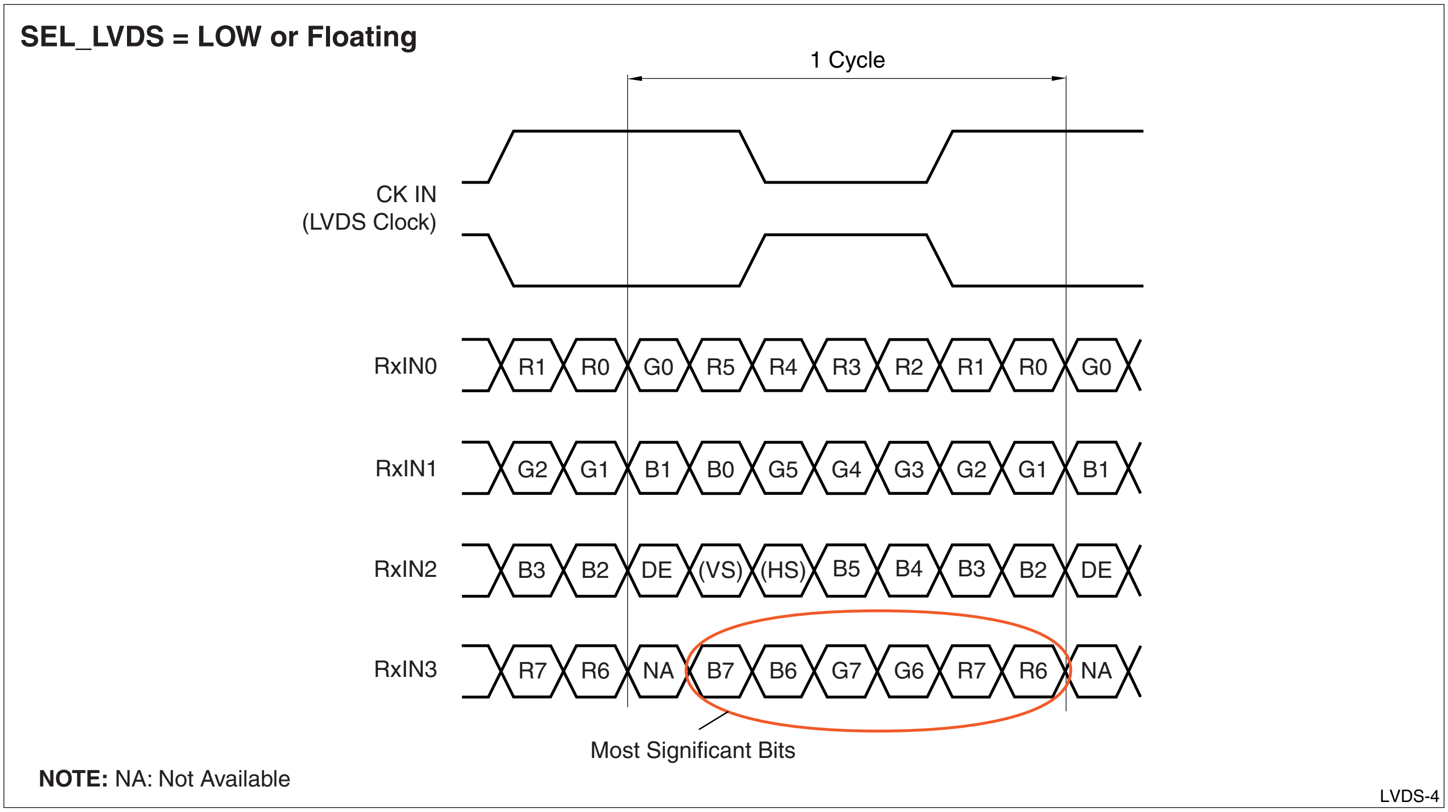

Figure 7. Most Significant Bits on RxIN0 (SEL_LVDS is LOW)

NOT ALL LVDS INTERFACES HAVE TWO MODES

Most, but not all, LVDS modules can accept MSB data on either RxIN0 or RxIN3 inputs. It's advisable to check the Specifications for your particular module before committing to a data structure.

For an example of this, let's check the LQ070Y3LG4A. At first glance, it appears that it can only accept MSB data on RxIN3. Table 2, which describes the interface connector, provides the first clue: there is no LVDS mode select (SEL_LVDS) pin in the list.

Table 2. LQ070Y3LG4A Interface

PIN NUMBER	SYMBOL	FUNCTION
1	GND	
2	VCC	+3.3 V Power Supply
3	VCC	+3.3 V Power Supply
4	NC	
5	NC	
6	NC	
7	NC	
8	RxIN0-	LVDS receiver signal CH0 (-)
9	RxIN0+	LVDS receiver signal CH0 (+)
10	GND	GND
11	RxIN1-	LVDS receiver signal CH1 (-)
12	RxIN1+	LVDS receiver signal CH1 (+)
13	GND	GND
14	RxIN2-	LVDS receiver signal CH2 (-)
15	RxIN2+	LVDS receiver signal CH2 (+)
16	GND	GND
17	CK IN-	LVDS receiver signal CK (-)
18	CK IN+	LVDS receiver signal CK (+)
19	GND	GND
20	RxIN3-	LVDS receiver signal CH3 (-)
21	RxIN3+	LVDS receiver signal CH3 (+)
22	GND	GND
23	NC	
24	LED_A	LED Backlight Anode Supply
25	LED_A	LED Backlight Anode Supply
26	LED_A	LED Backlight Anode Supply
27	LED_K1	LED Backlight Cathode Supply
28	NC	
29	LED_K2	LED Backlight Cathode Supply
30	LED_K3	LED Backlight Cathode Supply

The next step is to verify the module's data structure by checking for it in the Specifications. The LVDS Data diagram tells us what we need to know: See Figure 8.

Note how RxIN3 contains all the MSB information, while the other inputs contain sync and bits of lower significance.

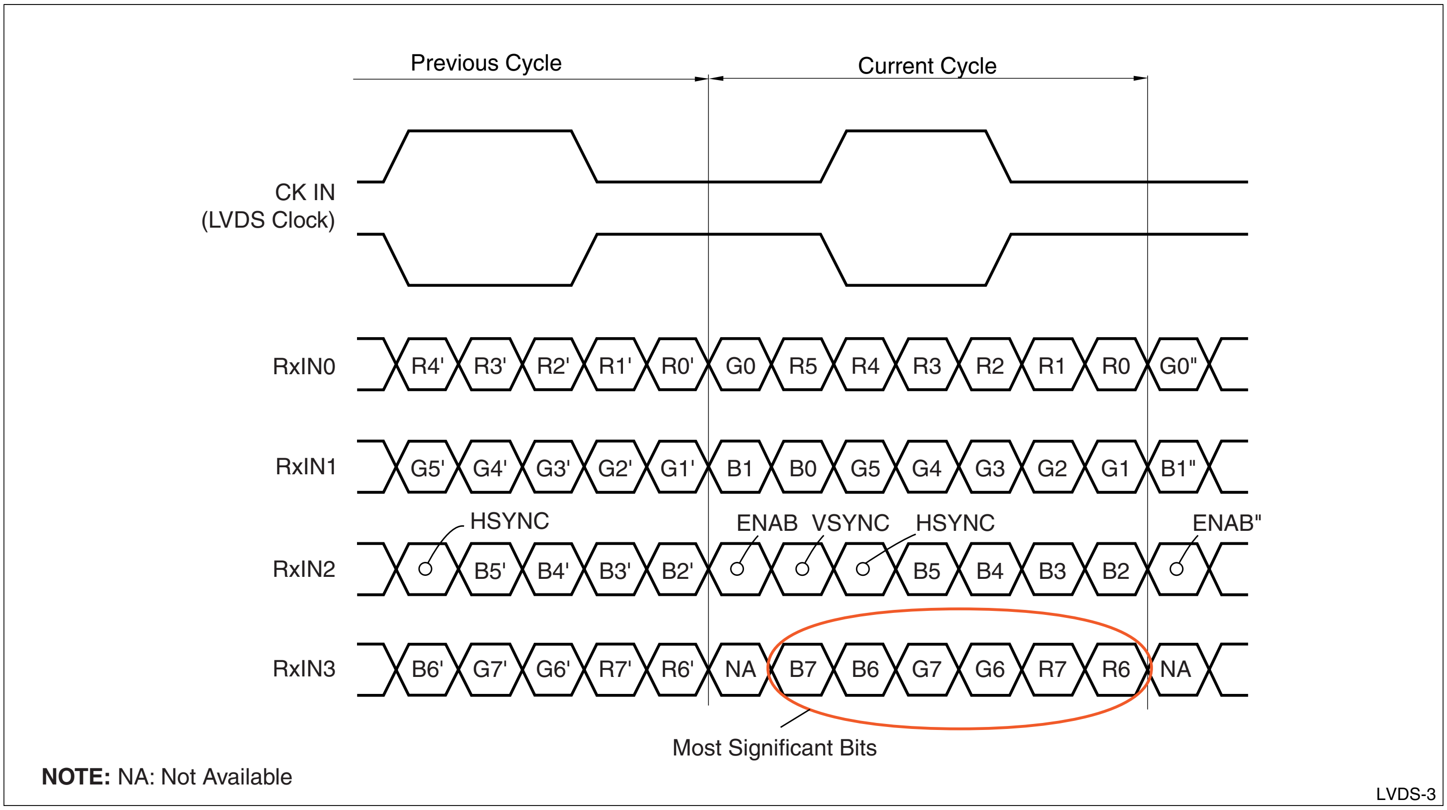

Figure 8. LQ070Y3LG4A LVDS Data Diagram

CONCLUSION

LVDS is increasingly a good fit for several reasons when designing a system requiring an LCD module; it is rel-atively immune to noise and the controller can be located some fair distance from the display. A bit more work is required in the design's display controller side, but generally there is no price penalty for an LVDS-based display.

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SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

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