Consider New Precision Amplifiers for Updated Industrial Equipment Designs

by Brian Black

Introduction

Industrial equipment is designed for long life cycles, so the electronic components used in industrial applications are often chosen with significant emphasis on proven performance, quality and reliability. Precision amplifiers are no exception. Even if new and innovative amplifiers become available over a product's lifetime, a redesigned board is often built using the same proven op amps in the old board. Even for entirely new applications, designers will choose amplifiers that have proven their mettle in other circuits, making a choice based more on familiarity than performance.

Although an amplifier may have been tried and proven in a design, it is not necessarily the best solution for every new design. Many can benefit from using more recently released amplifiers, which can improve overall system performance, reduce power consumption, shrink the board real estate and expand the capability of the system while reducing component count.

Table 1 shows is a list of high performance amplifiers and their features. Many are pin compatible with older amplifiers, making it easy to swap them into existing designs to update industrial applications.

Old and New Amplifiers Go Head-to-Head

What follows is a comparison of some old and new amplifiers, where the new can easily be swapped in for the old. Figures 1 and 2 show two applications that can benefit from the updated features offered in recently released amps.

Rugged LT1494 vs Miniscule LT6003

The LT1494 (introduced in 1997) is a precision micropower (375µV offset voltage at 1.5µA supply current) rail-to-rail input and output amplifier ideal

Table 1. Comparison of old and new high performance industrial amplifiers

Industry Standard Amplifiers	Features	Alternative Amplifiers	Feature Improvements
LT1078 LT2078	❑ Precision ❑ Micropower ❑ Single Supply	LTC6078*	❑ Higher Precision ❑ Lower Noise ❑ Faster
LT1012 LT1097	❑ Precision ❑ Low Noise ❑ Stable with any C-Load	LT1880	❑ Rail-to-Rail Out
LT1112 LT1114	❑ Low Power ❑ Matching Specs ❑ C-Load Stable	LT1881 Family LT6010 Family	❑ Higher Precision ❑ Rail-to-Rail Out
LT1494	❑ Ultralow Power ❑ Rail-to-Rail ❑ Precision	LT6003*	❑ Lower Power ❑ Lower Supply Range ❑ Smaller Package
LT1008 LT1055 Family LT1169	❑ Picoamp Input Bias Current	LTC6240 Family* LTC6084 Family* LTC6088 Family*	❑ Lower Power ❑ Lower Noise ❑ Higher Precision ❑ Faster ❑ Rail-to-Rail Out
LT1013 LT1014	❑ Low Offset	LT1490A LT1491A	❑ Rail-to-Rail In/Out ❑ Over-The-Top ❑ Lower Noise
LT1028	❑ Low Noise ❑ Low Drift ❑ Unity Gain Stable	LT6200 Family* LT6230 Family*	❑ Lower Power ❑ Faster ❑ Rail-to-Rail In/Out
LT1007 LT1037	❑ Low Noise	LT1677 Family	❑ Rail-to-Rail In/Out
LT1124 Family	❑ Low Noise ❑ Low 1/f Corner ❑ Precision	LT6202 Family* LT6233 Family*	❑ Lower Power ❑ Lower Noise ❑ Faster ❑ Rail-to-Rail In/Out
LTC1050 Family	❑ Zero Drift ❑ No External Capacitors	LTC2050 Family*	❑ Shutdown ❑ Lower Offset/Drift

* Maximum supply voltage is lower than predecessor

Table 2. LT1056 vs LTC6240HV

Feature:	LTC1056	LTC6240HV
Rail-to-Rail Outputs	NO	YES
Minimum Supply Voltage	10V	2.8V
Maximum Supply Voltage	40V	12V
Single Supply	NO	YES
Supply Current	7mA	3.3mA
V_{OS}	800µV	250µV
I_B	150pA	1pA
Noise Voltage Density	22nV/√Hz	10nV/√Hz
GBW	5.5MHz	18mHz
Slew Rate	14V/µs	10V/µs
Settling Time	600ns	900ns

for low power battery operated applications. Its rugged design includes reverse battery protection along with Linear Technology's Over-The-Top® feature, which allows inputs to operate above the voltage rails without affecting the amplifier.

For handheld systems where reducing space and extending battery life are top design priorities, the LT6003 can be swapped for the LT1494. The LT6003 is designed specifically with handheld devices in mind with higher integration, a smaller package, and a lower supply voltage than the LT1494.

The LT6003 also has a lower minimum supply voltage, 1.6V vs 2.2V for the LT1494. This feature allows the LT6003 to operate on a wider range of supplies and allows for a deeper discharge of alkaline batteries (known for the steep dropoff in battery voltage when depleted). The LT6003 further extends battery life with a lower supply current of 1µA vs 1.5µA for the LT1494. Consistent rail-to-rail inputs and outputs preserve dynamic range even at low supply voltages.

Furthermore, the LT6003 is offered in a tiny 2mm × 2mm DFN package, which is three times smaller than the LT1494's MSOP package. The LT1494 still has the advantage of higher maximum supply voltage of up to 36V vs the 18V of the LT6003. Also, the Over-The-Top inputs of the LT1494 make it a great choice for applications in which the inputs may go above the positive supply.

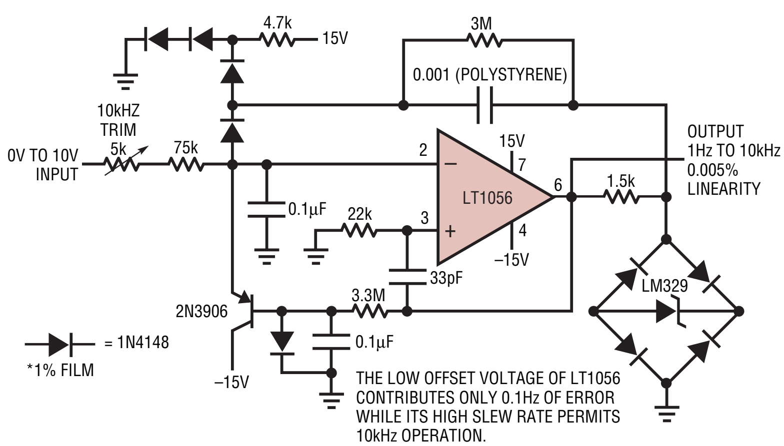

Figure 1. Precision: 1Hz to 10kHz voltage-to-frequency converter

The LT1677 Updates the LT1007 with Rail-to-Rail Inputs and Outputs

The LT1007, introduced in 1985 as one of Linear Technology's first product releases, is a precision low noise 40V amplifier with a great combination of DC performance, high gain, and low noise performance, making it ideal for small signal applications. However, since neither the inputs nor the outputs are rail-to-rail, the designer must take care to consider the headroom required for the part to function properly. Systems that can benefit from rail-to-rail inputs and outputs as a way to increase dynamic range, to reduce the supply voltage, or to eliminate the negative supply rail altogether, should consider using the LT1677.

The LT1677 is a single supply drop-in update to the LT1007 with the added benefits of rail-to-rail inputs and outputs. An important feature in low voltage (as low as 3V), single-supply applications is the ability to maximize the dynamic range. The LT1677's input common mode range can swing 100mV beyond either rail and the output is guaranteed to swing to within 170mV of either rail. This rail-to-rail benefit comes with minimal impact on noise and DC precision.

The LT1112 and LT1114 vs LT1881 Family and LT6010 Family

The LT1112 and LT1114 have a wide supply range of 2V to 40V, high precision and very low noise; there is not much missing from these older standards. An alternative to these parts is the LT1881 family, which adds rail-to-rail outputs. The LT1881 family brings the performance of the LT1112 to applications that need the wide dynamic range. Another option is the LT6010 family, which achieves higher precision than the LT1112/LT1114 and includes rail-to-rail outputs. It is especially attractive for low power applications due to its lower supply current and shutdown capability.

Conclusion

Amplifiers are highly versatile building blocks that can often be reused from one system design to the next, which can simplify redesign. The pitfall of reuse is that designers can miss out on the benefits offered by newer amplifiers, sometimes settling for sub-optimal performance, higher costs and larger system size, when a better solution is just as easy to use. Not only are most of the newer devices pin-to-pin functional equivalents, they offer additional benefits such as lower power, smaller size, or rail-to-rail outputs which can help next generation designs achieve longer battery life, better precision and smaller form factors.

Table 3. LT1078 vs LTC6078

Feature:	LT1078	LTC6078
Rail-to-Rail Outputs	NO	YES
Minimum Supply Voltage	2.3V	2.7V
Maximum Supply Voltage	44V	6V
Shutdown Mode	NO	YES
Supply Current	50µA	72µA
V_{OS}	120µV	25µV
I_B	10nA	1pA
Noise Voltage Density	$28nV/\sqrt{Hz}$	$16\ nV/\sqrt{Hz}$
GBW	200kHz	750kHz

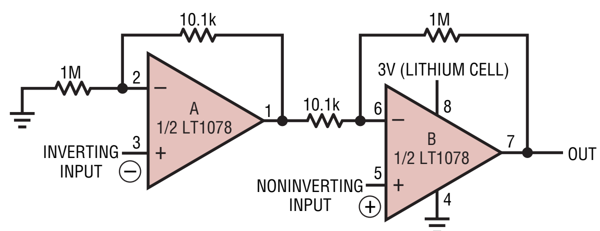

Figure 2. AC speed: single battery, micropower, gain = 100 instrumentation amplifier

LTC2978, continued from page 5

tion has been selected, the designer can save the parameters to a file and upload it to the LTC factory. LTC can use the file to pre-program parts, thus allowing the customer to bring up their boards with minimum hassle.

The LTC2978 utilizes the industry standard PMBus interface protocol which is a superset of the I^2C compatible SMBus standard. PMBus is an open and widely adopted standard that clearly defines the protocols for digital power management of individual DC/DC POL converters. The LTC2978 supports a large number of the PMBus commands. It also features a number of DC/DC converter manufacturer-specific commands to keep complexity low and versatility high.

Conclusion

With its unprecedented parametric accuracy, rich feature set, and modular architecture, the LTC2978 is an ideal solution for managing large arrays of DC/DC POL converters.

The industry standard PMBus interface, free PC-based graphical setup software, and integrated EEPROM make it easy to customize the LTC2978 for any application. Designers can use the PC-based graphical interface to configure a device and upload the configuration to the LTC factory. From this, Linear Technology can provide ready-to-use, pre-programmed devices, customized for the particular application.

Other features include an integrated precision reference, a multiplexed 15-bit ΔΣ ADC, eight 10-bit voltage-buffered IDACs, eight overvoltage and undervoltage 10-bit voltage supervisors with programmable thresholds and response times, and an integrated EEPROM for storing configuration parameters and fault-log information. The LTC2978 is offered in a 64-lead 9mm × 9mm QFN package.