Humavox PULLS the PLUG

Intuitive WIRELESS Charging

Fairchild’s Audio Jacks
Technology Worth Listening To

Making Wearables Fit the Bill
Power & Form

Interview with Omni Lachman Co-Founder & CEO at Humavox
Interview with Omri Lachman, Co-Founder & CEO at Humavox

that widen the performance gap in key switching figures of merit eGaN FETs that is keeping Moore’s law in check. The company’s family of eGaN FETs to reduce the static on-resistance of 33 mΩ and comes in an ultra-small footprint. At 100 mΩ, it offers one of the lowest on-resistance families in the market. The small footprint makes it suitable for high frequency power converter design, where switching losses are often the dominant loss mechanism.

IMPROVED SWITCHING SPEEDS

On-resistance comparison of the 2nd generation and 4th generation eGaN FETs.

In traditional hard-switching transitions, the inductive effect of the output inductor causes a delay. This delay is a result of the inductor’s impedance to any rapid change in current. The inductor acts as a series resistor, limiting the rate of change of current and causing a transient loss upon commutation. This inductor impedance delays the switching transition, which is quantified by the current rising and falling transition time. The gate-to-source charge from the device threshold to-drain charge, also known as the Miller charge, is a direct measure of this delay.

Varying the gain of the integral term will affect the time response of the system as shown in figure 5. Again, there is a trade-off between how fast the system settles and how much overshoot there is. Most systems are designed to settle within a few cycles before settling.

The PI Controller

A key point to note here is that putting in a PI term is not just an additional pole at 0Hz with a zero thrown in. Because of both these effects, the total system will now not only have an infinite DC gain, it also has a very respectable prerequisite phase margin. This is certain, the key to mass-market success of wearable devices is tackling power and form challenges.
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1.5Gbps 4-Data Lane Switch

The FSA644 is an SPDT switch that needs a supply voltage of as low as 1.65 – 4.50 V and operates effectively at the temperature range of -40ºC to +85ºC. The minimum bandwidth that can be handled by this device is about 750 MHz. This device is very suitable for cellular phones, smartphones and displays...

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Space-Saving Entry-Level Server

Fujitsu announces its new space saving entry level server, the M10-1 server. It has high performance and reliability that is ideal for center integration and virtualization. It supports as many as 16 cores, large-capacity memory modules, and a large-capacity disk in a space-saving one rack unit (1U) chassis...

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Integrated Step-Down Power Module

The ISL8203M is a dual 3 A output current or single 6 A step-down DC/DC power module. This device is ideally suitable for low power low-voltage applications and is optimized for producing low output voltages down to 0.8 V. It operates in an input voltage range from 2.85 V to 6 V. The two channels are 180° out-of-phase for input RMS current and EMI reduction. Each channel is capable of 3A output current. They can be combined to form a single 6A output in current sharing mode. While in current sharing mode, the interleaving of the two channels reduces input and output voltage ripple...

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Dual Linear Optocouplers

The LOC211P is a dual linear optocoupler featuring wide bandwidth and high gain stability. It couples analog and digital signals and offers low input/output capacitance with low power consumption in a surface mount tape and reel version available...

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High-Efficiency Medical-Grade Power Supplies

The MMK75S-24 is an enclosed switching power supply capable of delivering 75 W of rated power output. With an input voltage range of 90 – 264 VAC and frequency range of 47 – 63 Hz, the device is guaranteed to operate effectively at 0 ºC to 60 ºC. Following a convection cooling mechanism, the power supply also has a built-in EMI filter in its system. Safety and long life of the device is ensured by its over temperature, over current, over voltage and over current protection features...

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Multioutput Boost Converter LED Driver ICs

Allegro MicroSystems announced the release of its latest devices in addition to their LED Driver ICs for LCD backlighting applications portfolio. The A8518 and A8519 are multi-output boost converter LED driver ICs with fault tolerant protection. These devices combine a current-mode boost converter with an internal power switch with either two current sinks (dual string) in their A8518 or four current sinks (quad string) in their A8519. Both devices are targeted at the automotive and industrial markets with end applications to include automotive infotainment and instrument cluster LCD backlighting, heads-up displays, interior lighting, accent lighting and robust commercial and industrial backlighting and lighting applications...

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Miniature Ambient-Light Photo Sensor

Avago Technologies introduces a low-cost analog output ambient light photo sensor in miniature chipLED lead-free, the APDS_9006. It has a reverse surface mount package and consists of a photo sensor, whose spectral response is close to CIE standard photopic observer. This photo sensor provides an excellent responsivity, close to human-eye...

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192kHz Stereo DAC with 2 Vrms Line Out

The STR4A100 series are off-line PWM controllers with integrated sensing MOSFET intended for switching power supplies. The device features an automatic standby function with no load power consumption of less than 10 mW, current-mode type PWM control, random switching function, slope compensation function and leading edge blanking function...

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Low DCR, Shielded Power Inductors

The MSS7341T are power inductors designed for high ambient temperatures up to 125°C. It offers low DC resistance for greater efficiency and saturation current rating up to 3.72 A. The power inductors are highly reliable and qualify for AEC-Q200 Grade 1 standard...

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Industrial Specialty Adhesive System

Master Bond developed a specialty adhesive system for industrial applications. The EP21LVSP6 is a two-component epoxy system that cures at room temperature as well as at elevated temperatures. It provides a convenient mixing by equal weight or volume ratio. The EP21LVSP6 is ideally intended for applications where the combination of a long open time, low viscosity and excellent physical properties are all essential. The system also has very good chemical resistance to water, oil, fuel, acids and bases. EP21LVSP6 bonds well to a variety of substrates, including metals, composites, glass, ceramics, rubbers and plastics... Read More

Receiver for Optical Distance Measurement

The MAX30806 is the industry’s first 130 dB dynamic range transimpedance amplifier with switchable gain and mA sensitivity. The device is a preamplifier that consists of a selectable-gain transimpedance amplifier, a selectable 14 dB attenuator, and an output-driver block. The selectable-gain transimpedance amplifier linearly boosts the signal from the photodiode. Read More

MLX90314 Demonstration Kit

The DK90308/DK90309 is an evaluation kit used to communicate with MLX90308 and MLX90314. It is used in absolute voltage output mode in which the device uses an external FET; in ratiometric voltage output mode in which the output follows the supply voltage; and the current output mode in which the device supplies the current in a 4- to 20-mA current range as a 2-wire analog sensor. Read More

Digitally Enhanced Power Analog Controllers

Microchip Technology launched its two new Digitally Enhanced Power Analog (DEPA) controllers. The MCP19118 and MCP19119 offer simple yet effective analog PWM control for DC–DC synchronous buck converters up to 40 V, and are configured by a digital MCU. These devices are industry’s first devices to combine 40 V operation and control for DC–DC synchronous buck converters up to 40 V, and are configured by a digital MCU. These devices are industry’s first devices to combine 40 V operation and control for DC–DC synchronous buck converters up to 40 V, and are configured by a digital MCU. These devices are industry’s first devices... Read More

8kV Isolation DC/DC Converters

The A100H series of single and dual output DC/DC converters are designed to deliver 1.5 W of rated power. For flexibility purposes, the series offers 18 standard models to choose from with input voltage ranging from 4.5 – 5.5 VDC, 10.8 – 13.2 VDC and 13.5 – 16.5 VDC, depending on the client’s desired application. These converters are capable of handling as high as 8000 VDC of voltages without breaking down. Equipped with continuous (auto recovery) short circuit protection, the devices operate effectively at the extended temperature range of -40ºC to +85ºC. Read More

LED Driver Integrated Circuit

Mouser Electronics, Inc. announced the availability of SSL501ST/1Y (771-SSL501ST/1Y) LED Driver integrated circuits featuring highly integrated switch mode LED driver and an integrated circuit lifetime that meets and exceeds the required lifetime of LED lamps. It offers low BOM LED driver solution with full set of internal protections, such as under-voltage lockout and over-current protection... Read More

Isolated Quarter Brick DC/DC Converter

Murata introduces its RBQ series of single output isolated quarter brick DC/DC converters. It has a high output current of up to 33 A, input voltage range of 36 V to 75 V, and efficiency of 96 %. This RBQ series is housed in an industry standard quarter brick package requiring no heat sink for most applications... Read More

1-of-2 Decoder/Demultiplexer

The 74LVC1G19 is a 1-of-2 decoder/demultiplexer that features common output enable. The device operates in a wide supply voltage range from 1.65 V to 5.5 V. It features high noise immunity, ESD protection, low power consumption, and direct interface with TTL levels. It normally operates in a temperature range from -40 ºC to +85 ºC. This device complies with three JEDEC standards... Read More

14-Stage Binary Counter

The HEF4020B is a 14-stage binary counter. This device contains a clock input (CP), an overriding asynchronous master reset input (MR) and twelve fully buffered outputs (Q0 and Q3 to Q13). It features high speed and fully static operation, and standardized symmetrical output characteristics. The counter advances on the HIGH to LOW transition of CP. A HIGH on MR clears all counter stages and forces all outputs LOW, independent of the state of CP. Each counter stage is a static toggle flip-flop. A feature of the device is its high speed (typ. 35 nsec at VDD = 15 V) Read More

LED Design Selector

The STR4A100 series are off-line PWM controllers with integrated sensing MOSFET intended for switching power supplies. The device features an automatic standby function with no load power consumption of less than 10 mW, current-mode type PWM control, random switching function, slope compensation function and leading edge blanking function... Read More
Start-Stop Automotive MCU Power Supply

ROHM Semiconductor releases its BD39001EKV-C, a general purpose automotive microcontroller system power supply for the start stop system. It responds to instantaneous battery voltage drops during cranking. Also, it has improved efficiency which contributes to greater energy savings... Read More

144/288 Watt DC/DC Converters

The R Series is a family of cassette power supplies that outputs two (2) voltages ranging from 12 V to 96 V. This series offers seven (7) models now available on the market. This converters are designed for an extremely wide input voltage range, allowing for connection to all common railway batteries. The new 10:1 input MELCHER R Cassettes are the broadest and most flexible group of power supplies delivering extremely high efficiency up to 94%, high reliability, low output voltage noise and excellent dynamic response to load/increase changes, plus ONE wide dynamic input voltage range of 12 to 168 VDC. They can readily provide up to 300 W of power over two outputs that offer SELV, no load, overload, short circuit-proof protection, hold-up time, input reverse polarity, and current sharing... Read More

Single Power Supply Dual Comparator

The µPC277GR-9LG/µPC277MP-KAA/µPC393GR-9LG are bipolar analog integrated circuit series featuring a single power supply dual comparators that can be used for an extensive comparison of different voltages. It offers a DC parameter selection, as well as low voltage operation with reduced mounting area compared to the conventional 8-pin plastic SOP... Read More

Easy-to-Use Arbitrary Waveform Generator

The DG4062 belongs to RIGOL’s DG4000 series of highly efficient waveform generators. This dual channel arbitrary generator can handle maximum frequency of up to 60 MHz. The sampling rate of the device reaches as fast as 500 MSa/s and maintains 1 µHz frequency resolution. The instrument also features 7-inch TFT LCD for a better data display... Read More

MicroSMD Protection for AC LEDs

TE Circuit Protection announces its addition to its Surface Mount Device, the MicroSMD005F-2. It has maximum voltage of 30 V, maximum current of 10 A, minimum resistance of 3.60 Ω, and maximum operating temperature of 85 °C. It is commonly used as a circuit protection device for AC LEDs... Read More

MicroSMD Protection for AC LEDs

MicroSMD005F-2

Analog Output Sensor IC

ZSC31010, a new addition to ZMDI’s sensor ICs, is an analog output sensor signal conditioner. It enables an easy and precise calibration of resistive bridge sensors via EEPROM. It communicates directly via ZMDI’s ZACwire™ serial interface and easily mass calibrated in a Windows computer... Read More

Analog Output Sensor IC

ZSC31010
It seems like everyone is talking about wearable technology—and rightfully so! According to market research firm IHS, wearable technology saw revenues of $8.5 billion in 2012, but could reach $30 billion by 2018. Still in the early days of wearable technology, we’re constantly learning and refining our approach to these devices. One thing is certain, the key to mass-market success of wearable devices is tackling the challenge of meeting low-power and small form-factor requirements.
So what does a wearable device need to do? With such a wide range of use cases—from fitness trackers to more robust mHealth devices, to augmented reality devices—each and every wearable comes with its own set of needs and challenges. At the same time, some challenges are universal—connectivity, battery life, the ability be “always-on, always-aware,” and miniaturization.

Wearable devices must be connected in order to make sense in today’s technology ecosystem. A modern, marketable wearable device will be designed to link to services, interface with other devices and serve as part of the growing Internet of Things (IoT). While many will be built with 3G or 4G connections and Wi-Fi, the power concerns surrounding wearable devices make short-range Bluetooth LE a strong fit in most wearable devices. While not offering data at the speed of Wi-Fi, Bluetooth LE can still provide a useful 1-Mbit-per-second connection over a short distance with limited use of power.

Power consumption continues to be a critical factor in wearable devices. As wearables are often designed to be “always on” and to become part of the user’s daily routine, having to remove them to charge even once per day can be enough of a use barrier that it significantly limits the device’s value. A wearable device should be designed to be as low power as possible. To put this in context: the average smartphone requires a charge of around 3,000 mAh per day, but a wearable device should only use a 300 mAh charge once per week! That’s 70 times less power use, a testament to the need for ultralow-power technologies.

Efficient use of power is important enabling the “always-on, always-aware” paradigm around which wearable devices are designed. A given wearable might include any number of sensors: temperature and pressure sensors, accelerometers, gyroscopes, and GPS antennas. All of these create data, and all of this data needs to be processed and turned into something usable by the consumer. This requires the device to incorporate a specific combination of hardware and software best suited for constantly servicing this data stream.

On the software side, this solution can vary greatly depending on the device. Fitness trackers, for instance, might only require a simple operating system (OS) with little-to-no user interface (UI) since they are designed, almost exclusively, to ferry data from the device to a smartphone, a tablet or a computer. On the other hand, a smart watch might require a somewhat more sophisticated UI, built on an operating system such as a Linux or Android and complete with graphics capabilities and ability to support an ecosystem of apps.

The complexity of the device dictates the hardware needs. Simpler devices might be built using SRAM, ROM and flash memory but might lack a memory management unit. These devices could be served well by a chip designed to be a lightweight, low-power solution. But devices with a rich OS and display need a higher performance processor accompanied by DRAM and a high efficiency GPU, while still being conscious of the specific power needs of a wearable device.

At the core of all of this effort is the need to create a device that is as lightweight as possible. A bulky wearable device just isn’t very wearable. At the same time, the device needs to be powerful, energy efficient, and able to contain a multitude of sensors and other inputs. The market for wearable products is here now—from fitness and health devices to smart watches and beyond. As the industry continues to build and iterate on these devices, we will undoubtedly learn new lessons, break new ground, and work together to deliver a new generation of mobile, wearable devices that improve and enrich our lives.
The Raspberry Pi Compute Module along with the Compute Module IO board have the potential to boost custom electronics development. The new Raspberry Pi Compute Module is the Raspberry Pi, just smaller and without peripherals: the main components that power the Raspberry Pi have been put onto a chip the size of a DDR2 SO-DIMM module. To put this into perspective, the DDR2 SO-DIMM module is a typical size of laptop memory. While the Raspberry Pi Compute Module was designed for users interested in creating a printed circuit board (PCB), the Raspberry Pi Foundation has created an IO board that can house a compute module. This allows users to program the computer and provides pins for custom IO. The intention is to give users the ability to work with the Raspberry Pi processing power and test scenarios that would affect the outcome of developing a PCB. Designing a working PCB takes much time and money to complete, so Raspberry Pi is attempting to alleviate some of the stressors that come with creating such a PCB.
SMALLER SLICE OF PI

The compute module contains a Broadcom BCM2835 chip. This is the same processor as the original Raspberry Pi, but the qualities shine as the hardware is condensed onto a smaller chip. What makes the design even more remarkable on a smaller hardware profile is that the chip contains a low-power ARM1176JZ-F applications processor which only produces 0.21 mW/MHz including cache controllers. This allows the Raspberry Pi Foundation to construct a powerful chip that consumes much less power even with a smaller size. In addition to a low-power profile, the ARM1176JZ-F processor runs the ARM Thumb instruction set. The ARM Thumb instruction set is a reduced ARM instruction set. Originally, the ARM Thumb instruction set took the most common instructions, which are usually 32-bits long, and made them 16-bits long. These 16-bit instructions have a corresponding ARM instruction. During execution, the central processing unit (CPU) would enable a decompressor on instruction fetching so the CPU could understand the 16-bit ARM Thumb instruction. This would allow ARM to trim down code size and cache utilization with little changes to the hardware cores. The advancements made to instruction processing allow for faster computation on current processor cores.

While advancements in instruction processing were being made to increase the efficiency across CPU cores, there were also innovations being made in media processing. The single instruction multiple data (SIMD) model has been implemented to help with the processing of media. The SIMD allows multiple processing elements to execute the same instruction on multiple data points simultaneously. This decreases processing time and increases efficiency in tasks such as contrast on a digital image or adjusting the volume of digital audio. This allows up to two times the performance for video processing on the Compute Module.

VIDEO PIONEER

An advanced processor that provides improvements to video processing only becomes beneficial if there are advanced video capabilities of the hardware. The Raspberry Pi Foundation made sure the video capabilities were on par with the CPU capabilities. The IO board comes equipped with two camera serial interface (CSI) ports, two display serial interface (DSI) ports, and a full sized high-definition multimedia interface (HDMI) port. Included in the BCM2835 chip is a dual core VideoCore IV multimedia coprocessor. This processor is capable of BluRay quality playback by utilizing the H.264 video encode–decode codec. Using this codec, the video processor is capable of outputting 1080p30 full HD video quality. By combining the capabilities of the BCM2835 with the ports available on the IO board, the possibilities expand tremendously. The compute module can handle an HDMI output and two other displays as well as rendering camera input from two camera ports. The display and recording capabilities of the compute module combined with the IO board give engineers plenty of options for developing camera and display solutions.

A smaller form factor, HD displays, and camera ports are just some of the qualities that make the compute module and the IO board superb. Added improvements include the introduction of a 4GB eMMC flash device. The original Raspberry Pi covers the functionality of eMMC flash by providing a secure data (SD) card slot. In order to use the Raspberry Pi, an SD card had to be programmed with an OS and plugged into the SD card slot. With the eMMC flash, the OS can be installed directly on the system. Once the OS is installed, the system can run independent of external storage allowing for more flexibility. If extra storage needs to be added, the designer can use external USB storage. 4GB of storage is plenty for many custom applications, and because the storage is being directly integrated into the hardware, the connections made between the components allow for more efficient data transfer.

“Media capabilities of the compute module provide many options for camera and display solutions.”
The Raspberry Pi Foundation implemented a hefty amount of general-purpose input-outputs (GPIO) ports. The amount of GPIO included on the compute module IO board was actually the intended amount that would be available to use by the BCM2835 chip. But, the size restrictions on the original Raspberry Pi made it infeasible to include the sheer amount of GPIO pins that the BCM2835 is capable of handling. By modifying the original design of the Pi to fit on a DDR2 SODIMM module, the computing power fits on a small stick that can be inserted on to the compute module IO board. Hardware space is freed and allows for the expansion of IO capabilities. This is due to DDR2 SODIMM technology, which gives modules 200 pins to use to transfer data. By expanding the data paths, the BCM2835 functionality was unlocked, and more GPIO pins can be accessed for personal use, rather than processor use. Anything from sensors to switches or push buttons can be wired to these pins, and the compute module paired with the IO board can handle and control the specified IO.

The Raspberry Pi Compute Module was designed to give developers the computing performance of the original Pi while leaving the peripheral design up to the engineer. The Raspberry Pi Foundation developed a mini Raspberry Pi computer that fits into a DDR2 SODIMM slot. This allows an engineer to develop a PCB while having the computing power of a Raspberry Pi. If the user has no desire to create a PCB, then combing the Raspberry Pi Compute Module with the Compute Module IO board gives a designer a plethora of options. These extended options take the learning from mostly programming with the original Pi, to understanding electricity and configuring peripherals with the compute module and IO board. In the end, the Raspberry Pi Compute Module and the Compute Module IO Board allow a wider spectrum of users to create their own custom electronics.

"The compute module was designed to give developers the computing performance of the original Pi while leaving the peripheral design up to the engineer."
In my previous column, I showed bode plots for different types of transfer functions. I also touched on the basic principles of closed loop systems. As a refresher, the gain crossover frequency dictates the speed of the controller, and ensuring a phase margin of around 70 degrees achieves a nice trade-off between the overshoot and speed. Now I’d like to look at how different compensators affect the characteristics of the plant. In the course of this discussion though, we will see that not all systems need a full-blown proportional-integral-derivative compensator (PID compensator). Most of the time, a PI compensator or even a simple integral controller can do the job.

Knowing which type of compensator to use cannot only reduce the complexity of an implementation, it also helps give a clear understanding of the exact requirements of the complete system. In other words, we don’t want to add stuff in if it doesn’t help. In this part of the series, I’ll cover compensating first-order systems. Just remember that, as mentioned earlier, sometimes higher-order systems, which have dominant first-order characteristics, can fit the bill. For example, most thermal systems typically exhibit a very dominant first-order behavior.

The P, the I, and the PI

Compensating First-Order Systems
The Basic Controller

The proportional controller is probably one of the easiest controllers to implement either digitally (it’s just a simple multiply operation) or as an analog circuit (i.e., a differentiating op-amp with a gain). However, using a controller like this on its own can cause more trouble than it solves. If you recall from the previous article in the series, the relationship between close-loop gain and open-loop gain is governed by:

\[
\frac{G(s)}{1 + G(s)} \sim \begin{cases} \frac{G(s)}{1} & \text{for } |G(s)| \ll 1 \\ \frac{G(s)}{1} & \text{for } |G(s)| \gg 1 \end{cases}
\]

The larger the open-loop gain, the closer to unity the closed-loop gain is.

Picking up our previous example system (a low-pass filter with a gain of 10), and adding a proportional controller changes the open-loop transfer function to:

\[
\text{Open loop transfer function} = G_p \times \frac{10}{s + 1}
\]

Here, \( G_p \) indicates the proportional gain.

Adding a proportional controller is just equivalent to adding open-loop gain to the system. The plot variations can be visualized as shown in figure 1. Essentially, all we are doing is moving the open-loop magnitude (blue line) up and down. Because of this, several key characteristics change:

- Gain crossover moves higher.
- Closed-loop gain below the crossover gets closer to unity.
- Phase margin more or less remains in the same range of >90 degrees.

In the time domain, this equivalent will be as shown in figure 2.

Since this is a first-order system, the phase can only go to -90 degrees; therefore, the phase margin will always be greater the 90 degrees. So, if you just add a plain proportional controller to a first-order system, you will never have issues with overshoot or settling times. In practice, though, this doesn’t work out! Adding a proportional controller to first-order systems can cause

Using a proportional controller on its own can cause more trouble than it solves.
oscillations but not because of the characteristics of the system. It arises more because of the inherent nonlinearity associated with practical systems. Hold that thought; we'll get back to it soon.

From the plots, we can see that putting a high gain in the feedback path will give a negligible amount of settling error and will be real fast. This looks like a win-win situation but unfortunately is not always realizable. When implementing a proportional controller, using a high gain is equivalent to pushing out an enormous amount of instantaneous energy to force the system to move fast. For example, if we put a gain of 50 into the example system, the actual input we are pushing into the system is shown in figure 3.

Initially, the input is as high as 50 times the output, which for most plants is quite an impossible feat. If you consider this an op-amp equivalent circuit, for the compensator to settle to 1V, it will have to slew to 50 volts almost instantaneously. In such a case, you will be limited by the slew rates as well as the rail-rail voltage limits of the op-amp. How these nonlinearities affect the response will be covered in a little more detail later in the series.

In summary, using proportional control alone is not always feasible. However, if the trade-off between speed and settling error works for the application, using proportional control alone is an easy, cheap way to achieve closed-loop regulation.

The DC Error Minimizer

Now, for the same example system, adding an integrator changes the transfer function to:

$$\text{Open loop transfer function} = \frac{G_i}{s} \times \frac{10}{s + 1}$$

Here, $G_i$ indicates the integrator gain.

Assuming an integrator gain of 1, the frequency plots plot changes to (see figure 4):

---

**Figure 3.** Response and input for high-gain controller.

**Figure 4.** Adding an integrator with gain = 1.

---

So, if you just add a plain proportional controller to a first-order system, you'll never have issues with overshoot or settling times. In practice, though, this doesn't work out!
• We have infinite DC gain (since at 0Hz, frequency (1/s) tends to infinity).
• The total phase of the system is pushed by another -90 degrees (adding an integrator is like adding another pole).
• Both the gain crossover and phase margin are affected.

The infinite DC gain is fantastic as if we want to follow a DC reference as the close-loop gain is exactly 0dB; i.e., the reference settles perfectly to the DC value of the reference. However, due to the additional -90 degrees, the phase margin drops dangerously low to 17 degrees and will oscillate many, many cycles before settling.

Varying the gain of the integral term will affect the time response of the system as shown in figure 5.

Again, there is a trade-off between how fast the system settles and how much oscillation can be tolerated. This is definitely not what we want.

**The PI Controller**

Now, putting in a proportional and integral controller changes the equivalent transfer function to:

\[
\text{Open loop transfer function} = \left( \frac{g_p}{s} + \frac{g_i}{s} \right) \times \frac{10}{s + 1}
\]

A key point to note here is that putting in a PI term is not just equivalent to a pole at 0Hz with some gain thrown in. If you resolve the controller equation, you will see that it is actually a pole at 0Hz with a zero thrown in.

\[
\text{Controller transfer function} = \frac{g_p}{s} \left( s + \frac{g_i}{g_p} \right)
\]

Because of both these effects, the total system will now not only have an infinite DC gain, it also has a very respectable phase margin of 71 degrees. In theory (as well as most practical systems), for a first order system, a PI controller alone is sufficient to achieve the desired crossover in combination with a prerequisite phase margin.

Knowing which compensator to use reduces complexity of an implementation and gives a clear understanding of exact system requirements. In other words, we don’t want to add stuff in if it doesn’t help.

Figure 5. High vs. low integral gains.
How to design proportional and integral gains is a vast topic in itself. There are both rigorous mathematical approaches as well as empirical approaches, the most famous of which is the Zeigler-Nichols method. Personally, a rule set which has worked well for me is to ignore the phase margin and increase the integrator gain until the system reaches close to the desired crossover frequency. Then I increase the proportional gain until the required phase margin is reached. Keep in mind this also shifts the crossover frequency higher (i.e., the zero changes the magnitude roll-off from -40dB/decade to -20dB/decade), so a little tweaking will be required to get the specified crossover and phase.

In short, it’s important to remember the following:

- A PI controller is all you need for compensating first-order systems.
- Both proportional alone and integral alone can also be valid controllers IF your output tolerances can handle it.

Next time I’ll be looking at compensating second-order systems as well as some interesting practical second-order plants which can complicate controller design.

If you have comments or questions about the article, please click here to contact the author through his EEWeb profile.

There are empirical approaches to designing proportional and integral gains, the most famous being the Zeigler-Nichols method.
In the portable electronics market, cell phones and MP3 players have greatly expanded the use of headsets for listening to music, making phone calls, and watching videos. The advent of the earbud has brought these devices into the modern era. Over time, by adding function and features, electronic device manufacturers have implemented these headsets in many different configurations. Without a cohesive audio-jack standard body, these accessories have diverged in ways that have made universal support difficult.

The ability to support multiple versions of headset devices as well as support advanced features of these headsets would help the ultraportable product vendor deliver a value-added experience for the end user.

Fairchild recognized the difficulty manufacturers were having with this and devised a family of audio jack device (ADJ) products.
The early days of the “earphone” was a monaural device needing only two wires leading to and from the earphone to the audio device. These devices were typically included with “transistor radios” of yesteryear. This was the beginning of the now, very commonplace use of the 3.5mm audio jack.

The next version of the earphone-style headset was the move to stereo. There were two ear pieces that each needed their own wire and return for a total of three wires. The 3.5mm audio jack now needed to be modified to support the third connection.

When cell phones started using headsets, the need for a microphone and hence a fourth wire was necessary, so the 4-pole 3.5mm jack was adopted. In addition to needing a fourth connection, device makers wanted to add additional functions such as a send-end button for answering and hanging up phone calls as well as buttons for pause-play or volume up-down. The camera industry also adopted this 4-pole connector to port audio and composite video from their devices. This additional capability complicated the use of the four-wire approach. There also have been different implementations of the jack pinout, which has been a major driver in the need for Audio Jack Detection products.

“Call processors and audio codecs lack the agility to keep up with changes in the 3.5mm jack world.”

The illustration at right highlights the basic compatibility issues created by the evolution of the 3.5mm audio jack. There are two basic methods for audio-phone implementations, one from the Open Mobile Terminal Platform (OMTP), and the other is the Cellular Telecommunications Industry Association (CTIA) standards in North America. Both are in use today and mobile device manufacturers would like their devices to work for both.

To further compatibility complexity, there are differences in the implementation of the headset itself, even using a similar pin out. Speaker impedance, amplification, microphone characteristics, and button resistances all spell trouble for anyone working on compatibility. Resistive detection, production testing, and battery charging are yet even more capability being added to this interface. For makers of large-scale application processors, call processors, and audio codecs don’t have the agility to keep up with the changes happening in the 3.5mm jack world. This phenomenon has spawned the audio jack detection (AJD) product market.

INPUT CHARACTERISTICS
Many different types of headsets exist, so anyone working on compatibility needs to know the differences. The following list gives some of the common types of headset, amplifier, and speaker type products. It should also be noted that some manufacturers build docking devices that allow plug in to an amplified audio system such as a car or home stereo system.

• 3 or 4-pole active (amplified and noise cancelling) headset, typically high impedance.
• 4-pole headset with send-end key, sometimes with volume up-down keys.
• Card readers such as Square or PayPal that utilize any of the 4 pins with low or high impedance.
• Data cables such as universal asynchronous receiver-transmitter (UART) for production testing or customer problem testing.
• Docking cables for use as auxiliary inputs to stereo systems and car audio systems.
• Ultraportable devices using an FM radio typically use the headset as an FM antenna as well as an audio headset.
• Text telephone (TTY) devices for the hearing impaired.

As shown by the above list, the headphone jack is being used for more than just audio. Modern devices such as cell phones and tablets need to be able to distinguish between these devices without burdening the end user. To add to the challenge of addressing the list above, it all must be done using very little power as battery drain is one of the largest annoyances of the end customer.
DON'T GET WET

The most attractive and sought after feature in cellular phones and MP3 players is their portability. This means people can take these devices just about anywhere in any weather condition. The downside of portability is the likelihood of the device getting wet either by natural causes such as rain or snow or something as simple as a spill. When moisture enters the device, the phone will not see a detach when the cord is unplugged, creating the same problem.

Manufacturers of these portable devices are always looking for ways to make their products more robust. Fairchild has developed technology to solve the moisture problem by being able to detect the difference between a valid device insertion and an accidental moisture event.

FAIRCHILD AUDIO JACK TECHNOLOGY

To accommodate all of the input and environmental possibilities, Fairchild has developed expertise in the following areas:

• **Audio Jack Detection** - Fairchild’s AJD devices employ a very low power initial detection circuit that allows other more power-hungry processors to be shut down. Fairchild has adapted the detection to differentiate between different types of audio headsets, not just the standard 16-32Ω versions. Headsets include passive and active versions as with noise cancellation or amplification.

• **Moisture Sensing and Detection** - For applications sensitive to moisture from perspiration or rain, for example, Fairchild technology can automatically avoid a false insertion or can report the condition to a higher processor for alternate decision making.

• **Microphone (MIC) and Ground Switching** - To accommodate both CTIA and OMTP headset implementations, the detection process needs to be able switch the GND and MIC contacts. This involves detection capability and a low resistance in addition to a low crosstalk method of switching the two connections. Bandwidth is also a concern in the case of FM antenna applications.

• **Lint Detection** - It is common for users of ultraportable devices to put them in their pockets, purses, or bags where dirt or lint could enter the audio jack and impair the insertion of a headset or other accessory. Fairchild’s most recent AJD products can detect the presence of lint and follow through with the detection process to determine proper accessory insertion.

• **Multikey Press Detection** - Many applications use buttons to control a phone call, audio muting, and audio volume. Typically this involves sensing resistors of various values. Fairchild’s AJD products can detect multiple resistance values to accommodate these applications.

• **Click and Pop Suppression** - One of the most common artifacts of plugging and unplugging audio jack accessories is the clicking or popping noises heard in the headset while inserting or unplugging. Typically this is due to MIC bias voltage being present on the sleeve, or outermost ring of the jack that gets dragged across the left and right headset connection on the way in or out. Fairchild has developed patented technology to prevent the MIC bias voltage from interfering with the attach-detach process.

• **On-Chip MIC Bias & MIC Preamp** - Having onboard bias ensures clean power to the microphone that is resistant to power supply rejection ratio (PSRR) events. The integrated preamp provides a low noise amplification that might otherwise pick up small-signal perturbations on the way to the codec amplifier.

• **Integrated UART Switch** - For devices requiring product testing, a UART switch is available to provide optional testing through the audio jack. Fairchild has implemented a switch with impressive total harmonic distortion (THD) and cross-talk specifications, even during audio listening with UART data switching on the off side of the switch.

For more information about Fairchild’s audio jack products, check out fairchildsemi.com.
HARDWARE DESIGN MADE EASY.


PCBWeb Designer is a free CAD desktop application for designing and manufacturing electronics hardware. The tool supports schematic capture and board layout, including integrated "click-to-order" manufacturing.

www.PCBWeb.com
Humavox PULLS the PLUG

Intuitive WIRELESS Charging Stations

Interview with Omri Lachman, Co-Founder & CEO at Humavox

Humavox hates a tangled mess of power cords, so they did something about it. The Israeli-based electronics developer took a fresh look at people’s tech habits when creating technology for box-like, wireless charging stations that suit just about any device. Whether hearing aids, smartphones, or tablets, Humavox has the technology to make recharging electronics devices a seamless, intuitive experience for users. By applying “the Dad Test”—Would my father use this technology?—the Humavox team is developing a portfolio of effortless charging solutions.

EEWeb spoke with Omri Lachman, co-founder and CEO at Humavox, about the company’s work to replace the 5-cent USB cord, the benefits of wireless charging, and how RF cavity resonance enables wireless charging stations. Lachman also discussed his company’s collaboration with Texas Instruments as well as the user-centered philosophy which defines research and development at Humavox.

“When I get in my car and place my smartphone in the cup holder, that cup holder is a charging cavity waiting to be activated.”

Omri Lachman (left) with Asaf Elssibony, Humavox Co-Founder and CTO.
Humavox specializes in wireless charging solutions, so could you give a little history on the field, explaining the company’s development rationale and current technology offering?

Nikola Tesla developed wireless power technology using magnetic induction over a century ago, and since then various companies have attempted to perfect this method, mostly aiming to charge cell phones. The initial motivation for wireless charging started to show up with smartphones and tablets. At Humavox, we think about wireless charging from a user-experience point of view first and then from a technological standpoint.

The first question that we had to ask ourselves was whether the device that needs to be charged, should actually be placed on a mat. Is doing that intuitive for users? Probably not, because people constantly engage with a device, continually picking it up and checking it. So even if I had a charging station here on my desk, charging would start and stop every second. That’s the big void that we saw, and we decided to develop a solution. Ultimately, we are trying to replace the 5-cent USB cord and the USB port on the PCB of the device. Our replacement has to be cost-effective and deliver a true value—not just a mild improvement. Our replacement has to work seamlessly, and if it is turning into a small rocket-science project, then we have gone too far.

When we started to work on the technology, we made a decision to build a platform rather than a component or product. You can’t force users to do something that you want them to do—it has to be intuitive. When I see a new technology, I always say to myself, “Awesome, but will my father use it?”

We were looking at technology that can be integrated into products and devices from all life categories, not just smartphones and tablets. I wanted a real solution that everyone could use.

How exactly does this technology work, and what advantages does it offer the user?

We did not start developing a technology without knowing how to fit it into a product; we thought about the user first, then the product, and then about how we can make the technology fit that idea. Our one guideline was to make sure that the technology fit the user seamlessly. This meant that the charging station could not be limited to just a single surface.

Our first project was studying device-usability patterns of the hearing impaired. In the study, we discovered a window of opportunity—when going to sleep at night, a hearing impaired person takes the hearing aid out of his or her ear and drops the device in the box that it originally came in. We knew that was the exact action we needed to mimic with our charging station. Instead of dropping a device into a box just for storage, we wanted the device to charge while being stored overnight.

We noticed that there are already so many boxes and storage areas for devices, so our goal with our product NEST was to turn these boxes, or cavities, into chargers. For me personally, when I get into my car, I place my smart phone in the cup holder. That cup holder is a charging cavity waiting to be activated. The technical name for this technology is “RF cavity resonance,” but we are doing it in a very unique way. Allowing the user to drop a device, especially one as tiny as a hearing instrument, into a storage cavity where it would charge at high efficiency no matter its alignment angle or placement position on the charging pad was the biggest challenge, and this is what our technology enables.

We are taking the concept of RF cavity resonance and applying it to various cavities, which means that the technology has no volumetric or geometric limitations. It also allows us to use a single, very simple, very small receiver unit, which—as opposed to magnetic coils for magnetic induction—is done in a shielded cavity. This provides a Faraday cage-like environment, which is used to block frequencies from coming in. However, we are doing the exact opposite; we are transmitting energy from within a Faraday cage, which exhibits an atypical RF behavior. It’s completely different from everything you know about RF technology has to be cost-effective and work seamlessly, but if it’s turning into a small rocket-science project, we’ve gone too far.”
in free space and communication purposes. This behavior allows us to get coupling conditions just like magnetic induction and magnetic resonance. However, with magnetic induction, coupling is dependent on the user; with our technology, coupling is achieved automatically, no matter how the device is placed in the charging station. Our wireless power-transfer efficiency—or RF-to-RF link—is usually over 90 percent.

We have the NEST charging station, which resonates RF. Any ETERNA platform-enabled device can be charged by NEST. The device will need to integrate ThunderLink® which is our receiver unit that functions as a virtual USB cord. Unlike other technologies, we developed a proprietary form of communication protocol that does not require Bluetooth or any other communication components, allowing our ThunderLink circuit the merit of small size in any form factor. This means our technology benefits from smart charging, while overcoming the receiver-module size hurdle in the device under charge.

The brains of the technology actually lie in NEST, which is the charger, rather than in the receiver, which allows ThunderLink and a very small and diversified form-factor capability. We seek to integrate ThunderLink with the power management chip or charger chip, which is already in any rechargeable device. NEST can be designed into any size and shape as well as charge multiple devices.

How large can the NEST be scaled? Could a tablet fit on it?
Yes, absolutely. NEST is a completely design-free concept with no strict volumetric or geometric design rules. It can be as big or as small as the designer would want it to be. A top-tier brand that has smartphones, tablets, and wearables can definitely design a charging station. The station can be placed in a way that will allow the user to interact with the devices while they’re charging. This allows designers to break free from the design limitations they have been given with wireless charging applications.

What exactly are the benefits of wireless charging?
When we look at wearables and IoT-connected devices, most of these devices will last more than one day on a single charge, so you don’t have the same issue with a smartphone, running around looking for a place to charge it. Our issue, rather, is to be ready with solutions, knowing that down the road there will be so many devices to charge. Whether smart watches, wristbands, or hats, our offering will store these devices together while simultaneously charging them.

When the device is charging, do you have to close a lid on it, or does it have to reside in a cavity in order to charge?
A Faraday cage does indeed need to be sealed. The first iteration of our device was actually an enclosed box, but it was not sealed in a traditional sense. Since then, we did manage to open that lid, so we are still capable of maintaining Faraday cage conditions with an open NEST.

The beauty of NEST is that if you are designing an application that needs to be in a closed box, that’s available, and if it needs to be partly open, then that’s also possible. Even if the Faraday cage is partially open, because of the power-transfer efficiency, only some energy or signal is lost to free space.

What is the next technological step you plan on taking with Humavox?
Right now, we are working with communications. We are already involved with original-equipment-manufacturer integration in some degree. You will be seeing Humavox-charged devices, or “Powered by ETERNA” devices in the coming year. On a longer-term scale, we are looking at how two technologies can come into one charging station. Many of our partners and customers work with us because we have the charging technology for tablets and laptops that will result in a smart charging station.

Could you talk about your work with Texas Instruments, and what that has opened up for Humavox?
We have received support from Texas Instruments’ power and battery-charge management group. They spotted us in an earlier stage in Humavox’s life cycle. Texas Instruments (TI) is a significant player in wireless charging. We are doing much work with them on new power-management chips that can complement our wireless charging enabler, ThunderLink, and vice versa.

We developed technology for wearables before the term “wearables” was coined. TI shared that vision with us, and we have worked together toward enabling this new frontier. We got the opportunity to combine our circuitry with their chips into a single enabler that can be offered to devices that are sensitive to size. That’s also a great part of our strategy—we are teaming up with several semiconductor and contractual engineering companies that cater to top-tier brands, as well as small startups looking for wireless charging solutions.
Maxim

1-Wire® Contact Packages

Maxim’s 1-Wire contact packages are designed for electromechanical connection in end products, not the typical solder-mount attachment. Combining this with 1-wire communication technology, Maxim is able to provide a smaller, simpler, lower cost, and more durable solution to add electronic functionality, such as memory or device authentication, to peripherals and consumables that typically don’t have such capabilities.

The ideal solution to add intelligence to a peripheral
Maxim's 1-wire contact package provides small solutions. This eliminates the cost, complexity, and reliability issues associated with the module approach. By leveraging Maxim's 1-Wire communication interface and its multi-drop capability, the host is able to address and parasitically power multiple peripherals with a single I/O, further reducing overall system complexity and cost.

The 1-Wire contact package can be used in any application where a peripheral needs to exchange data with a host. In a medical device, this might be to prove a sensor is authentic, provide the host with calibration data, and limit the number of times that sensor can be reused; all to ensure the system is being used properly and the patient is receiving the level of care promised by the OEM. Industrial applications could use this to identify peripheral modules to the host and provide usage history, reducing setup time and the possibility of human error in configuring the system and tracking usage.

**Features**

- Patented package solution adds electronic functionality to traditionally nonelectronic peripherals or consumables.
- 1-Wire interface requires only two large gold plated pads for easy alignment and a corrosion free, reliable contact system.
- Mechanically attaches to accessory with adhesive, heat stake, or retention clip.
- Simple pogo pin or sliding contact interface on accessory or host.
- Competing technologies mount IC package or die on substrate and sell as a module solution.

**Watch Video**

To watch a video overview on Maxim's 1-Wire contact packages, click the image below:
How To GaN

Generation 4 eGaN FETs

Widening the Performance Gap with the Aging MOSFET

The eGaN® FET Journey Continues

Alex Lidow
CEO of Efficient Power Conversion (EPC)
The previous columns in this series discussed the benefits of eGaN® FETs, their potential to improve performance in a variety of applications, and techniques to maximize the performance of GaN transistors. In this installment we will discuss a new family of eGaN FETs that is keeping Moore’s Law alive with significant gains in key switching figures of merit that widen the performance gap with the power MOSFET in high frequency power conversion.

INCREASED CURRENT CAPABILITY
Previously, increasing the output current in eGaN FET-based DC-DC converters required paralleling of multiple devices [1]. While paralleling high performance eGaN FETs could provide higher output power, the increased part count adds cost and complexity while reducing the power density of the system. The new family of eGaN FETs demonstrates a significant reduction in on-resistance (RDS(on)), enabling high current, high power density eGaN FET-based DC-DC converter applications. Figure 1 shows the latest generation of eGaN FETs with a voltage range from 30 V to 100 V and on-resistances ranging from 1.0 mΩ to 2.4 mΩ. Also part of the new Generation 4 family is the 200 V rated, EPC2019 that has a typical on-resistance of 33 mΩ and comes in an ultra-small footprint.

IMPROVED SWITCHING SPEEDS
While reducing on-resistance, as shown in figure 1, demonstrates the ability of the latest family of eGaN FETs to reduce the static conduction losses required for higher current operation, this metric does not directly correlate to better in-circuit performance, especially for high frequency power converter design, where switching losses are often the dominant loss mechanism.

In a traditional hard-switching transition, the switching losses are impacted primarily by two device parameters: \(Q_{Gd}\) and \(Q_{Gs}\). The gate-to-drain charge \(Q_{Gd}\) also known as the Miller charge, controls the voltage rising and falling transition time. \(Q_{Gs}\), which is the portion of the gate-to-source charge from the device threshold voltage to the gate plateau voltage, controls the current rising and falling transition time. The hard switching figure of merit (FOMHS) given below can be used to compare the in-circuit performance capability of a given device technology [2] in different hard-switched applications.

\[
FOM_{HS} = (Q_{GD} + Q_{GS})\cdot R_{DS(on)}
\]  

The new family of eGaN FETs demonstrates a significant reduction in on-resistance, enabling high current, high power density eGaN FET-based DC-DC converter applications.
As eGaN FETs increase the switching speeds capable with a power device, they are exposed to significantly higher voltage and current slew rates. The 4th generation of GaN power transistors demonstrates over a two-fold reduction in FOM over the previous generation, as shown in figure 2 (a). The 4th generation family of GaN transistors reduces FOM by 4.8 times, 8 times, and 5 times respectively for 40 V, 100 V, and 200 V devices when compared to the best state-of-art Si power MOSFETs. With lower FOM, improved device packaging, and low parasitic PCB layout, the high frequency performance of GaN based converters is significantly improved compared to Si MOSFETs, as will be demonstrated later.

**HIGHER DV/DT CAPABILITY**
As eGaN FETs increase the switching speeds capable with a power device they are exposed to significantly higher voltage and current slew rates. These conditions need to be well understood in order to fully utilize the technology. A high, positive-voltage slew rate (dv/dt) on the drain of an off-state device can occur in both hard- and soft-switching applications, and is characterized by a quick charging of the device’s capacitances. During this dv/dt event, the drain-to-source capacitance (Cds) is charged. Concurrently, the series combination of gate-to-drain (Cgd) and gate-to-source (Cgs) capacitors is charged. The concern is that, unless addressed, the charging current through the Cgd capacitor can charge Cgs beyond Vth and turn the device on. This event, sometimes called Miller turn-on, can be highly dissipative and even result in converter failure.

To determine the dv/dt susceptibility of a power device a Miller charge ratio (Qgd/Qgs) as function of drain-to-source voltage can be evaluated. A Miller ratio of less than one will ensure dv/dt immunity [3]. In figure 3 the large reduction of the Miller ratio in the 4th generation eGaN FETs is shown, with the entire product line falling below a value of 1 at half their rated voltage.

**EXPERIMENTAL RESULTS**
To highlight the improved performance of the 4th generation eGaN FETs in lower voltage point of load (POL) applications, a buck converter was built using a combination of the 4th generation eGaN FETs as the synchronous rectifier and 2nd generation eGaN FETs as the control device (see figure 4(b)). The converter combined the 30 V, EPC2023 (4th generation) with the 40 V EPC2015 (2nd generation) in a 12 V — 1.2 V DC-DC POL converter. Shown in figure 4(a) are the experimental results of the 12 V to 1.2 V, 40 A POL converter operating at switching frequency of 1 MHz achieving efficiencies above 91.5% and demonstrating the superior in-circuit performance of the 4th generation eGaN FET power devices compared to the 2nd generation of eGaN FETs (shown in green), and state-of-the-art Si MOSFET modules (shown in red).
With the improved performance provided by eGaN FETs, higher frequency can be achieved without significantly sacrificing efficiency. Shown in Figure 5 are the efficiencies of the 12 V to 1.2 V buck converters operating at switching frequencies of 1 MHz and 2 MHz. For both eGaN FET designs, increasing the switching frequency has a lesser impact on efficiency than a highly integrated MOSFET module.

**SUMMARY**

In this installment of the How to GaN series, the new 4th generation eGaN FETs have been introduced. eGaN FETs continue to raise the bar for power conversion performance. In on-resistance and in hard-switching applications, the 4th generation family of eGaN FETs doubles performance over the 2nd generation eGaN FETs. The result is a quantum step in efficiency improvements for DC-DC converters.

The EPC9018 demo board and the 4th generation eGaN FETs are available for purchase. Please visit [epc-co.com](http://epc-co.com) for more information.

**References**


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*Figure 5: Experimental efficiency comparison between eGaN FET and Si-based buck 12 V to 1.2 V P/W POL converters operating at switching frequencies of 1 MHz and 2 MHz.*