Interview with
Pierre-Yves Lesaicherre
CEO of Philips Lumileds

Philips Lumileds
LIGHT UP LIFE
with Color-Rich LEDs

Banana Pi, The New Age of Single-Board Computers

How to GaN: Simplifying Design & Increasing Efficiency
Why You Should Measure Jitter
doesn’t arrive at its destination when it should, an element of achieving first-pass design success. Thus, analyzing jitter is a key aspect of the design and implementation to transmit data with as few bit errors as possible. Therefore, understanding and mitigating jitter sources and measuring them is crucial for the success of serial-data channels.

Figure 1: Designing a serial-data channel with first-pass success means analysis and mitigation of jitter sources. A typical channel consists of multiple structures, including elements such as microstrip lines, vias, connector, decoupling capacitors, and board or chip interfaces. These components can introduce potential sources of jitter.

There is a proper, or expected, time for a signal to pull into the station, so to speak, and when it fails to do that, well, that’s no way to run a railroad (or a serial link). Wrong edge timing begets incorrect control. That can’t be right. What about the gain of the system is close to 0dB for frequencies below the crossover. Phase Margin (degrees)

A More Complex Example

Consider an arbitrary second-order system with a couple of poles. This is equivalent to a series RLC circuit with us observing the capacitor voltage. I've ignored phase margin so far, but to understand what phase margin is, we will return to it in more detail a little later in the series.

A very common example where we use this behavior is an open-loop gain of the system, the closer the closed-loop gain is to 0dB. This brushes upon the basic concept of a simple proportional controller, we simply feed the output back to the negative input almost precisely (remember that the closed-loop gain will become 0dB) until it get close to the crossover frequency.

Crossing or zero. The vertical cursor at the latch (strobe) level or zero. The vertical cursor at the latch (strobe) time. In Figure 3, the yellow trace represents a clock signal while the blue trace represents a data edge. As we can see, the data signal’s crossing is late relative to the clock, and that rings up as a bit error.

Unfortunately, one crosses the detection level too late, while the other simply fails to cross at the detection level at the same time as the clock. As we can almost see people thinking, 'I knew it! Here comes the edge!' That can’t be right. What about the detection level at the same time as the clock, and that rings up as a bit error.

Figure 2: Here we see two signals latched as low or zero. The vertical cursor at the latch (strobe) is quite costly.

The difference between the measured time of detection and the expected time of detection is called Time-Interval Error (TIE). In Figure 3, the yellow trace represents a clock signal while the blue trace represents a data edge. As we can see, the data signal’s crossing is late relative to the clock, and that rings up as a bit error.

Back to Basics: Why You Should Measure Jitter

Analyze jitter for first-pass design success.
AVAGO TECHNOLOGIES’ ACFP R4X25PL Series ROSA is a 4x25Gb/s, 1310nm LAN WDM receive optical subassembly, containing an optical de-multiplexer, to separate the four incoming wavelengths, four high reliability, high performance PIN photodiodes, and a quad transimpedance amplifier (TIA). These are packaged in an hermetic, planar package with an LC receptacle. The electrical interface is via two flex circuits. The ROSA is intended for use in CFP, CFP2 and CFP4 modules hermetic, planar package with an LC receptacle. The electrical interface is via two flex circuits. The ROSA is intended for use in CFP, CFP2 and CFP4 modules.

Collaborative PCB Design Tool

Altium presents its PCB Design and Editor Tool that features real-time collaboration between the users. With this tool, differences between different versions of the same board are seen, thereby enables easier tracking of all the modifications made on a single design. The tool also has Compare and Merge Features that enables a designer to identify, change and remove the implementations he or she has incorporated on the board.

600 W Single Output Power Supply

The PSP600-24 is a 600 W single output enclosed power supply that has an input voltage range of 90 – 264 Vac. It is capable of producing an output of 24 V, current output of 25 A and power output of 600 W. With an efficiency of 0.86, the device also comes up with a DC voltage adjust function and power factor correction. For safety purposes, the product includes an over temperature, over current and over voltage protection.

4x25Gb/s ROSA for 100 Gigabit Ethernet

Avago Technologies’ ACFP R4X25PL Series ROSA is a 4x25Gb/s, 1310nm LAN WDM receive optical subassembly, containing an optical de-multiplexer, to separate the four incoming wavelengths, four high reliability, high performance PIN photodiodes, and a quad transimpedance amplifier (TIA). These are packaged in an hermetic, planar package with an LC receptacle. The electrical interface is via two flex circuits. The ROSA is intended for use in CFP, CFP2 and CFP4 modules serving links at 4 × 25.78125 Gb/s, per 100GBASE-LR4...

SoundClear Technology

SoundClear Technology of Cirrus Logic is a technology that offers different features for voice, audio playback (stereo headphone and speaker modes) as well as speech. It offers unique advantage for applications such as in smartphones and tablets and as well as wireless speakers. Cirrus Logic recognizes the importance of elevating the sound clarity of the consumer mobile audio experience. SoundClear products are designed to be flexible and robust to improve voice quality and speech recognition performance by eliminating noise through advanced processing features including noise reduction, ASR Enhanced™ and echo cancellation....

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High Temperature Power Inductors

The MSS1038T Series are high temperature power inductors designed for high ambient temperatures. It is magnetically shielded with low DC resistance for greater efficiency. Its core material is made up of ferrite with RoHS compliant matte tin over nickel over copper terminations....

New SPM® Smart Power Modules

The total energy consumption of the society today is drastically increasing compared to the usage of the past generations. However, the use of appliances especially air conditioners, no matter how great is consumes electricity, is inevitable especially for offices and business establishments. This leads to seeking for possible solutions to maximize efficiency of existing commonly-used appliances. Fairchild Semiconductor answers to this call for innovations towards maximized efficiency and power management solutions....

Advanced 6-Phase Green PWM Controller

Intel® Corporation introduces its first digitally programmable multiphase Intel® VR12/12.5 compliant controller designed for server and high-end desktop applications. The ISL6388 is an advanced Linear Enhanced Active Pulse Positioning (EAPP) digital six-phase pulse-width modulation (PWM) controller with non-volatile memory (NVM) and auto phase shedding. The ISL6388 features multiple time programmable NVM that allows for the creation of custom configurations during the design process, eliminating the need for a soldering iron to make adjustments....

PCI Peripheral Core

The PCI Peripheral Core is PCI V2.1 compliant with 32/64-bit PCI and application datapath. It features fast back-to-back master cycles and full bandwidth burst support. The PCI Synthesizable Core is a part of the Fujitsu IPware Library. The Fujitsu PCI cores are RTL synthesizable modules that provide an interface between an application and the PCI bus. All PCI protocol and timing requirements are handled by the core, which is controlled through a simple application interface....

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Single Board Computing Solutions

Digi-Key Corporation announced its global distribution agreement with ARBOR Technology, a manufacturer of single-board computers. ARBOR Technology is an official name in the field of Single Board Computing (SBC), offering embedded and networking experience over ten years. The company takes great care in design methodology for wide temperature range design, from component selection, through schematic and layout, to verification and production testing....

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**Multifunction Telecom Switch**

The TS120 is a multifunction telecommunication switch integrated circuit low drive power requirements and an FCC and VDE compatible. It has no moving parts and does not generate EMI/RFI interference. The TS120 integrated circuit device combines a 350 V normally open (1-Form-A) relay with a Darlington transistor optocoupler in a single package. The relay uses optically coupled MOSFET technology to provide a 3750 Vrms of input to output isolation. [Read More]

**Toughened Two Part Epoxy System**

The EP21FL is a polymer system from Master Bond that has low viscosity and flexibile for high performance bonding, coating, sealing and encapsulating. It is a two part component epoxy system capable of withstanding extreme thermal cycling and cures at room temperature or more rapidly at elevated temperature, having a four to one mix ratio by weight. This compound is 100% reactive and does not contain any solvents or volatiles. It bonds well to a variety of substrates, including metals, glass, ceramics and many plastics. Since it is a toughened system, it is ideal for bonding dissimilar substrates with differing coefficients of expansion. [Read More]

**Low Cost RF Up/Downconverter**

The MAX2410 is a Maxim Integrated low-cost RF up/downconverter with low-noise amplifier (LNA) and power-amplifier (PA) driver that requires a voltage supply range of as low as 2.7 V to 5.5 V. The MAX2410 has been characterized at 1.9 GHz for use in PCS band applications; however, it operates over a much wider frequency range... [Read More]

**InfraRed Thermometer for Non-contact**

The MLX90614 is digital, plug and play, infrared thermometer that is small in size and low cost. It is easy to migrate and features high accuracy and medical accuracy benefits. It is factory calibrated and offers different package options for different applications. The MLX90614 is a non-contact infrared thermometer for non contact temperature measurements. It is integrated into the MLX90614 are low noise amplifier, 17-bit ADC and powerful DSP unit to achieve high accuracy and resolution of the thermometer... [Read More]

**Power Factor Corrected AC/DC Power Supplies**

The MPU-800SE is a series of Single Output 800 W Power Factor Corrected AC/DC Power Supply that features a built-in internal fan. The series includes three models, the MPU-800S-12yEI, MPU-800S-24yEI and MPU-800S-48yEI, all three now available on market. The series has to meet a universal input type voltage range of 90-264 VAC and an input frequency of 47-63 Hz. These models have an output regulation of ±0.5% and all of these features a power factor correction that meets the C1000-3-2 Class D standard... [Read More]

**Bluetooth Low E Wireless Network Processor**

The new Bluetooth low energy, wireless network processor is an embedded blue- tooth with low energy stack operating at a supply voltage of 2.0 to 3.6 V. It has an integrated linear regulator and an excellent RF link budget (up to 96 dB). The new STMicroelectronics BlueNRG Bluetooth Low Energy Wireless Network Processor, available from Mouser Electronics, is a single-chip processor and Bluetooth 4.0 RF transceiver. The entire Bluetooth low energy stack runs on the embedded Cortex-M0 core... [Read More]

**10-Amp SIP Mount DC/DC Converters**

This comprehensive Okami DC/DC power converter offers designers a 10A module in surface mount format. The use of common, industry-standard pinouts across the range helps simplify inclusion of the device in both existing and new designs. The OKR-T/10 series of converters is available in SIP package type. The converters are tested and specified for input reflected ripple current and output noise using designated external input/output components, circuits and layout... [Read More]

**Dual Double-Pole Double-Throw Switch**

The NXS3V899 is a dual-pole double-throw (DPDT) analog data switch with dual channel intended for use as an analog or digital multiplexer/demultiplexer. This device has a wide supply voltage range from 1.4 V to 4.5 V. It also features a very low On resistance, break-before-make switching and high noise immunity. It has low power consumption and its latch up performance exceeds 100 mA per JESD 78B Class II Level A. It consists of four switches, each with two independent input/outputs (nY0 and nY1) and a common input/output (nJ)... [Read More]

**Dual AIGS modem with Processor**

The ASC312HV is an integrated device combining two NXP’s programmable DSP based AIGS modem with a powerful 94 MHz ARM Cortex™ M5 processor with embedded flash program memory. The device is ideally suited for tower mounted amplifiers, antennas with remote electrical tilt control, adjustable filters/combiners or any other device in the base station tower with AIGS control or the need for multiple AIGS transceivers. The combination of functions represents a highly optimized and cost-effective solution for any tower mounted device requiring multiple AIGS transceivers and a CPU... [Read More]
Plug-and-Play Driver for 1700V IGBTs

The 2SB315B is a plug-and-play driver with 2 channels in a single module designed for IGBTs up to 1700 V. This driver is based on CONCEPT’s SCALE-1 technology for reliable driving and safe operation of IGBTs. The 2SB315B features Vce-monitoring for short circuit protection, operation inhibit after fault, and supply undervoltage shutdown...

Open Frame AC-DC Power Supply

The ABC Series developed by Power-one is a family of open-frame power supplies that have a wide universal input range of 90-264 VAC and high power density. Depending on the model chosen, 40 W to 450 W of output power and a variety of single and multiple output voltages is achievable. The ABC450 under the same series, offers six (6) models now available on the market. The models have a universal input voltage range of 120-390 VDC and an input frequency of 47-63 Hz. ...

Precision Timer Integrated Circuit

The HA17555 Series are precision timers featuring mono multivibrator and astable-multivibrator. It has delay time and pulse duty that can be controlled. HA17555 Series are ICs designed for accurate time delays or oscillations. It provides both of trigger terminal and reset terminal in order to enable a wide scope of application including Mono Multi Vibrator and Astable Multi Vibrator, and the number of external components is fewer. Further, it’s compatible with NE555 of singnetics...

Compact Spectrum Analyzers

The DSA800 series is one of RIGOL’s compact size, light weight economical spectrum analyzers. It employs digital IF technology that guarantees its reliability and performance to meet the most demanding RF applications. The DSA800 has a unique widescreen display for a friendly interface and easy-to-use operations. It enables users to compare spectrums when the RBW settings are changed with different color trace. It also features Zero span to demodulate the AM signal and measuring signals lower than -130dBm is made possible with the presence of a standard preamplifier...

SiC Power MOSFET

The SCTM001F is an N-channel SiC Power MOSFET developed by ROHM Semiconductor, especially designed for audio applications. The device include voltage characteristics of 400 V drain-source voltage and -6 V to +22 V gate-source voltage, while current characteristics include a 20 A continuous drain current and 60 A pulsed drain current. The product dissipates 132 W rated power. The SCTM001F should be stored at places with temperature range of -55 to +150 degrees Celsius...

High Efficiency Solar PV MPPT Regulator

The ZSPM4523 is a high efficiency solar PV MPPT regulator for supercapacitor systems featuring temperature independent MPPT regulation. It offers high efficiency of up to 92% at typical load and programmable temperature compensation. The ZSPM4523 is a DC/DC synchronous switching super capacitor charger with fully integrated power switches, internal compensation, and full fault protection...

Metal Hybrid Protection Devices

The Metal Hybrid PPTC with Thermal Activation (MHP-TA) series is a thermal protection device intended for battery application. This series of device features ability to do ReSettable Thermal cut-off (TCO). It provides a 9 VDC rating and higher current rating compared to typical battery strap devices to meet the battery safety requirements of higher-capacity LFP and prismatic batteries found in latest gadgets such as tablet and ultra-thin computing products. Hybrid MHP technology connects a bimetal protector in parallel with a PPTC (polymeric positive temperature coefficient) device...
If you have been interested in programming, electronics, or computing in general in the past several years, then you probably have used the Raspberry Pi. It is a wonderful, little piece of hardware that can help you learn how to code. At least, that was the intended use of the Raspberry Pi. With advanced knowledge about electronics and coding, the Raspberry Pi can be turned into more than a coding tutorial. This powerful piece of hardware can be converted into a weather station, a retro-gaming device or a touchscreen tablet. The Pi does this by boasting a 700 MHz processor, 512MB SDRAM, and a dual-core multimedia co-processor. These components allow the Raspberry Pi to be a great embedded single-board computer.

But, what if a project required more processing power and more data storage? A BeagleBone Black could be used, or the Raspberry Pi could be upgraded.
It takes a lot of experience to design a circuit board. It takes even more knowledge to be able to spin the board, meaning to design and produce a physical copy of a circuit board. So, performing electronic surgery on the Raspberry Pi to upgrade the components is not recommended. Lemaker has taken the difficulty of upgrading the circuit board to create what is called the Banana Pi. The Banana Pi has very similar architecture to the Raspberry Pi except that it is fitted with an AllWinner A20 SoC, which runs at 1GHz and 1GB DDR3 SDRAM. The AllWinner processor is actually an A20 ARM® Cortex™-A7 dual core.

Having a dual-core processor gives the Banana Pi twice the processing power of the original Raspberry Pi. The dual core gives the operating system the illusion that the computer has two 1GHz processors. All of those projects that you could not accomplish with the Raspberry Pi because of computing power? The worry can be eliminated with the Banana Pi. The AllWinner A20 SoC can more than make up for the lack of processing power.

Along with a beefier processor, the Allwinner A20 SoC comes with an accelerated graphics processing unit (GPU). This GPU follows along in the footsteps of the main processor and sports a dual-core Mali 400MP2 graphical unit. Along with dual cores, the Mali 400MP2 has 256 KiB of level 2 cache. This allows for greater storage of recently accessed information, as this is how the GPU works.

“With this technology, a graphical user interface (GUI) will load very quickly, graphical engines will process more efficiently, and movies or images will load with a higher definition.”
the level 2 cache is used. This transfers into faster computing, and in terms of graphical displays, this means the faster rendering of computing intensive graphical units. With this technology, a graphical user interface (GUI) will load very quickly, graphical engines will process more efficiently, and movies or images will load with a higher definition. This GPU was built for the accelerated creation of objects on a screen. With this design, the user is able to run an operating system such as Android or Ubuntu without any of the hiccups that may come with a slower GPU.

Now, what can you do with a little bit more processing power, more RAM, and more storage space? Actually, quite a bit. What use to be a weather station, a retrogaming device, and a touchscreen tablet can become a full-fledged multimedia PC, a general purpose computer, or a modern gaming device. The specs of the Raspberry Pi are no longer limiting. The Banana Pi comes with all of the standard peripherals that a Raspberry Pi has, such as HDMI out, 10/100/1000 Ethernet out, audio out, and GPIO headers.

With such a board, you can turn your home into the Internet of things. By adding sensors in various rooms, and a Banana Pi interfaced to the sensors, you can create a life that is connected to the Internet. This will help you remember your habits, assist with daily functions, and make life easier in general. All this is possible because Banana Pi’s advanced technology. Along with advanced projects, the Banana Pi can run many of today’s modern operating systems. With the addition of a touchscreen, or even a regular monitor, the Banana Pi can fly through operating systems such as Android 4.4 KitKat, Ubuntu 13.01 or even a multimedia OS such as XBMC.

But, many of the Banana Pi’s features are comparable to other cutting edge single-board computers. With all of the single-board computers coming out at Maker’s Fair, at Consumer Electronics Show, and across the Internet, it is hard to find one that will be perfect for any project. The Banana Pi builds on the famous Raspberry Pi, to create a fast, yet inexpensive solution for many electronic projects that need intensive computing. This is all possible because the Banana Pi is an open source. Being one of the first boards to use a dual-core processor, the Banana Pi leads the way into the development of faster and more inexpensive single-board computers.

Dual core makes it possible to accomplish many more tasks that the Raspberry Pi cannot. The next generation of single-board computers is here, and the Banana Pi is leading the way.

“The Banana Pi builds on the famous Raspberry Pi, to create a fast, yet inexpensive solution for many electronic projects that need intensive computing.”

BIBLIOGRAPHY


Overview of the INTEL Galileo Arduino GSM Shield

GSM communications enable embedded designs to communicate from almost anywhere, allowing for more mobile designs or remotely located devices where Ethernet and Wi-Fi are not available or practical. The Arduino GSM shield includes a quad-band GSM and GPRS module, an integrated antenna, and a full-size SIM-card slot.
**Included Hardware**

**Intel Galileo Arduino GSM Shield**

1. Quectel M10 GSM modem
2. SIM-card holder
3. Antenna
4. Power connector
5. Arduino headers
6. External antenna connector

**Tech Specs**

The shield uses digital pins 2 and 3 for software serial communication with the M10. Pin 2 is connected to the M10's TX pin and pin 3 to its RX pin. The modem’s PWRKEY pin is connected to Arduino pin 7.

The M10 is a Quad-band GSM/GPRS modem that supports GSM850MHz, GSM900MHz, DCS1800MHz and PCS1900MHz. It supports TCP/UDP and HTTP protocols through a GPRS connection. GPRS data downlink and uplink transfer speed maximum is 85.6 kbps.

As a result, the Arduino GSM shield is a perfect fit for domestic automation applications such as remote opening of doors or gates, switching of lights, and controlling of heat. It is also ideal for security devices.

**Watch Video**

To watch a video overview and demonstration of the Galileo Arduino GSM Shield, click the image below:
Before diving into proportional-integral-derivative (PID) design, an important factor to understand is how to interpret frequency plots as a time response. Having a rough idea of some key characteristics like ringing and amount of overshoot will help you develop an intuitive feel for the frequency plots and make compensator design much easier by visual inspection.

I will keep this discussion very brief, given the availability of a wide range of comprehensive textbooks that cover these concepts in great detail. I have simplified the concepts to the essentials, and you might consider reviewing basic frequency plots and transfer functions before diving in.
Bode Plots, Stability, and Time Response

The Bode plot is just one of many different tools you can use to understand stability. I lean towards the Bode plot because, personally, I find it is one of the easier plots to correlate the time and frequency domains. The discussion here can be extended to include other plots and representations as well. As always, it’s best to choose a plot you are most comfortable with.

Bode plots, in the frequency sense, are easily understood since all they show is the magnitude and phase change of the output signal when a sine wave of a specific frequency is passed through the system. For example, if we have a first-order low-pass filter with a gain of 10, the bode plot will be as shown in figure 1.

As you can see, the graph is really quite simple and easy to understand. We can even approximate the step response as an exponential curve (see figure 2). Throughout this series, the step response is regularly given that, in most practical systems, the required set point is typically a DC value (temperature, position, velocity), and so it gives the best approximation of what the practical response will look like.

We also know from experience that if the pole is pushed further, the output moves faster. To put a simple circuit equivalence to this, if we have a simple resistor-capacitor (RC) network, lowering either the capacitance (we need less energy) or the resistance (we can pump more energy in) will increase the output slew. Either of these cases is the same as pushing the pole to a higher frequency.

For the mathematically inclined, if we know the exact filter pole, we can even figure out the 90 percent rise time by:

\[
\text{Rise Time (90\%)} = \frac{1}{(0.35 + 2\pi \times f_p)}
\]

But I digress. The key to all closed loops is feedback. For almost all systems which use PID controllers, the feedback is negative; i.e., if we have a reference value and we want the output to follow it faithfully, we need to work on the error between what we want (reference) and what we have (current output).

So, what exactly happens to the frequency characteristics when we close the loop with negative feedback?

“You might be thinking, ‘So this means my output and input will be almost identical as gain of the system is 0dB for DC quantities? So all I need to do is close my loop and my control is complete? That can’t be right. What about the PID compensator?’”

The transfer function of the closed-loop with negative feedback:

\[
\text{Closed Loop TF}(s) = \frac{G(s)}{1+G(s)}
\]

This particular expression, though innocent looking, does something very interesting to the characteristics. We can deduce that if the gain is high, the closed-loop gain is close to unity while if the gain is low, the closed-loop and open-loop gains are almost the same.

\[
G(s) \ll 1 \Rightarrow \frac{G(s)}{1+G(s)} \approx 1
\]

\[
G(s) \gg 1 \Rightarrow \frac{G(s)}{1+G(s)} \approx \frac{G(s)}{1}
\]

Once we plot the new characteristics, we see quite a few differences. Before we progress though, I will need to formally define two parameters for future discussions. I can almost see people thinking, I knew it! Here comes the blasted math! But I need some leeway here, or we will be left with a mess later.
1. Crossover frequency ($f_{cr}$) is defined as the frequency where the open-loop gain plot crosses 0dB

2. Phase margin is defined as:

\[ \text{Phase Margin (degrees)} = -180 - (\text{Phase at } f_{cr}) \]

From the closed-loop plot (figure 4), we see the corner frequency shifted to the open-loop gain crossover frequency. On top of that, the gain of the system is close to 0dB for frequencies below the crossover.

Wait, you might be thinking, "So this means my output and input will be almost identical as gain of the system is 0dB for DC quantities? So all I need to do is close my loop and my control is complete? That can't be right. What about the PID compensator?"

Here's the catch: it's close to 0dB but not exactly 0dB. The more the open-loop gain of the system, the closer the closed-loop gain is to 0dB. This brushes upon the basic concept of a simple proportional controller, we will return to it in more detail a little later in the series.

A very common example where we use this behaviour is an op-amp in the follower or buffer configuration. In this configuration, we simply feed the output back to the negative terminal and feed the input at the positive signal. Functionally, this will be identical to figure 3. Since an op-amp's open-loop gain is very high, this means that, in this configuration, it follows the input almost precisely (remember that the closed-loop gain will become 0dB) until it get close to the crossover frequency.

**A More Complex Example**

I've ignored phase margin so far, but to understand what phase margin really means, let's look at a more complex example. Consider an arbitrary second-order system with a couple of poles. This is equivalent to a series RLC circuit with us observing the capacitor voltage. The transfer function is:

\[ f(s) = \frac{50}{s^2 + 2s + 20} \]

I've also thrown in a gain factor to make the plots more entertaining. If you're picky, this is an RLC with an op-amp gain thrown in.

**Figure 4. Closed loop versus open loop (first order).**

**Figure 5. Second order system (Bode plot).**
Again, from experience we know that the RLC circuit tends to oscillate around the resonant frequency and damps itself out depending on the Q-factor of the circuit. From the plot, we can infer that the oscillations will be around 0.72Hz. Q-factor is measured in decibel (dB), so the actual value is 2.26 (10^7.11/20). The damping here is really bad, and the step response will oscillate quite a bit.

Figure 6 shows how Q-factor of a two pole system affects the time response of the system. What we would always like to see is a Q-factor between 0.5 and 1, which will give us the fastest response with a reasonable amount of overshoot.

If you’re feeling brave, you can calculate the exact amount of overshoot, the damping, and all the other values by using even bigger formulas which are present in almost all control-theory textbooks. Since we don’t particularly care about the exact amounts in this example, I’ll be skipping this.

So what happens when we close the loop?

The gain is still okay, but the peak still remains. This is a bad sign since the last thing we want is a wobbly, overshooting response. Here is where the phase margin comes into play. Most engineers will tell you that the basic rule of thumb is to keep the phase margin between 60 to 80 degrees, and you’ll be just fine. Better to err on the side of caution and keep it higher to account for practical errors in the circuit.

Now, for why this is, I must ask for a leap of faith. The Q-factor of the closed-loop system is dependent on the phase margin of the open-loop system given by the formula:

\[ Q = \frac{\sqrt{\cos \phi}}{\sin \phi} \]

As much as I hate unexplained formulas, this derivation is something which delves deeper into theory. For practicing engineers, a plot between the Q-factor and the phase margin makes a lot more sense.

This is much more straightforward. I can see that if I want a closed loop response Q-factor of 0.5 (no overshoot and quick), I’ll need an open-loop phase margin of 76 degrees. If I can handle a little bit of overshoot, I can be more aggressive with the phase margin and drop it lower.

“"If you're feeling brave, you can calculate the exact amount of overshoot, the damping, and all the other values by using even bigger formulas.”
I’ll stop at second-order systems as in real life almost all higher order systems can be approximated very nicely to fit to second-order systems. This not only makes the math easier, it also drops compensator complexity by quite a bit. There are special cases though, and we will pick one of these up later in the series.

In short:

• All the important characteristics of the closed-loop system can be interpreted from the open-loop plots.

• More crossover frequency means a faster closed-loop response.

• More phase margin means lesser overshoot, but push it too high and you’ll have a slow system.

In the next part, we will see how compensators affect the open-loop characteristics so that we can adjust the characteristics to get the responses we need.

“Most engineers will tell you that the basic rule of thumb is to keep the phase margin between 60 to 80 degrees, and you’ll be just fine. Better to err on the side of caution and keep it higher to account for practical errors in the circuit.”
How To GaN
Simplifying Design and Increasing Efficiency with DrGaN PLUS

The eGaN® FET Journey Continues

Alex Lidow
CEO of Efficient Power Conversion (EPC)
SIMPLIFYING DESIGN

Power converters are constantly trending towards higher output power, higher efficiency, higher power density, higher temperature operation, and higher reliability, all while providing a simpler solution to the designer. The DrGaN\textsuperscript{PLUS}, shown in Figure 1, demonstrates the high-power density capability of eGaN FETs in an easy-to-use building block. With a footprint occupying only 30 percent of a U.S. penny, the optimized half-bridge design is developed on a 9.15 mm x 9.15 mm four-layer printed circuit board (PCB) with six mounting pads allowing for connection into any existing converter.

The previous columns in this series discussed the benefits of gallium nitride field-effect-transistors, eGaN\textsuperscript{®} FETs, their potential to improve performance in a variety of applications, and techniques to maximize the performance of gallium nitride (GaN) transistors. This installment will address an eGaN FET module designed as a way for power-conversion systems designers to easily evaluate the exceptional performance of gallium nitride transistors.

The block diagram of the half-bridge circuit design, shown in Figure 2, consists of two eGaN FETs, a driver integrated circuit (IC), pulse width modulation (PWM) logic, dead-time adjust, and high-frequency input capacitors. The design and layout of these components is critical to fully utilize the high-speed capability of the eGaN FET technology. The DrGaN\textsuperscript{PLUS} gate-drive circuitry ensures the gate-drive requirements for eGaN FETs are met and provides optimized performance with the latest GaN driver IC technology. The logic and dead-time adjust circuit allows for the designer to input a single PWM signal and obtain an optimized dead-time to maximize performance. The high-frequency input capacitors, located on board, are arranged with the two eGaN FETs in an optimized PCB layout, minimizing the common source inductance (L\textsubscript{s}) and the high-frequency power commutation loop inductance to decrease switching losses and voltage overshoot. The DrGaN\textsuperscript{PLUS} eliminates complexity and provides the designer an easy-to-use optimized solution with just six pads to mount to the PCB, shown on the right in Figure 1. The DrGaN\textsuperscript{PLUS} provides high efficiency with unmatched power density, which will be shown in the following section.

INCREASING EFFICIENCY

The most straightforward way to improve power density is to increase switching frequency, enabling a volume reduction in the passive components. The practical issue with increasing switching frequency is a decrease in efficiency as a result of higher losses, which limits current silicon-based solutions to the range of a couple hundred kilohertz. To enhance the performance of high-frequency converters, there have been many efforts to improve device characteristics and packaging. For improved device performance, the switching-related parameters, gate-to-drain charge (Q\textsubscript{GD}), gate-to-source switching charge (Q\textsubscript{GS2}), and gate charge (Q\textsubscript{G}) for the top switch have decreased. In addition, body-diode reverse recovery (Q\textsubscript{RR}) and forward voltage (V\textsubscript{DF}) for the synchronous rectifiers have been improved with the addition of an internal Schottky diode. Advanced packaging techniques have also increased performance by providing reduced parasitic inductances. The gains in silicon-based device performance have slowed in the past decade as the technology reaches its theoretical limit, and the package improvements have been limited by the inherent trench structure at higher voltages. This is where GaN transistors come in.
The first commercially available enhancement mode GaN-on-silicon power devices are good potential replacements for the aging power metal-oxide-semiconductor field-effect transistor (MOSFET). eGaN FETs provide lower figures of merit (FOMs), lower package parasitics, which combined with lower parasitic printed circuit board (PCB) layouts provide significant performance benefits over state-of-the-art silicon (Si) technology. Shown in Figure 3 is a switching waveform comparison of eGaN FETs and Si MOSFETs. The GaN device, with a substantially lower on-resistance ($R_{\text{on}}$), enables faster switching speeds with lower voltage overshoot. This enables circuit designers to achieve both lower dynamic-switching losses and lower static-conduction losses, improving converter efficiency. Comparing the efficiency of a DrGaN™ PLUS solution using 100 volt (V) eGaN FETs to a Si-based solution using 80 V transistors operating at 300kHz, the full-load power loss of the system is decreased by almost 40 percent as shown in Figure 4. With the low-dynamic switching losses provided by eGaN FETs, the switching frequency and power density of the system can be increased without sacrificing performance. A 500kHz eGaN FET-based design provides around a 25 percent reduction in full-load power loss compared to a 300kHz silicon-based design.

**SUMMARY**

The introduction of high-performance GaN devices offers the potential to switch at higher frequencies and with higher efficiency than possible with traditional Si MOSFET technology. The eGaN FET-based DrGaN™ PLUS building block demonstrates the ability to simplify high-power density and high-efficiency power conversion by providing an easy-to-use way for designers to evaluate the exceptional performance of gallium nitride transistors.

The EPC9202 demo board, a 100 V DrGaN™ PLUS, is available for purchase. Visit epc-co.com for more information.

“*The most straightforward way to improve power density is to increase switching frequency, enabling a volume reduction in the passive components.*”
Philips Lumileds

LIGHT UP LIFE
with Color-Rich LEDs

Philips Lumileds Lighting Company is a leading manufacturer of high-power LEDs and a pioneer in the use of LED lighting solutions for everyday life. The company developed the use of solid-state lighting in breakthrough products such as the first LED backlit TV, the first LED flash in camera phones, and the first LED daytime running lights for cars. Today, Philips Lumileds continues to offer products engineered for optimal light quality and efficacy at the lowest overall cost.

EEWeb spoke with Pierre-Yves Lesaicherre, CEO of Philips Lumileds, about advancements in LED technology and about applications for mid-power LEDs. Lesaicherre also discussed the company’s innovative Hue lighting system and its impact on the illumination industry.

*Interview with Pierre-Yves Lesaicherre, CEO of Philips Lumileds*
What advancements in the LED technology are driving the improved efficiency and cost, in terms of lumens-per-watt and lumens-per-dollar?

Lumileds is one of the few vertically integrated suppliers of LEDs. We develop the epitaxy of the blue LED, which is the basis of every white LED. For the epitaxy, we do the research and development ourselves. We also produce the phosphor materials—we are one of the only LED companies that does research and development on phosphors. Finally, we develop all of the semiconductor processes that go on top of the LED as well as the packaging. We are involved in every step of the fabrication of our LEDs.

In terms of improved efficiency and cost, much of it comes from innovation in epitaxy. We believe we have the best high-power blue pump in the industry today. We also excel in the device architecture—we’ve introduced new and innovative chip-scale packaging for LEDs. In addition, we developed a few unique phosphors with very high light extraction efficacy in the green area of the spectrum. All of these areas contribute to the overall performance of the product, but they also contribute to the cost. When we go from a very complex architecture to a simple one, we reduce the number of steps in manufacturing, which enables a much lower cost solution.

When you talk about cost efficiency in terms of lumens-per-dollar, the device architecture is very important. However, you can reduce the cost further by increasing the scale of the manufacturing operation, which gives you a lower cost-per-unit. We also drive very strong cost-reduction programs. We are trying to increase the yield year after year, and we have achieved significant progress in the last two years. Our yields have gone from the mid 70 percent range to the 90 percent range, which is about the same range as semiconductors. This means that our LED devices will be much cheaper to produce, and they’ll be more efficient.

What kinds of applications are you seeing for your mid-power LEDs?

Typically, people in the industry refer to mid power as below 1 watt. The other definition refers to using a lateral device architecture. Most of the mid-power devices use this lateral die, which is a five-sided emitter, meaning it also emits from the sides of the LED. Many of the high-power LEDs, which are 1 watt or above, typically emit directly from the surface in one direction only. High-power LEDs are very useful for directional applications, and mid-power LEDs are good for distributed light applications like backlighting and distributed illumination.

"When we go from a very complex architecture to a simple one, we reduce the number of steps in manufacturing, which enables a much lower cost solution."
Could you talk about how these are being implemented in multichip packages (MCPs)?

We just introduced the 3535 2D and the 3030 2D (“3535” refers to package size—3.5 mm by 3.5 mm). With these products we put two die—hence “2D”—next to each other inside the package to save packaging costs. With the 2D, we more or less double the light output from a single package, which is really the key innovation in terms of lumens-per-dollar. Many new lamps are moving to these types of 2D packages.

What led to the development of Hue?

Hue is essentially three light bulbs in one. At the base of each light bulb is a ZigBee receiver. When you install Hue in your home, you connect through Wi-Fi to a hub, which in turn communicates through the Zigbee wireless protocol with the lamp. This allows you to access the bulb through your wireless device, whether it’s your phone tablet or computer. The Zigbee protocol allows for very low-power communication between the lamp and the hub. With this setup, the Hue bulb can be controlled through a wireless device using the Wi-Fi hub.

Inside of the Hue lamp, we installed three types of LEDs: blue, red, and green LEDs. The key to unlocking 16 million colors with high efficacy lies with the green LED, which is what we refer to as “lime green.” The triangle between the green, red, and blue LEDs enables the device to blend color in up to 16 million different ways. In the LED industry, blue and red LEDs are very well mastered. However, the green LED is not as easy to produce. The epitaxy that emits a direct green color is very low efficiency, which means you need many LEDs to do green, up to twice as many as red. For Hue, we did two years of research and development on phosphors. We took a blue LED and completely turned the blue photons into green photons at a high efficiency. This is absolutely unique to Lumileds—nobody else in the industry is capable of producing this saturated green color at this high efficiency.

Hue is widely considered to be a “smart bulb.” How does this reflect the larger vision of smart lighting within Lumileds?

I think Hue is a prime example of the Philips vision around connected lighting. The idea is to allow users to control their environments as they please through an easy-to-use and appealing product. We see applications of that in homes where people want to change the atmosphere in the evening to warmer or brighter colors. In fact, Philips has conducted studies on how lighting affects the user. We found that exposure to bluish lights enhances the ability to concentrate or to study. We also found that exposure to warmer light in the evening—reddish light like the sunset—allows people to sleep better at night. The arrival of the LED at the right price point allows the new tailored lighting applications to come to life. Here at Philips, this is where we see technology and the vision of connected lighting converge.

What are some other surprising applications you have seen with Philips Lumileds LEDs?

The newest airplanes from Boeing and Airbus have adjustable color for interior lights in order to help passengers recover from jetlag when traveling between time zones. This adjustable lighting mimics the circadian cycles of the passengers. Warm, reddish light helps the passengers fall asleep while blue light helps wake them up.
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Programmable Sensors
For The Sustainable Future

Watch How The Dual Mold Package Can Simplify Sensor Assembly
Upgrade To Re-Programmable Digital Hall Sensors
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Why You Should Measure Jitter

As mentioned in an earlier post on some basics of jitter, the bane of serial-link design is a signal that doesn’t arrive at its destination when it should, whether early or late. The goal of serial-link design and implementation is to transmit data with as few bit errors as possible. Thus, analyzing jitter is a key element of achieving first-pass design success.

The physical makeup of a typical serial-data channel (Figure 1) is chock-full of structures that are potential sources of jitter. Impedance mismatches can crop up anywhere in the critical path, which includes elements such as microstrip lines, vias, connectors, decoupling capacitors, and board or chip interfaces.

The raw truth is that jitter results in bit errors. There’s a proper, or expected, time for a signal to pull into the station, so to speak, and when it fails to do that, well, that’s no way to run a railroad (or a serial link). Wrong edge timing begets incorrect latching, which begets... you guessed it... bit errors.

Let’s look at two simple examples as shown in Figure 2. Here we see two signals latched as low or zero. The vertical cursor at the latch (strobe) time represents the point in time at which we expect these signals’ voltages to surpass the crossing detection level (the horizontal cursor). Unfortunately, one crosses the detection level too late, while the other simply fails to cross at all. Both of these instances would be chalked up as bit errors.

It’s impossible to design a high-speed serial-data channel that is completely free of bit errors. But what the design team should be chasing is the lowest possible bit-error rate (BER). The specifications for most serial-data protocol standards demand a very low BER. For example, the specification for USB 3.1 calls for a BER of less than one in every 10^12 bits at data rates of 5 GT/s. Failing to meet that requirement can prove quite costly.

The difference between the measured time of arrival of an edge and the expected time of that edge’s arrival represents its time-interval error (TIE). In other words, TIE describes how early or late an edge arrives versus its expected arrival time. In Figure 3, the yellow trace represents a clock signal while the blue trace represents a data signal expected to cross the crossing detection level at the same time as the clock. As we can see, the data signal’s crossing is late relative to the clock, and that rings up as a bit error.

While a low BER is the overall goal for the data channel’s design, the quantification of the jitter that causes bit errors is arrived at through measurement and subsequent analysis of time-interval errors (TIE).

Hopefully, this post fills in the reason why one would measure jitter (quantified in TIE) in the first place. Measuring time-interval errors is a multi-step process, and in subsequent posts in this series on jitter, we’ll cover that process as well as the subsequent analysis of the measurement results.