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#### APPLICATION NOTE 4269

# Switching LVDS Graphics in a Laptop Computer

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*Abstract: Unlike desktop computers that have easily upgraded video graphics capabilities, laptops have historically been incapable of allowing such an upgrade. Ideally, laptop design would allow the graphics card to be an add-in feature. To permit this possibility, a simple solution would be to add a switch to the design that would select either internal graphics or the LVDS output of the add-in card. Because the MAX4889 can switch between two LVDS sources to a single destination, it is an ideal choice of switch for a laptop design.*

For many years, video graphics have been a feature that consumers could upgrade at will in desktop computers. Early IBM computers were configured with either an MGA (monochrome graphics adapter) or a CGA (color graphics adapter). The consumer could pick the same model computer, but choose either graphics card, depending on the monitor selected. These early adapters evolved to become the VGA (video graphics array) standard, which could drive either monochrome or color graphics with many colors or gray levels, respectively.

Video graphics have progressed so much that the GPU (graphics processor unit) has become one of the most sophisticated processors in the desktop computer. These processors have evolved into miniature complete systems with as much as 512MB of memory and very sophisticated floating-point processing, as well as multiple outputs to drive various monitors.

In recent years, laptops have surpassed desktop computers in unit volume sold. The cost of the laptops has dropped dramatically, and many consumers are viewing laptops as desktop replacements. A 17in laptop with a full size keyboard makes a very reasonable replacement for a desktop. With WiFi in the home, the consumer only needs to plug in the AC power to keep the unit charged, and all the wires, keyboard, mouse, and speakers are gone. However, high-end laptops are also being used by the gamer and the at-home/telecommuting professional, both of whom need a large screen and full-size keyboard.

Until 2007, nearly all laptop computers were built with internal graphics. The computer manufacturer built either a low-cost unit with built-in graphics, or a high-end machine with third-party graphics built onto the board. The inclusion of third-party graphics always made the cost of the system much higher. In 2004, NVIDIA® worked with industry-leading notebook manufacturers to create a consistent graphics interface, called MXM<sup>1</sup>, which would permit a manufacturer to create a notebook design that is compatible with any graphics solution from any vendor. This allows multiple configurations and upgradeability from a single system design, similar to what desktop computers have allowed for years.

**Figure 1** shows an actual MXM GPU with a row of standard MXM connectors on one edge. With a bit of switching, the notebook manufacturer can design one motherboard that contains built-in chipset vendor graphics and an MXM slot for upgrading to higher powered third-party graphics.



Figure 1. An MXM GPU, showing the standard MXM connector pins at the bottom edge.

Upgrading a notebook design to allow an add-in graphics module is a bit tougher than simply adding in more memory, as the cooling of the module must be addressed. However, the notebook manufacturer can reduce the number of different motherboards that need to be designed and inventoried. Thus, the particular graphics desired by the consumer can be addressed at the time of final assembly. In many cases, a retailer or distributor can add in the requested module just before the consumer receives the laptop, thereby reducing lag time and the possibility of losing a sale because the unit has the wrong graphic capabilities for the customer's needs.

When a consumer or vendor adds in a graphics card to a desktop computer, the consumer simply plugs in the monitor to the VGA or DVI connector on the card. In a notebook, the unit has an LCD screen to drive. Indeed, the built-in LCD screen is almost certainly the primary screen that the consumer will use. There would be little point in purchasing a high-end graphics card if that card were only for external graphics.

Notebook displays traditionally use a ribbon cable to receive data from the graphics card. The data in MXM applications is communicated in the form of four or eight pairs of LVDS signals, where the module input is a PCI Express® (PCIe®) interface with up to 16 lanes and the output includes VGA, TMDS® (for DVI™/HDMI™), DisplayPort™, and LVDS.

If a notebook manufacturer wants to have a design that uses internal graphics for the lowest cost model, but that can be upgraded to third-party graphics for a higher end model, then several sets of signals must be switched. This article only addresses the LVDS signals. Low-cost laptops use a single-link LVDS, whereas higher end systems use a dual-link LVDS. Data rates as high as 800Mbps per pair may be expected. LVDS signals are DC-coupled, so they do not have a problem with long-term DC balance. These signals have a DC component of ~1.25V with a swing of  $\pm 250\text{mV}_{\text{P-P}}$  (min). Receive sensitivity is  $100\text{mV}_{\text{P-P}}$ , thus permitting an 8dB loss between transmit and receive signals.

In order to switch the LVDS signal, the switch should insert no more than 1dB of total losses. In addition, the switch should be of low capacitance so as not to add reactive components that could cause reflections and mismatch. The MAX4889 PCIe passive switch fulfills these needs and is ideal for LVDS applications. When operating at +3.3V, it can easily handle the full LVDS signal range (0.67V to 1.8V) and has an input capacitance of < 2pF. Insertion loss is < 0.5dB for LVDS data rates  $\leq 800\text{Mbps}$ .

The MAX4889 switches four pairs of signals in a 2:1 application, which has two possible sources (internal graphics or MXM graphics) and one destination. For 18-bit graphics, only one MAX4889 is required; for 24-bit graphics, two MAX4889 switches must be used. The MAX4889 is then used to select between the two sources, either the internal graphics or MXM module—it tests for the presence of an MXM module and, if present, permits the MXM to be selected as a graphics source.

**Figure 2** shows the MAX4889 being used to switch four pairs of LVDS signals in a 24-bit graphics application. Although it is expected that an LVDS switch is used for the full set of upper and lower bits, the diagram shows only R, G, B (upper bits), and clock signals<sup>2</sup> for clarity. As this is a 24-bit graphics application, a second MAX4889 switch (not shown) would be used to handle the lower bits.

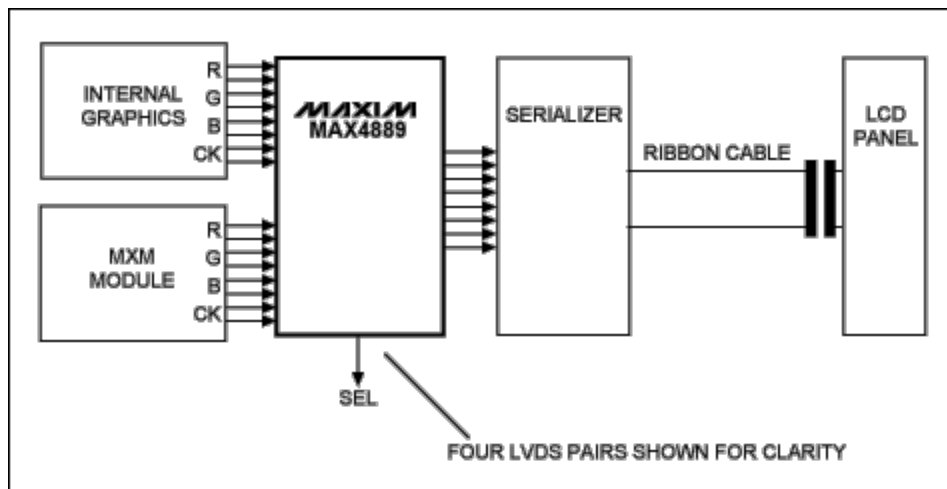


Figure 2. The MAX4889 switches four LVDS signal pairs in a 24-bit graphics application. Note that only the upper bits and clock are shown; a second MAX4889 would handle the lower bits.

## Conclusion

MXM permits notebook manufacturers to build one motherboard that can use internal graphics for lowest cost, or permit the use of an add-in MXM GPU for improved graphics and to satisfy consumer demand. In order to permit both the MXM module and the internal graphics to address the laptop's LCD panel, some form of switching must be performed. The ideal switch is electrical, so that either the system can simply sense the presence of the MXM module, or the user manually can select internal or MXM graphics. In either case, the switching is done with a semiconductor switch for reliability and minimum size/power requirements. The MAX4889 is an ideal switch for such LVDS purposes. When operated from 3.3V, it easily handles LVDS signal levels up to 800Mbps, draws  $\leq 120\mu\text{A}$  under any operating conditions, inserts  $< 0.5\text{dB}$  loss, and has  $< 2\text{pF}$  capacitance.

## References

1. MXM: Mobile PCI Express Module. This is a consistent interface for mobile PCI Express graphics. Details on MXM can be found on the [MXM Graphics Module website](#).
2. Open LDI: Open LVDS display interface, May 13, 1999. The Open LDI standard describes the following signals: two red, two green, two blue, and a pixel clock.

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