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Third Generation E^2POT Devices From Intersil-Part 1

The X9315 and X9316

The introduction of the X9315 and the X9316 from Intersil marks the beginning of the third generation of E^2Pots. Characterized by low power, low noise and small size, this generation of devices finds application in a number of new products. These range from portable, battery powered systems to audio control to sensor circuits sensitive to noise levels. This Application note presents some application ideas, the benefits of using E^2POTs and illustrates E^2Pot industry trends.

Intersil introduced the first E^2Pots in 1987 as NMOS devices. These revolutionary products found many applications where standard mechanical potentiometers were hard to adjust, made the system hard to design and were sensitive to unexpected resistance changes. But, these early E^2Pots were limited in their application by high power consumption. In 1992, the introduction of second generation CMOS E^2Pots brought a new standard to the industry. These devices offered lower power to systems designers. By 1995 3-V operation allowed designers to consider E^2Pots for portable applications.

The X9315 and X9316 third generation E^2Pots continues the trend to low power and add low noise and small packages to make true portable solutions possible. In addition to power and noise considerations, there are a number of reasons designers now choose digital potentiometers over mechanical types. The major areas are form factor, automated calibration, and reliability.

Often one of the first advantages of a digital pot (over a mechanical counterpart) is the ability to place the device in the most convenient location in the system. This lets the designer make the best use of the physical space to achieve small size or lower the cost of manufacturing. At the same time, the package designer places the pot controls at the most convenient location for the user. The result is a system that better meets the needs of both the designer and the user. New innovations in semiconductor packaging further increases the value of digital pots in system design, since single E^2Pots now fit in packages as small as 15 mm^2. In the future, quad potentiometers will fit in packages as small as the 24-lead TSSOP (only 50 mm^2). As more functions reside together with the digital pots on the same silicon, new small packages provide additional pins, without a significant loss of board space.

Automating system design is a key factor in the use of digital potentiometers. Today we have a global manufacturing model. It is no longer possible to design and build systems in the same plant. Often, a system designed in one country is manufactured in several others. This creates problems in communicating calibration procedures for optimum performance. Digital Pots become key in these situations. The designer can now build testability and automated calibration into the design while specifying the calibration procedure. This built-in procedure is repeatable at all manufacturing locations and is easily upgraded at any time in all sites by a simple software change. Now, with the addition of the new low power X9315, building in this automation need not add loading to the power supply or compromise circuit design performance.

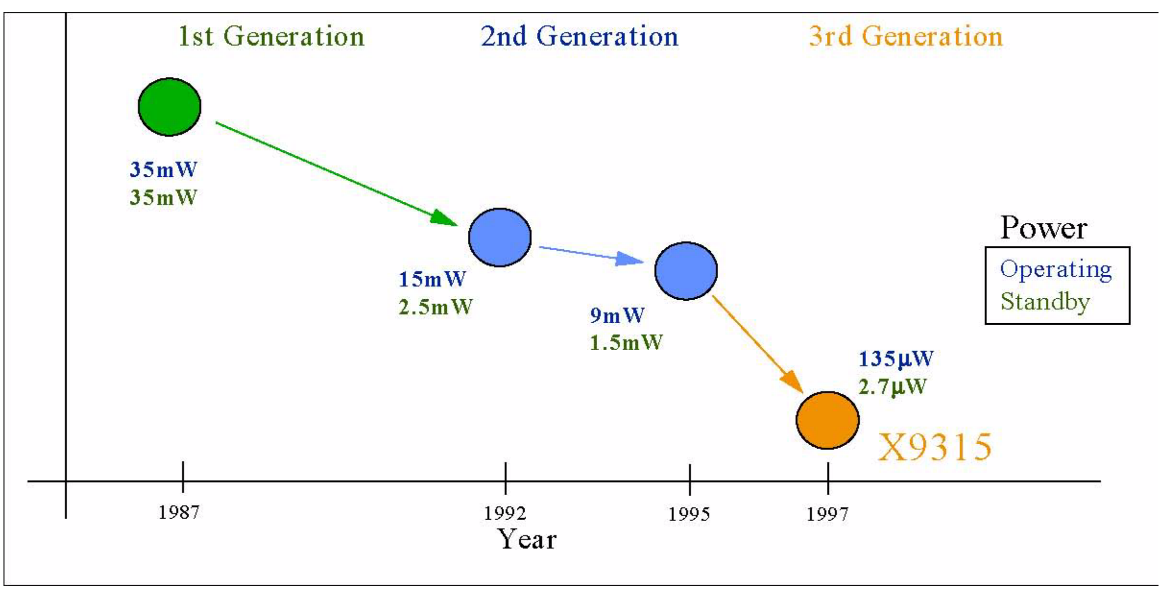

FIGURE 1. DIGITAL POT POWER TRENDS

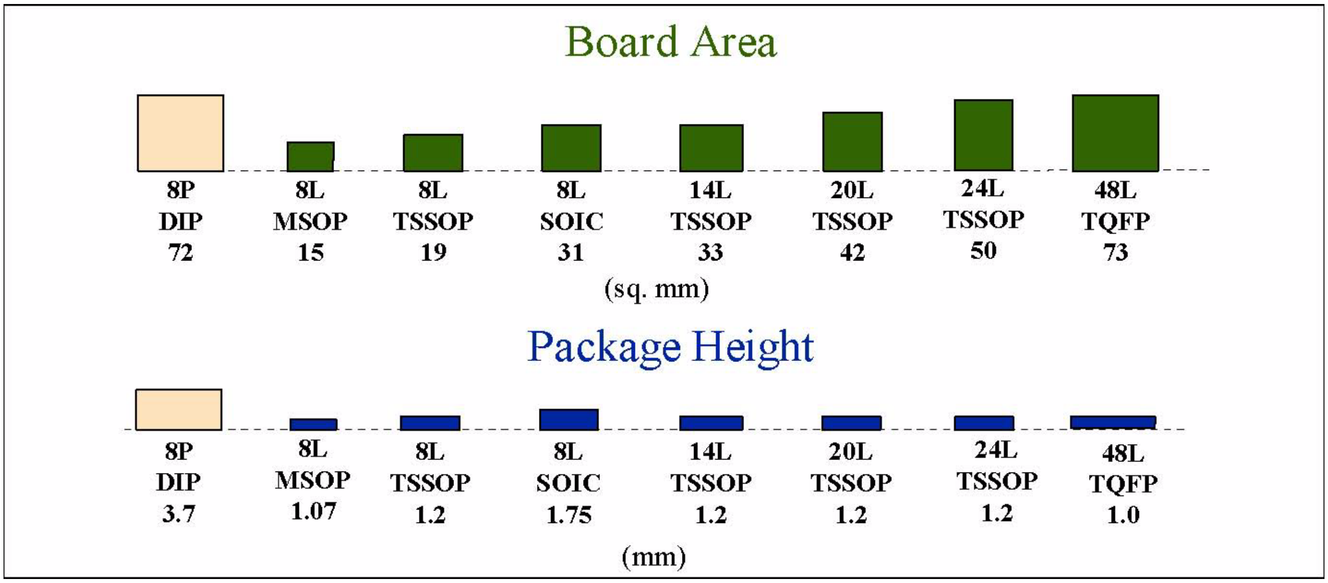

FIGURE 2. SMALL SIZE PACKAGES FIT ANYWHERE

Automatic calibration adds two additional features to a system design - for free! The first of these is remote calibration. What this means is that equipment in the field can now be recalibrated without sending a technician. A phone call is sufficient to make a change to a digital pot. This can save a tremendous amount of money on service calls and it can maintain equipment at the highest level for a very low cost.

The ability to adjust a potentiometer in-circuit adds another capability. In a system, components are always being stressed, by use or by the environment. With digital pots, the circuit itself can automatically and continuously recalibrate itself. The circuit then becomes adaptive, reacting to the environment and maintaining optimal performance.

The digital potentiometer increases system reliability. This improvement results from reducing the impact of environmental effects and by removing the temptation by individuals to recalibrate or optimize the system. Because there are no moving parts and because the wiper controls are separated from the active element, digital potentiometers can be sealed in a rugged weather-proof container. This virtually eliminates unwanted changes to the potentiometer setting.

Reliability of a system increases also because of the combination of non-volatility and digital control. A product calibrated in the factory and programmed one time only by special pot adjustment hardware maintains it's calibration and cannot be tampered with in the field, since there may be no control circuitry shipped with the device. This can dramatically reduce the number of returned units that the user thought to make better by "tuning" the circuit.

Third generation E^2Pots from Intersil implement a number of improvements to the circuit design to enhance operation. The first of these is the use of CMOS switches to lower overall operating current (when the wiper is moving) and standby current (when the device is powered, but not the wiper is not moving.) The X9315 operates with V_{CC} as low as 2.7V @ 50μA and takes only 1μA of current in standby. Future third generation E^2Pots from Intersil will be even more miserly.

The second improvement in the new E^2Pots from Intersil is the reduction of noise. One source of noise in earlier devices resulted from on-chip "charge-pumps". The charge pump provided higher voltages for biasing the wiper FETs. In the new devices, this bias voltage is supplier elsewhere. In the X9315, the biasing comes from the same digital supply that powers the device. This required FETs that do not need a high voltage bias. Another new device, the X9316 provides isolation between the digital and analog supplies. In these devices, the separate V+ and V- resistor bias voltage provides both low noise operation and power supply isolation. These changes result in 25dB less noise for the X9315 over the X9313. Future products will continue the use of these circuits for noise reduction.

The E^2Pot finds application in a wide variety of systems. To show the range of these applications, some examples appear in Figures 3 and 4.

LCD Contrast Control

LCD panels often require a backlight to improve display readability. The output level of the backlight must be adjusted to suit the ambient light levels. So this setting is often adjusted by the user to suit individual preferences. A potentiometer is a good choice for making these adjustments. A digital potentiometer is a better choice. With a digital potentiometer, software in the system can now control the contrast. This means that the system can use a “virtual knob” for adjustment that only exists as an image on the screen or as part of an existing keyboard. Since the LCD control typically requires a high voltage, the E^2Pot is typically coupled with an Op Amp that can supply the needed voltage. This combination works for controlling other high voltage applications as well.

Power Supply Adjustment

In this application, the E^2Pot controls the setting on a power supply. This adjustment is made as a final step in the manufacturing to calibrate the power supply output. This is a set and forget application, with the wiper position maintained in a nonvolatile register. This register maintains the wiper position even in the absence of power. Using the pot in this application prevents tampering with the output voltage. Because there is no unauthorized field adjustment, there are fewer “out of spec” returned units.

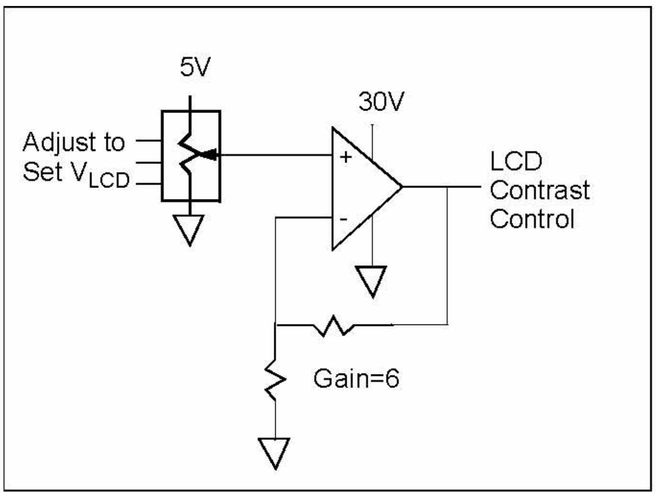

FIGURE 3. LCD CONTRAST CONTROL

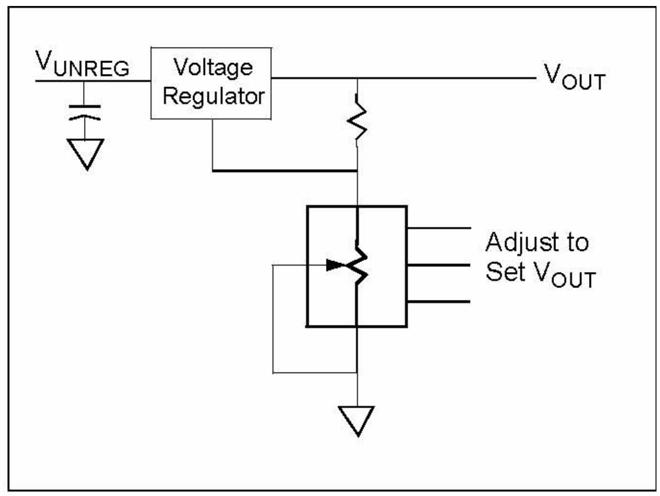

FIGURE 4. POWER SUPPLY ADJUSTMENT

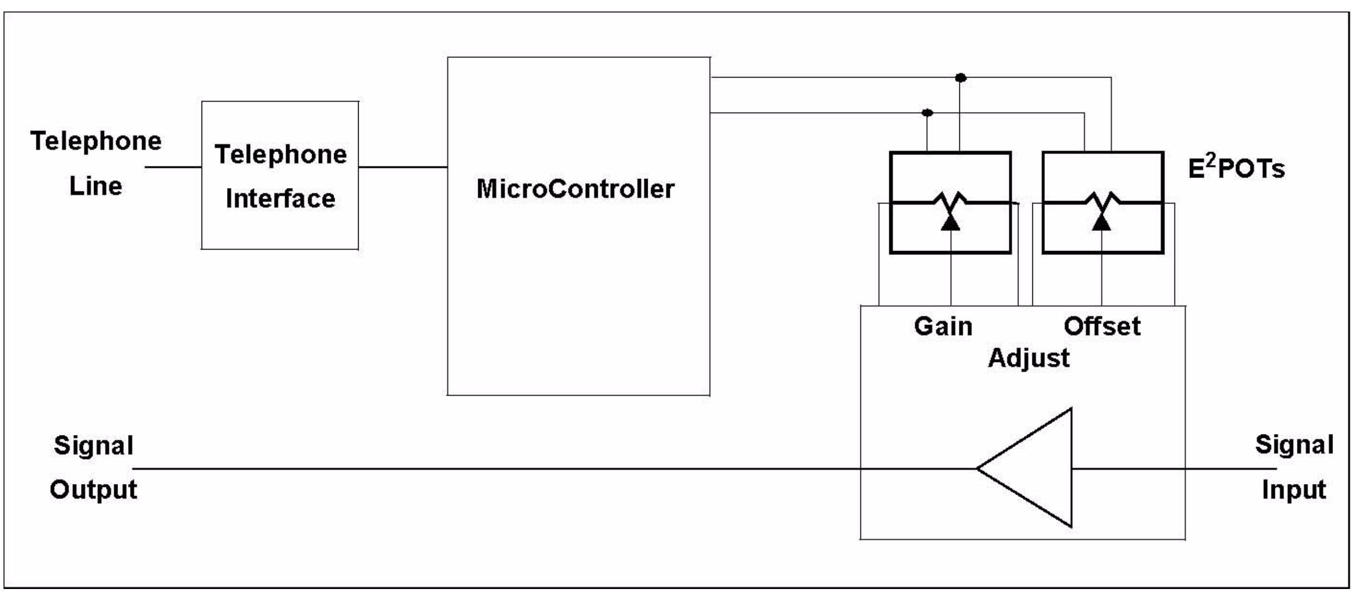

FIGURE 5. REMOTE CALIBRATION

Remote calibration

In this application, the E^2Pot resides in a piece of equipment located at a remote site. Because of the lack of access, it is very difficult to send a service person to make adjustments to this device. However, it is important to periodically calibrate the equipment to maintain offset and gain parameters to guarantee optimum signal levels. In this application, a telephone line communicates to the remote system. By sending signals to the remote system via the phone line and monitoring the output voltage levels on a separate cable, the signal conditioning circuits are maintained from hundreds of miles away.

The applications presented here are simplifications of actual system solutions. They are meant to convey the range of possible applications of digital potentiometers and the importance of Intersil's third generation advances. This technology will find it's way into new and innovative mixed signal devices from Intersil in the future as digital control of analog signals continues to gain in importance.

Part 2 of this Application note will accompany a new family of Third Generation devices from Intersil. In this Application Note the focus will be digital control of analog circuits and the benefits and application of increased integration.

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