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Fairchild Semiconductor
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LVDS Technology Solves Typical EMI Problems Associated with Cell Phone Cameras and Displays

Differential technologies such as Low Voltage Differential Signaling (LVDS) will be explained and compared to legacy single ended LVTTL. Through specific application examples, this article demonstrates the improved spectral content and advantages offered by LVDS technology.

Today's Cell Phones

Today's cell phones, that are becoming continuously smaller and lighter, have an increasing possibility to adversely affect surrounding devices. This is because of the increased shear number and opportunity for close proximity to other ultra-portable electronic devices. Twenty years ago, a cell phone would not be in close proximity to an implanted defibrillator. Today it can be a common occurrence.

Typical EMI Problems

EMI (Electromagnetic Interference) problems with cell phones usually fall into one of three categories:

1. Blatant EMI radiation that exceeds regulatory emissions limits during product qualification (FCC, and ETS/EN testing, etc.).
2. EMI that although meets regulatory requirements, continues to adversely affect devices in close proximity.
3. EMI that adversely affects the cell phone itself through harmonics and other spurious signals.

Products on the Edge

Cell phones, although usually designed by a single supplier, can be marketed in many countries. Unfortunately, regulatory requirements vary from country to country, and often one country does not recognize the standards or test results of another country. For example, a cell phone must undergo EMI testing for the requirements of each respective country. A device that "squeaks by" regulatory testing in one country, may barely fail in another country. Commonly, the same product design may be marketed under separate model numbers to reflect the different EMI testing, and can include minor circuit changes to allow regulatory compliance for a specific locale.

Harmonics and Why They are Bad in Cell Phone Applications

Harmonics are exact multiples of a fundamental frequency. As an example, a square wave clock operating at 100MHz in a cell phone can have visible harmonics on a spectrum analyzer at 300MHz, 500MHz, and 700MHz. Additional peaks are often seen with the spectrum analyzer but may represent additional spurious signals as a result of a local parasitic oscillation or signal reflection. Unfortunately, in this example of a 100MHz clock in a cell phone, a harmonic may exist at 700MHz and at 900MHz. According to the FCC Frequency Allocation Table dated April 13, 2004, 900MHz is the frequency utilized by fixed land mobile stations and 700MHz is allocated to fixed mobile broadcasting. In this case, a cell phone with a noisy clock will likely interfere with these mobile stations and nothing else.

The realistic application of this cell phone clock may not be a perfect 100MHz. It may be off slightly, say 97MHz. In this case, the 9^{th} harmonic winds up at 873MHz. The FCC frequency allocation table identifies 873MHz as nearly the middle of the cell phone frequency band. This means that the clock frequency of this cell phone can dramatically reduce the sensitivity of the cell phone receiver itself, potentially rendering it inoperative.

LVDS Technology

LVDS technology is a comparatively new technology that is rapidly replacing legacy TTL or LVTTL technologies. LVDS is a standards-based technology that utilizes two conductor paths rather than one as with TTL or LVTTL. At first glance, it may seem inefficient to utilize two conductors rather than one, however this two conductor system has the distinct advantage of operating at much higher speeds than its predecessor. It should be noted that with either TTL or LVTTL, a second conductor exists that is actually the power ground. The architecture of the LVDS technology is such that the two wires will utilize opposing polarities that will change at the same time based on a change with the data input. This means that the two wires (or other medium such as flex circuit wires, twisted pair of wires, etc.) will have opposing currents during the polarity change. The opposing currents in effect cancel each other so that the net current change is comparatively quite small. It is this advantage, combined with the fact that the voltage swing is typically 350mV, rather than 3.3V or 5.0V with TTL, that results in significantly reduced overall current change, ultimately resulting in less EMI.

Compare and Contrast Typical Application Emissions with LVTTL to LVDS

As a means of directly comparing technologies, a test was designed to compare only the interface technologies. The remaining parameters, equipment, and test environment remain the same. In this case the parameters were a single bit, 100MHz, repetitive square wave, and the transmission medium was a 10cm flex circuit. 10cm represents a typical length found in many cell phones available today. Identical circuit boards were fabricated with the exception being 1 set utilized LVDS devices and the second set utilized LVTTL devices. Figure 1 shows the test set-up.

Compare and Contrast Typical Application Emissions with LVTTL to

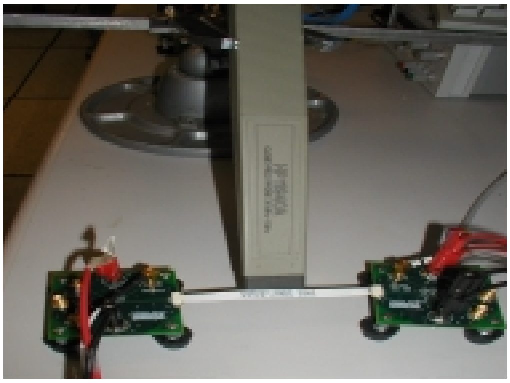


FIGURE 1. Test Set-up

FIGURE 2.

Measurement Technique

Classical emissions testing involve a Faraday cage with a spectrum analyzer with antenna sets for a given band. This method is highly effective for far field highly sensitive measurements wherein the circuit boards, cable lengths, and over all product design can have a dramatic impact resulting in a very specific EMI signature for a given product. This means that two circuit boards may be well behaved with an interconnect flex cable of 1/2 meter, but a full meter cable represents an entirely lower 1/4 wavelength resonance point.

A measurement technique that lends itself to the EMI comparison of only different interface technologies where conducted emissions testing are not appropriate, is one called near field EMI testing (Figure 2). Near field testing involves placing a calibrated "probe" in close proximity to the transmission medium. This probe, in actuality, is a very small dipole antenna with a 50Ω feed point that can be directly interfaced to a spectrum analyzer. This near field probe can be used to measure radiated currents that represent actual radiation, and can be moved to "sniff" out specific radiation nodes. The near field probe is based on Faraday's induction law, wherein the output voltage of a single turn loop is proportional to the time rate of change of the total magnetic flux passing through the loop. A picture of a typical near field probe is shown in Figure 2.

Measurements

The spectral content was measured in several different bands chosen to adequately present magnitudes of harmonics, and not "chop off" any important peaks due to the bandwidth of the test equipment. It is important to note that when the spectrum width becomes relatively, large, the gain becomes offset by a magnitude of 10 on the 95 - 305 and 100 - 1000MHz bands. The spectral content was displayed in three different bands to provide a clear illustration of the technology differences.

- Appendix 1: LVDS to LVTTL comparison at the fundamental frequency of 100MHz
- Appendix 2: LVDS to LVTTL comparison from 95MHz to 305MHz
- LVDS to LVTTL comparison from 100MHz to 1000MHz

The spectrum analysis shown in the appendices can be summarized into Figure 3. At the fundamental frequency, the emission can be more than –30dB than with LVDS than with LVTTL. This overall trend continues, but diminishes as the harmonics approach the noise floor of the measurement equipment.

Measurements (Continued)

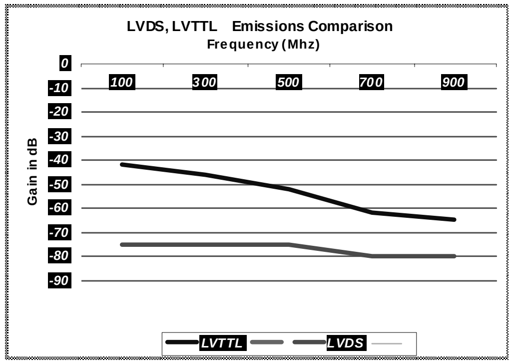


FIGURE 3.

Direct Benefits to Product Design

There are several benefits of utilizing lower emissions components from the inception of a circuit design. Unfortunately, this is often not recognized until after several iterations of product design.

1. Lower Component Cost: Very often and in order to survive stringent regulatory requirements, many components may be added to quell the adverse effects of EMI. These components can include ferrite beads/disks, capacitors, common mode chokes, and even additional circuit board ground planes. Using LVDS type technologies can often reduce the number of; if not completely eliminate these components.
2. Shorter Product Design Cycles: The time to mitigate the adverse effects can be substantial. Engineering, technician, and lab resources can easily be tied up for months.

Additional benefits exist that are beyond the scope of this paper. However, the designer is encouraged to look at parameters such as power consumption and ESD that can afford additional improvements within cell phones.

Examples of LVDS in Cell Phones

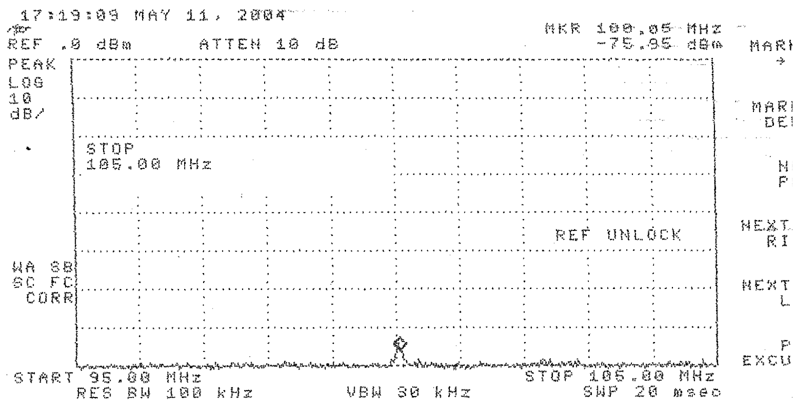
- Data from baseband to display
- Control signals from baseband to display
- Camera pixel clock and data from flip to baseband

Summary

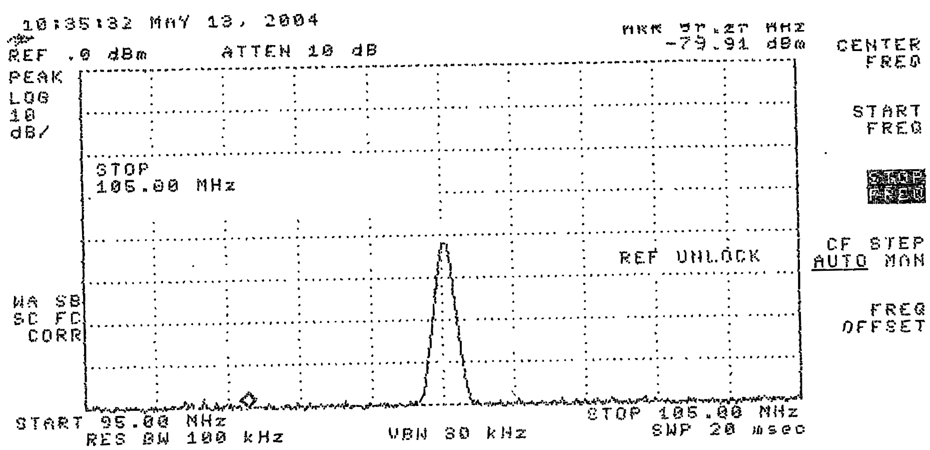
Using LVDS technology devices in cell phones makes good sense with the primary benefits:

1. There is an incremental product performance improvement. LVDS standards based interface devices, are designed and characterized to provide excellent signal integrity well into the 500MB/S data rates and beyond.
2. Due to the improved EMI characteristics of LVDS over single ended LVTTL technologies, overall product cost can be reduced. Because fewer problems are left to solve to meet regulatory standards, a product can pass a qualification more quickly and the time to market can be shorter.
3. Because there have been fewer problems to solve to pass qualification, fewer associated EMI attenuation components (ferrites, capacitors, etc.) are required to achieve acceptable regulatory emissions standards. This means a smaller overall component count per product.

Appendix 1

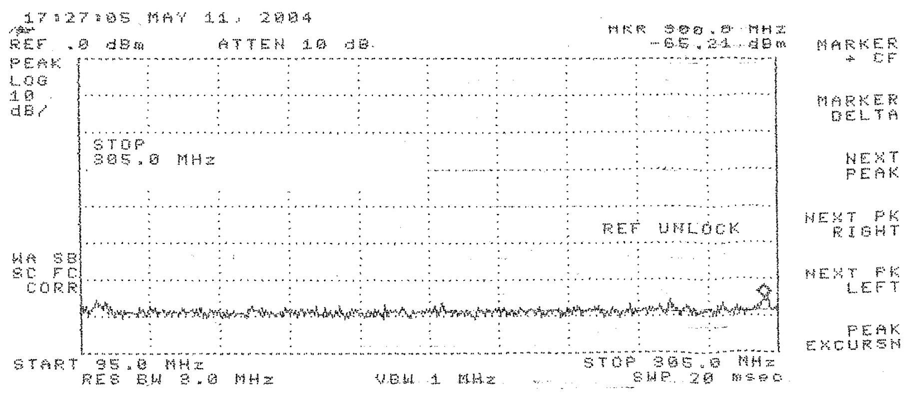


LVDS Spectrum Analysis 95MHz to 105 MHz

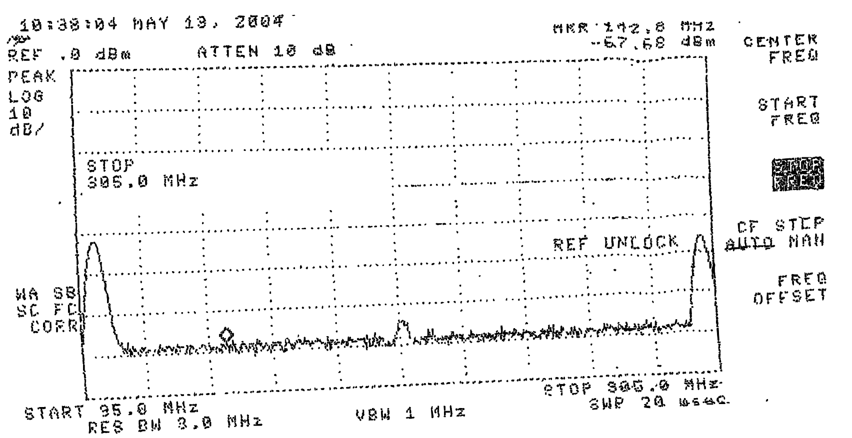


TTL Spectrum Analysis 95MHz to 105MHz

Appendix 2

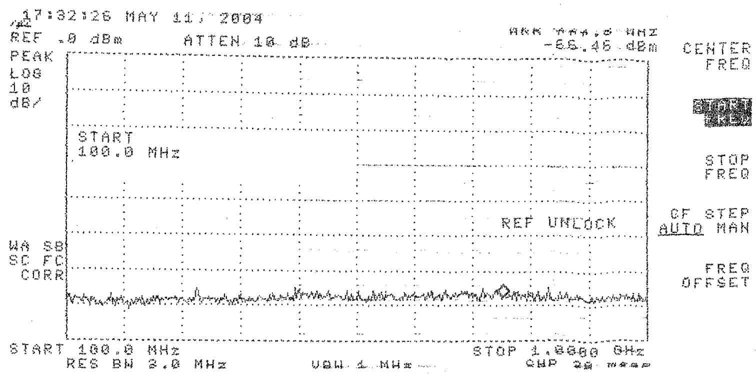


LVDS Spectrum Analysis 95MHz to 305MHz

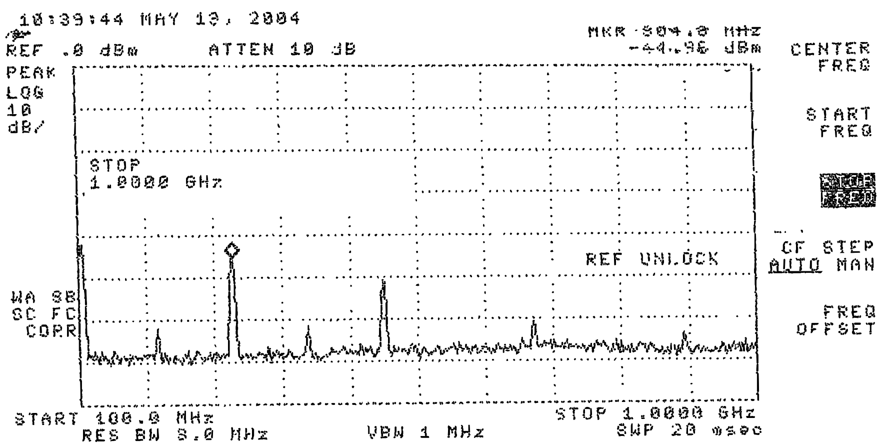


TTL Spectrum Analysis 95MHz to 305MHz

Appendix 3



LVDS Spectrum Analysis 100MHz to 1000MHz



TTL Spectrum Analysis 100MHz to 1000MHz

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