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News Briefs

Maxim-Tektronix Deal Complete

Maxim officially completed the acquisition of Tektronix's monolithic integrated circuits (IC) operation located in Beaverton, Oregon on May 28, 1994. The deal included a joint venture with Tek to operate the hybrid IC business of Tek's wholly owned subsidiary, Tektronix Components Corp. As a major sales opportunity for Maxim, it provides a significant growth potential for the years to come. Maxim will maintain two separate sales organizations to support our growing standard product line and our new custom high-frequency product line.

Maxim's new custom high-frequency products consist of custom and semi-custom, high-frequency bipolar ASICs designed by the customer or by Maxim. For semi-custom products, analog designers use QuickChip/Bipolar arrays of transistors, capacitors, resistors, Schottky diodes, and JFETs that quickly interconnect to meet application requirements. The full custom products allow designers to determine the size and location of each specific component. To date, we have fabricated over 200 custom designs with a first-pass success rate that is unequaled.

In addition to new custom products, Maxim is offering new standard high-frequency products. Most notably, we have the MAX2101, the MAX445, the MAX3260, the MAX3261, and the MAX3262. The MAX2101 is a 6-bit quadrature digitizer providing an RF-to-Bits™ conversion for direct-broadcast satellite TV, HDTV, wireless LANs, and compressed digital-video cable TV. The MAX445 is a high-performance, monolithic display driver with a variable-gain transconductance amplifier offering a high-voltage, open-collector output for driving video displays directly. And, the MAX3260, MAX3261, and MAX3262 are a set of high-speed interface ICs for fiber optics communications. We are very excited to offer customers new standard IC products and new custom IC products.

New RS-232 ICs feature 1µA supply current, ±15kV ESD protection, and 3V operation

Maxim pioneered the use of charge-pump dc-dc converters for RS-232 interface ICs, and now offers more than 54 such products. Maxim's first products operated from +5V, and produced outputs greater than ±5V as required by the RS-232 standard. New products feature improvements such as 3V operation (using only four 0.1µF external capacitors), ±15kV ESD protection, and 1µA no-load supply current.

Many digital systems have moved towards 3V operation in order to increase density while decreasing power consumption. Maxim has responded with RS-232 interface ICs that operate at 3.0V and 3.3V, many of which use only four 0.1µF capacitors (**Table 1**).

Maxim is the only RS-232 IC manufacturer to specify and achieve ±15kV ESD protection using both the human body model and the IEC 801-2 air-gap discharge method (**see sidebar**). Maxim's extended ESD protection eliminates the need for costly external protection devices such as TransZorbs™, while preventing expensive field failures.

To further simplify RS-232 applications, Maxim has recently introduced transceivers that shut down automatically when not in use, reducing supply current to 1µA—a thousand-fold improvement over other parts. This action helps extend battery life in portable equipment such as notebook computers, palmtop computers, and bar-code scanners.

Also simplifying applications is an internal, digitally controlled switch that transforms a Maxim RS-232 transceiver from a DTE port (Data Terminal Equipment) to a DCE port (Data Communications Equipment).

The move to 3V operation

The standard supply voltage for notebook computers and other portable equipment is rapidly changing to 3V. To meet the needs of this market, many 5V RS-232 devices have been recharacterized for 3V operation. While these

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Table 1. 3V and 3.3V RS-232 ICs

Device	Supply-Voltage Range		No. of Drivers/ Receivers	Shutdown: No. of Receivers Active/ Current Drawn (µA max)	No-Load Supply Current (mA typ/max)	DC-DC Converter Architecture	Mouse Driver	Auto SHDN
	RS-232 (V)	RS-562 (V)						
MAX212	3 to 3.6	>3.0	3/5	5/15	1.5/3	Inductor	Y	N
MAX3212	2.7 to 3.6	>2.7	3/5	5/15	1µA/10µA	Inductor	Y	Y
MAX3232	3 to 3.6	>2.7	2/2	2/10	0.3/1	Regulated Capacitor Doubler	N/A	N
MAX3223	3 to 3.6	>2.7	2/2	0/10	1µA/10µA	Regulated Capacitor Doubler	N/A	Y
MAX3222	3 to 3.6	>2.7	2/2	2/10	0.3/1	Regulated Capacitor Doubler	N/A	N
MAX3241	3 to 3.6	>2.7	3/5	5/10	0.3/1	Regulated Capacitor Doubler	Y	N
MAX3243	3 to 3.6	>2.7	3/5	5/10	1µA/10µA	Regulated Capacitor Doubler	Y	Y
MAX218	1.8 to 4.25	>1.8	2/2	2/10	1.9 to 3	Inductor	N/A	N
MAX3218	1.8 to 4.25	>1.8	2/2	2/10	1µA/10µA	Inductor	N/A	Y
MAX562	–	2.7 to 5.25	3/5	5/130 0/50*	20/33	Regulated Capacitor Doubler/Tripler	N	N
MAX561	–	3 to 3.6	4/5	0/10	5/8	Unregulated Capacitor Doubler	N	N
MAX560	–	3 to 3.6	4/5	2/50	5/8	Unregulated Capacitor Doubler	N	N

** Receivers disabled*

Maxim achieves Industry's highest ESD protection: ±15kV

Protection level complies with human body model and IEC 801-2 air-gap discharge method

ESD (electrostatic discharge) threatens an electronic system every time someone replaces a cable or touches an I/O port. The discharges accompanying these routine events can render an I/O port useless by destroying one or more interface ICs connected to the port. These failures can be expensive in terms of both warranty repairs and perceived quality.

ESD can cause further damage to manufacturers, since equipment manufacturers may soon be barred from selling to the European Community if their equipment fails to meet minimum levels of ESD performance, as spelled out by IEC 801-2.

These two factors have led Maxim to develop a family of RS-232 products with ±15kV of ESD protection (**Table A**). These interface ICs are the only ones to specify and achieve ±15kV ESD protection using both the human body model and the IEC 801-2 air-gap discharge method. Maxim's high-ESD protection eliminates the need for costly external protection devices such as TransZorbs™, while preventing expensive field failures.

Older ESD Test Methods

Two methods have been commonly used for testing the ESD susceptibility of integrated circuits. The oldest, method 3015.7 of MIL-standard 883 (also known as the human body model), was developed to aid manufacturers in understanding the precautions necessary for packaging and handling ICs. This method tests each package pin against all other pins, and classifies a device according to the voltage at which the *first* failure occurs (which is usually on the pin most susceptible to ESD). The applied ESD waveform is derived from a circuit called the human body model (**Figure A**). The capacitance (100pF) models that of the human body, and the resistance (1500Ω) models the typical series resistance in the discharge path that includes the body, the IC, and ground.

The other method, EIAJ Method IC-121 (also known as the machine model) applies a waveform similar to that produced when an IC makes contact with automatic handling equipment. This method was developed by the Electronic Industries Association of Japan (EIAJ), and also uses the setup of Figure A, but with different values for R1 and C1. The resistance represents a human holding a metallic object such as a screwdriver, and the capacitance is that of a human body. For the resulting waveform, rise and fall times are steeper than those for the human body model.

The two methods are complementary, so one shouldn't be chosen over the other. Because ESD can affect ICs during manufacturing, during pc-board assembly, and after the end product is put into service, a test should be based on both methods to provide adequate assurance of the IC's tolerance for the rigors of manufacturing and insertion.

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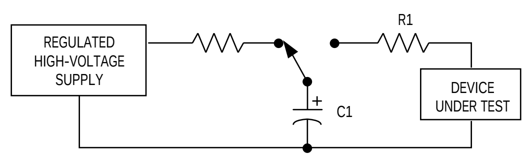

ESD TEST METHOD	R1 VALUE (Ω)	C1 VALUE (pF)
MIL-STD 883, METHOD 3015.7	1500	100
EIAJ, METHOD IC-121	0	200
IEC 801-2	330	200

Figure A. Most ESD standards specify the same test circuit, but with different component values.

Table A. RS-232-interface ICs with ±15kV ESD protection

Device	No. of Drivers/ Receivers	ESD Level (kV) Human Body Model	ESD Level (kV) IEC 801-2 Contact Discharge	ESD Level (kV) IEC 801-2 Air-Gap Discharge	Capacitor Value (µF)	Latchup Free	Data Rate (kbps)	No. of Active Receivers in SHDN	SHDN I_{CC} (µA)	Price 1000 pc. ($)
MAX202E	2/2	±15	±8	±15	0.1	Yes	120	0	N/A	1.85
MAX211E	4/5	±15	±8	±15	0.1	Yes	120	0	1	3.62
MAX213E	4/5	±15	±8	±15	0.1	Yes	120	2	15	3.62
MAX232E	2/2	±15	±8	±15	1.0	Yes	120	0	N/A	1.85
MAX241E	4/5	±15	±8	±15	1.0	Yes	120	0	1	3.62

parts do not generate the ±5V output swings required by RS-232 communications, they do meet the EIA/TIA-562 requirements of ±3.7V output swings. EIA/TIA-562 is interoperable with RS-232, although its output voltage is not sufficient to power a mouse, whose microcontroller typically requires 5mA at 5V.

To overcome the limitations of these recharacterized devices, Maxim has developed the MAX3241 family of 3V transceivers, which feature a low quiescent current, the capability to drive a mouse, a low-power standby mode in which some (or all) receivers are active, a flow-through pinout, and operation to 230kbaud (to support high-speed modems).

Unique output stage uses 50% less power

Maxim's key innovation in developing 3V parts is a driver output structure with very low voltage drop from input to output. Low voltage drop is important because the ideal dc-dc converter for 3.3V RS-232 transceivers is a capacitive voltage doubler. A perfect doubler would produce 6V for 3V minimum inputs, leaving a drop of just 1V for losses in the driver output stage and the dc-dc converter itself.

Moreover, the output swing for an ideal RS-232 transceiver would be ±5V with a tolerance of zero. A minimum of ±5V is needed to comply with the RS-232 specification, but any swing above 5V or below -5V simply wastes power. Regardless of input voltage, therefore, members of the MAX3241 family regulate their internal, voltage-doubling dc-dc converter to 5.4V—just enough to provide a safety margin after covering the 200mV drop in the driver output stage. The result is minimal power consumption at the nominal 3.3V supply rail.

An ideal (lossless) capacitive voltage doubler, unregulated, produces 6.6V with a 3.3V input and 10V with a 5V input. Thus, an RS-232 transceiver with internal 5V doubler wastes the 5V difference between its output (10V) and the desired ±5V as specified by the RS-232 standard. An internal 3.3V doubler, which wastes only 1.6V, is therefore much more efficient.

Similarly, an ideal 3.3V capacitive tripler generates 9.9V. The desired output is 5V, so the overall efficiency is only 5/9.9 (51%). Another way to compare the 3.3V doubler with the 3.3V tripler is to note that, for every 1mA drawn by the RS-232 load, the doubler draws 2mA (from the 3.3V supply) while the tripler must draw 3mA. Thus, the power saved by a 3.3V doubler is even greater when driving the capacitive load of a long RS-232 cable at high speed (**Figure 1**).

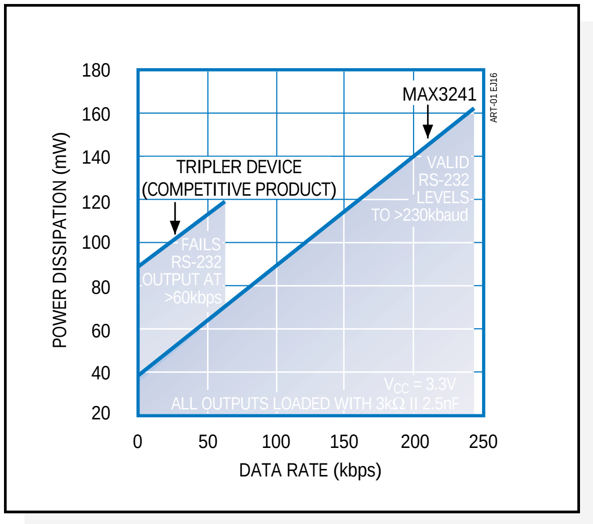

Figure 1. The MAX3241 (with voltage doubler) consumes only half as much as power as does the competitive device based on a voltage tripler. Note also, the MAX3241 maintains valid RS-232 output levels at quadruple the data rate.

RS-232 drivers must also supply output current for driving the input resistance (3kΩ to 7kΩ) associated with the RS-232 receiver at the far end of the line, and for charging and discharging the load capacitance (up to 2.5nF, as specified by the RS-232 standard). This charge/discharge current increases with frequency, and exceeds the resistive current at a data rate of 80k bits/sec (40kHz). Thus, a voltage doubler at high data rates saves even more power.

Auto-shutdown—the ideal RS-232 IC

The RS-232 port in most portable systems transmits and receives for only a small percentage of the time that power is applied; for the rest of the time it may waste power needlessly. An ideal RS-232 transceiver, therefore, should shut itself down when not transmitting or receiving.

Early RS-232 ICs for portable systems provided a shutdown pin, but the result was complete shutdown (deep sleep) in which the chip had no way to detect incoming data. So, the next step was to provide receivers that remained active during shutdown.

The operating system can theoretically shut down an RS-232 port if, after a suitable delay, it sees no incoming data transitions or status-line changes. But the choice of delay period presents a problem—you can miss data if you happen to power down just as a data burst begins, and you'll probably miss some of the data that wakes up the system and initiates power-up. For these reasons, designers seldom go to the trouble of introducing a monitoring delay by rewriting the BIOS/operating system.

Table 2. RS-232 transceivers with automatic-shutdown circuitry

Device	Supply Range (V)	No. of Drivers/ Receivers	No-Load Supply Current (µA typ/max)	No. of Receivers Active in Standby
MAX3212	2.7 to 3.6	3/5	1/10	5
MAX3218	1.8 to 4.25	2/2	1/10	2
MAX3223	3 to 3.6	2/2	1/10	2
MAX3243	3 to 3.6	3/5	1/10	5

Maxim engineers had the following goals in designing a new RS-232 transceiver:

1) Use power only when transmitting and receiving data.

2) Meet goal #1 with no compromise in performance.

3) Meet goal #1 with no increase in cost.

An obvious approach is to include a timer that shuts down the IC after a desired time interval. But this thwarts goal #3 by increasing the die area. The better solution is to monitor all incoming data lines for valid levels of RS-232 signal voltage. All receiver inputs will be near ground, for example, if the RS-232 port is not connected or if the far-end transceiver is turned off. Either way, the absence of valid signal levels causes the chip to enter its shutdown mode automatically, reducing the typical no-load supply current to 1µA.

Maxim has recently introduced four devices with automatic shutdown (**Table 2**). Most include an output (valid RS-232) that indicates to the system processor whether an active RS-232 port is connected at the other end of the cable. The MAX3212 goes one step further; it includes a transition-detect circuit whose latched output, applied as an interrupt, can wake up the system when a change of state occurs on any incoming line.

To see the benefits of automatic shutdown, compare the supply currents of Maxim's earlier RS-232 transceivers against those of their auto-shutdown counterparts:

Original Device	No-Load I_{SUPPLY} (µA max)	Auto-Shutdown Device	No-Load I_{SUPPLY} (µA max)
MAX3222	500	MAX3223	10
MAX3241	1000	MAX3243	10
MAX218	3000	MAX3218	10
MAX212	3000	MAX3212	10

Auto-shutdown devices have FORCE ON/$\overline{\text{FORCE OFF}}$ controls (**Figure 2**) that can override the automatic circuitry and force the transceiver into its low-power-standby state or its normal-operating state. When neither control is asserted, the IC selects between these states automatically. As a result, the system saves power without changes to the existing BIOS/operating system.

DTE/DCE in one IC eliminates null modem

Also useful for RS-232 transceivers is the capability for switching between two standard configurations: DTE port and DCE port. The most common example is a dumb terminal or personal computer (DTE port) connected to an external modem (DCE port). For this case, the connecting cable provides straight-through, 1-to-1 connections. Similarly, the serial cable for a printer is designed to plug into a DTE port at the computer end.

But, problems arise if you must connect two computers together. Both are DTEs, so the standard DTE-to-DCE cable won't work. The usual solution is a special LapLink™ cable, or a "null modem" that converts one of the DTE ports to a DCE. A null modem is nothing more than two back-to-back connectors with various wires transposed. The most common type of null modem is fully implemented by a single chip (MAX214) whose internal circuitry (under the control of a single logic-level input) performs all the necessary wiring transpositions.

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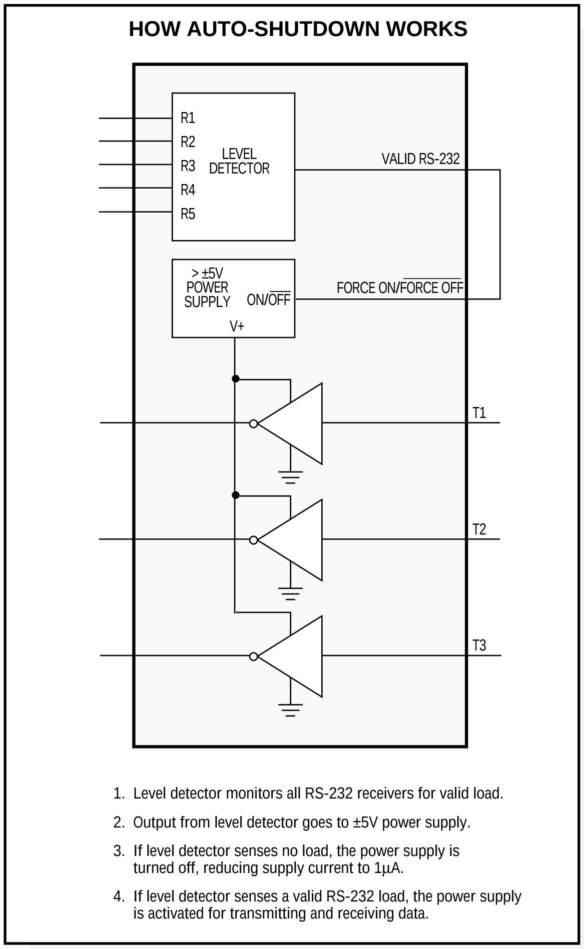

Figure 2. The MAX3223 transceiver family combines ease of use (automatic shutdown) with the flexibility of override controls that force the IC into shutdown or normal operation.

(Circle 1)

(continued from page 4)

But, neither method can accurately assess the reliability of an IC connected to the outside world. Both methods rate an IC according to the lowest-voltage failure on *any* pin, which is not an adequate test if the device includes I/O pins. I/O pins usually require (and often have) higher levels of ESD protection than do other pins.

As an example, an IC's I/O pins might withstand ±15kV while its other pins withstand only ±2kV. The two methods above would therefore rate the IC for only ±2kV. To resolve this problem, manufacturers are using a newer test method—IEC 801-2 (a test developed by the European community)—for rating RS-232 ICs and other devices that connect directly to the "outside world." As a result, the successful completion of IEC 801-2 may soon become a necessary condition for selling equipment in Europe.

Newer ESD Test Method

Although originally intended as an equipment-level test for Europe, IEC 801-2 is now gaining acceptance worldwide as the most appropriate ESD test for IC pins accessible to users of end equipment. The IEC 801-2 method, unlike the two previous ones, tests only I/O pins. A device's ESD rating with this method, therefore, is determined solely by the protection afforded by its I/O pins.

IEC 801-2 specifies ESD testing by either contact discharge or air-gap discharge. The commission prefers contact discharge, though this represents a compromise. An ESD event caused by actual contact is more repeatable, but less realistic. Air-gap discharge is more realistic, but varies widely in amplitude according to temperature, humidity, barometric pressure, distance, and rate of closure with the IC.

IEC 801-2 defines four levels of compliance (**Table B**), according to the lowest-maximum voltage withstood by the I/O pins. The levels accommodate both contact and air-gap discharge. Maxim's ICs meet the highest level (level four) for contact and air-gap discharge, and are the only RS-232 ICs to achieve this level of protection.

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Table B. IEC 801-2 Compliance Levels

IEC 801-2 Compliance Level	Maximum Test Voltage	
	Contact Discharge (kV)	Air Discharge (kV)
1	2	2
2	4	4
3	6	8
4	8	15

(continued from page 7)

Testing ICs for ESD ruggedness requires the use of an "ESD gun." The gun allows testing with either contact or air-gap discharge. Contact discharge requires physical contact between the gun and the IC before the test voltage is applied. Air-gap discharge, on the other hand, requires the gun to be charged with the test voltage before approaching the IC (from the perpendicular, and as fast as possible). The second technique produces a spark at some critical distance from the test unit.

ESD produced by air-gap discharge resembles actual ESD events. But, like actual ESD, the air-gap discharge variety is not readily duplicated. It depends on many variables that are not easily controlled. IEC 801-2 therefore recommends the contact-discharge technique, attesting to the general importance of repeatability in testing. In either case, the test procedure calls for at least ten discharges at each test level.

DO'S AND DON'TS OF ESD TESTING

1) **DO** USE STANDARD TEST EQUIPMENT. Repeatability in ESD testing is difficult enough as it is, without introducing additional unknowns through home-built setups. For IEC 801-2 testing, Maxim uses an NSG 435 ESD gun by Schaffner. For testing to MIL-STD-883 Method 3015.7, Maxim uses a Model 4000 tester by IMCS.

2) **DO** PERFORM A COMPLETE SET OF PARAMETRIC TESTS ON THE DEVICE UNDER TEST, BEFORE AND AFTER THE ESD TESTING. ESD usually causes catastrophic failures, but it can also introduce subtle and latent damage that appears later as a field failure. Leakage currents in particular should be closely monitored to detect this damage.

3) **DO** TEST THE ENTIRE RANGE OF ESD VOLTAGES (not just the upper limit). Many ESD-protection structures can withstand the highest ESD voltage for which they are guaranteed, but fail at a lower level. Maxim tests each device pin, starting at 200V and progressing in 200V increments until failure occurs or the ESD tester's limit is reached.

4) **DO** REQUIRE PERFORMANCE TO ALL RELEVANT STANDARDS. MIL-STD-883, for example, simulates the ESD encountered by an IC during assembly and distribution (shipping). IEC 801-2, which applies only to pins that connect outside the local system, simulates ESD events that might occur in the end equipment.

5) **DO** PERFORM IEC 801-2 TESTING WITH POWER ON AS WELL AS OFF. Some competing ICs, both bipolar and CMOS, exhibit SCR latchup when subjected to an ESD event while the power is on. SCR latchup can cause destructive supply currents. Even if not destructive, latchup usually prevents normal operation until removed by turning off the IC's power.

♦ ♦ ♦

1) **DON'T** MISAPPLY THE STANDARDS. Some standards address the survival of all pins during distribution and manufacturing; others address only the survival of pins that are externally accessible in the end equipment.

2) **DON'T** TRUST UNSUBSTANTIATED CLAIMS that give no information regarding the test equipment or procedures used.

3) **DON'T** ASSUME that bipolar ICs are inherently better than CMOS ICs, or vice-versa. What counts is the actual performance in an application.

DESIGN SHOWCASE

Dual, V_{OUT} DAC consumes miniscule power

The dual voltage-output DACs of **Figure 1** employ a combination of power-conserving tricks to draw less than 20µA from a 5V supply. The circuit suits a need for programmable voltage generation in slow or static applications, such as the nulling of offsets in a micropower instrument.

Current-output DACs normally waste power by routing the complement of I_{OUT} to ground. The circuit of Figure 1 avoids wasting power by operating each DAC in the reverse voltage-switching mode, in which the reference voltage is applied to the pins normally labeled I_{OUT}.

The OUT pins in this circuit have a constant and relatively low input impedance of 11kΩ. To reduce input currents, the reference voltage is divided by 100 (from 5V to 50mV), and therefore delivers only 5µA to each DAC input. Signal levels are restored by a compensating gain of 100 in each output amplifier. Inexpensive 10MΩ/100kΩ resistor networks are a good choice for the multiple 100:1 attenuators required. Though only 2% accurate, their matching and tracking is much better than that of discrete resistors.

Greater scaling is impractical because of 0.5mV (maximum) offsets in the output amplifiers shown. Amplified by 100, these offsets produce worst-case output errors of ±1% (0.05V). The errors are constant over temperature, but additional error due to drift over a range of 40°C is typically ±½LSB. The micropower output amplifiers shown in Figure 1 were chosen for their low supply current—their typical I_{DD} is only 1µA.

The last requirement for minimizing the overall current drain is to insure that logic signals applied to the digital inputs of IC1 swing to within 0.2V of each rail. The maximum specified I_{DD} for that condition is 100µA over temperature, but this specification (like most CMOS I_{DD} ratings) is extremely conservative. I_{DD} is negligible for rail-to-rail swings, but rises dramatically as the swings approach TTL levels.

A version of this idea has appeared in Electronic Design.

(Circle 2)

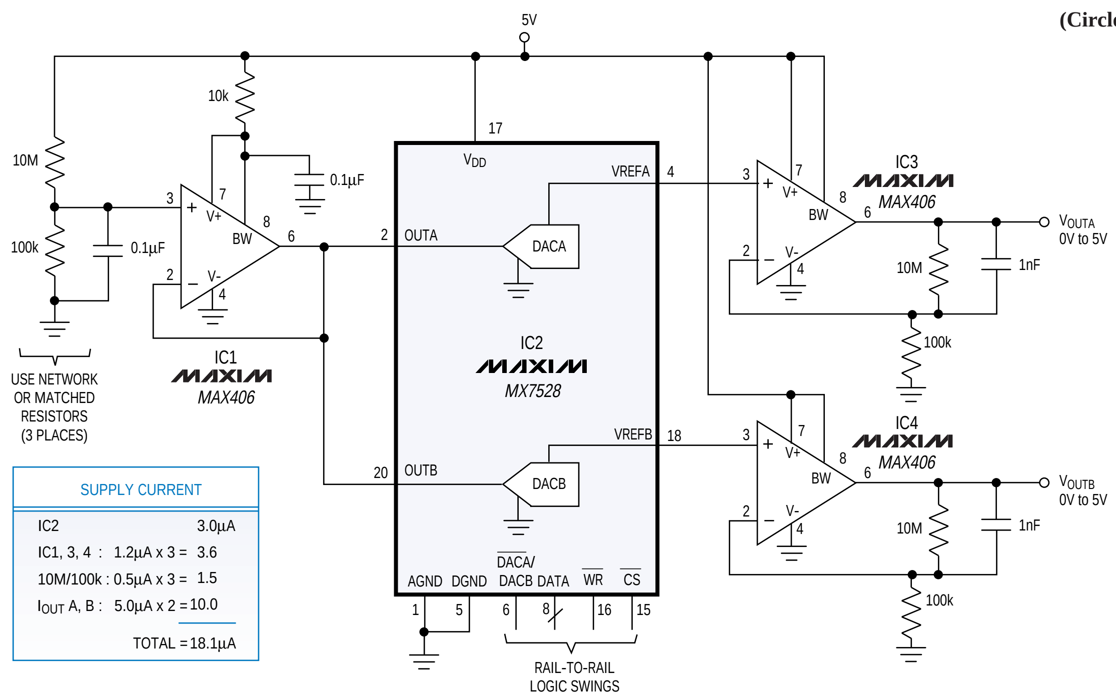


Figure 1. Providing two independent 8-bit DACs with voltage outputs and a common reference, this dual-DAC circuit draws less than 20µA from a 5V supply.

Allpass network shifts 90° over wide frequency range

Unlike lowpass, bandpass, and other magnitude-shaping filters, allpass filters are able to shift the phase of a signal without affecting its amplitude. For a first-order allpass, the transfer function is:

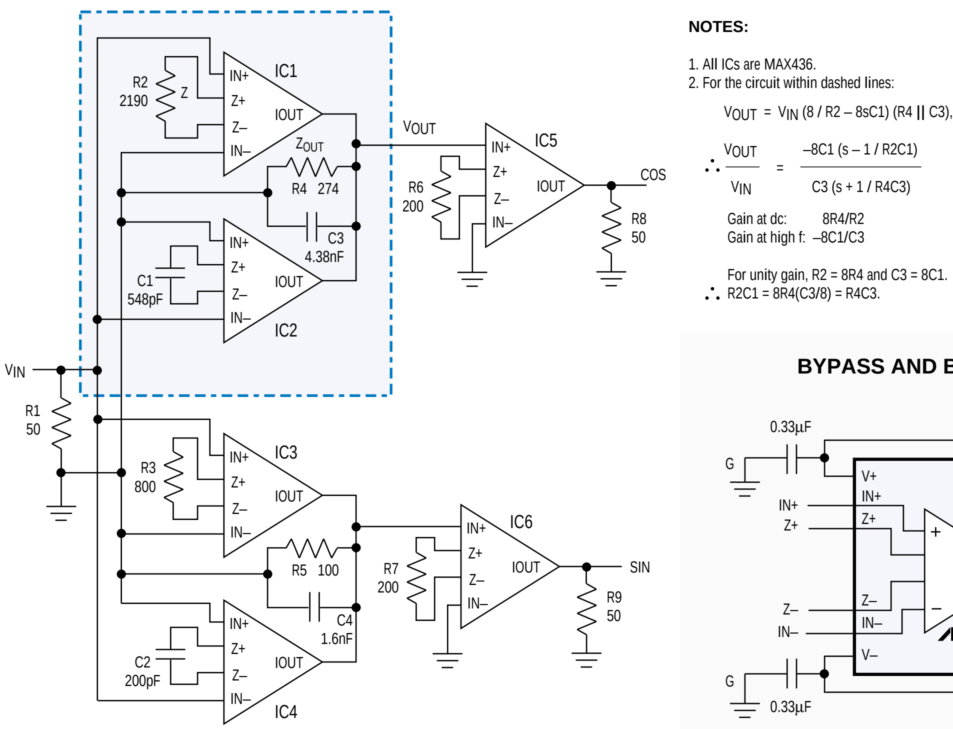
$$H(s) = -\frac{s - a}{s + a}$$

As you sweep the variable "s" from zero (dc) to infinity, the sign of H(s) changes from plus to minus, indicating a change in phase from zero to 180°. You can implement this function with two wideband transconductance amplifiers (WTAs), as shown within the dotted lines of **Figure 1**.

The WTA's transfer function is $I_{OUT} = 8V_{IN}/Z$, where "8" is an internal constant and Z is the gain-setting impedance. Most transconductance-amplifier applications require a resistive Z, but the WTA has an unusual capability that enables synthesis of the allpass function—it lets you connect an inductor, a capacitor, or any other impedance network for Z. $V_{OUT} = I_{OUT}Z_{OUT}$, so the transfer function for voltage amplification is $V_{OUT}/V_{IN} = 8(Z_{OUT}/Z)$. Unity gain demands $Z = 8Z_{OUT}$, as shown.

The allpass circuit combines a resistive-Z WTA (IC1) with a capacitive-Z WTA (IC2). At low frequency the circuit's output current is dominated by IC1 because C1's high impedance produces low I_{OUT} from IC2. Rising frequency lowers this impedance, causing the current from IC2 to dominate at high frequencies. Moreover, IC2 inverts and IC1 does not, which provides the desired effects of noninverting unity gain at dc and inverting unity gain at high frequency.

Allpass networks are widely used in communications and signal-processing applications. An example is the 90° phase-shift network used (with mixers) to produce a single-sideband signal. In Figure 1, the two allpass circuits have corner frequencies



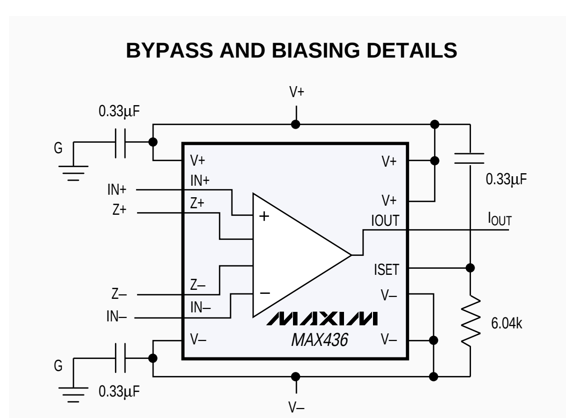


Figure 1. Two wideband transconductance amplifiers (dotted lines) produce an allpass network. Combining two such networks as shown produces two outputs with a constant 90° phase shift (vs. frequency) between them.

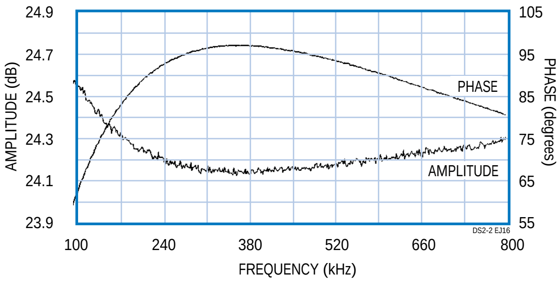


Figure 2. This network response for Figure 1 shows a ±7° deviation in phase and a 0.2dB deviation in amplitude over the range 180kHz to 740kHz.

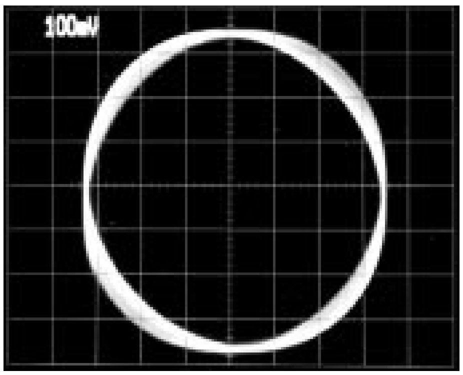


Figure 3. The XY display of an oscilloscope gives another measure of performance for the Figure 1 circuit (a perfect circle of uniform thickness indicates a constant 90° phase shift).

(determined by the output RC networks) that differ by a factor of 7.5. The result is an output phase difference that remains close to 90° over a wide frequency range.

This allpass performance can be illustrated in two ways. The network response (**Figure 2**) shows 0.2dB amplitude variations and a phase difference of 90° ±7° from 180kHz to 740kHz—a 4:1 range. An oscilloscope's XY display offers another way to assess the deviations from 90°: constant 90° produces a circle, and phase deviations cause a thickening of the trace as shown in **Figure 3**. The photo represents an input-frequency sweep from 100kHz to 800kHz.

A version of this idea has appeared in EDN.

(Circle 3)

Voltage regulator converts to current source

The switching regulator of **Figure 1** includes independent loops of current and voltage feedback for maintaining regulation. By disabling the voltage loop, you can use the current loop to implement a general-purpose current source.

First, apply 5V to V+. Because the chip expects 12V of feedback at that terminal, it assumes a loss of regulation and shifts control to the current loop. This mode of operation allows an increasing ramp of current through Q1, causing the voltage at CS (pin 8) to increase until it reaches the internal comparator threshold (210mV). Timing circuitry then turns off Q1 for a fixed 2.3µs, and the cycle repeats. The result is a relatively constant inductor current, which is also the load current (**Figure 2**).

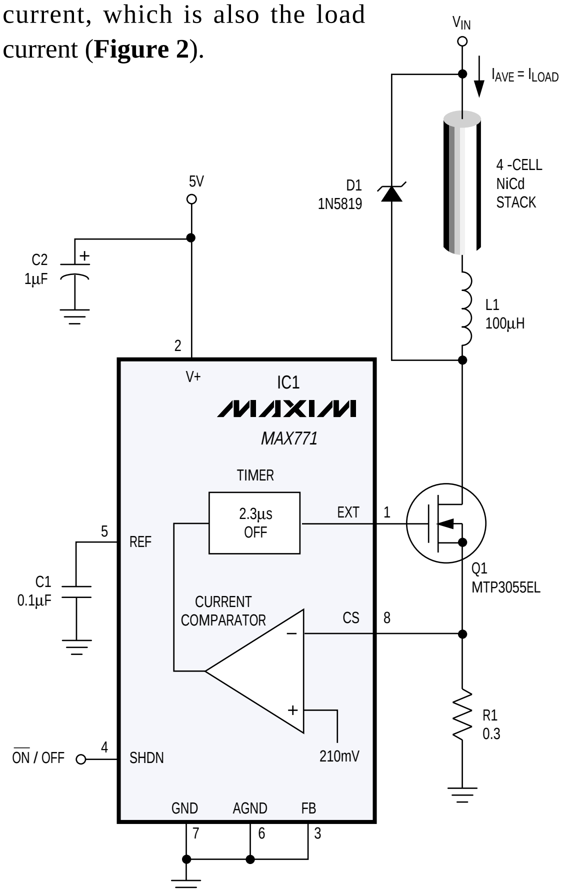


Figure 1. The connections shown convert this switch-mode voltage regulator to a general-purpose current source.

With the proper component values, the circuit generates constant current over a wide range of input voltages. The Figure 1 circuit (with component values shown) is a fast charger for NiCd batteries that provides 600mA charging currents. Calculations are as follows:

The peak inductor current is $I_{PEAK} = V_{SENSE}/R1$, where V_{SENSE} is the 210mV threshold of the current-sense comparator. The dither current (peak-to-peak value of the ac component of load current) is:

$$(1) \qquad I_{DITHER} = V_{BATT}t_{OFF}/L,$$

where V_{BATT} is the battery voltage, t_{OFF} is the 2.3µs interval mentioned earlier, and L is the inductance of L1.

As illustrated in Figure 2, the average inductor current is $I_{AVE} = I_{PEAK} - \frac{1}{2}I_{DITHER}$. Substituting from above,

$$(2) \qquad I_{AVE} = \frac{V_{SENSE}}{R1} - t_{OFF}(V_{BATT}/2L).$$

First, choose an average current for the proposed current source (600mA in this circuit). Next, determine the nominal value of V_{BATT} (4.8V in this case). Next, to ensure a relatively small ac (vs. dc) component, set the dither current in equation 1 less than $0.2I_{AVE}$ and solve for L:

$$(3) \qquad L \geq \frac{V_{BATT}t_{OFF}}{I_{DITHER}} = \frac{4.8V(2.3\mu s)}{0.2(600mA)} \geq 92\mu H.$$

(Use L = 100µH.)

Next, plug this L value (100µH) into equation 2 and solve for R1:

$$(4) \quad R1 = \frac{V_{SENSE}}{I_{AVE} + V_{BATT}t_{OFF}/2L}$$

$$= \frac{210mV}{600mA + 4.8V(2.3\mu s)/200\mu H} = 320m\Omega.$$

(Use R1 = 300mΩ.)

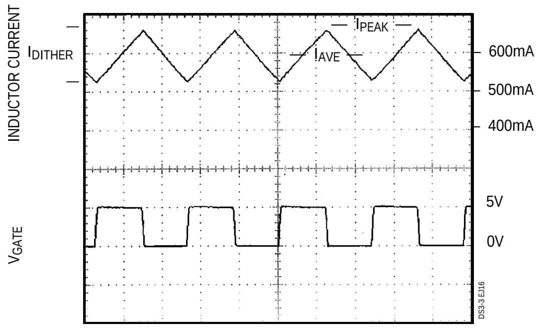


Figure 2. The gate drive for Q1 and the resulting current through L1 are related as shown.

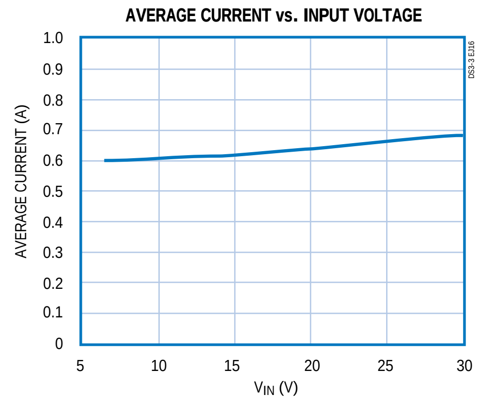


Figure 3. Current-source errors increase with input voltage, as explained in the text.

Three forms of error cause I_{AVE} to deviate from the specified 600mA (**Figure 3**): variations in V_{SENSE}, delay through the comparator and MOSFET (Q1), and tolerance on the current-sense resistor R1. At lower voltages, the largest error is that of V_{SENSE}, specified in the IC1 data sheet as 210mV ±30mV or about 14%. (In this circuit the value was about 190mV.)

At higher voltages, delays cause the peak current to overshoot the current limit. You can minimize this error by choosing the inductor value as follows:

(5) $L \text{ (in µH)} \geq 5.5(V_{IN} - V_{BATT})$,

with V_{IN} and V_{BATT} in volts.

Other error sources—the variations in V_{BATT}, t_{OFF}, and L—are relatively small because they relate to I_{DITHER}, which is limited to a small fraction of I_{AVE}.

(Circle 4)

DESIGN SHOWCASE

Boost/linear regulator derives 5V from four cells

Boost regulators usually fall out of regulation when V_{IN} rises above V_{OUT}. But, following the boost regulator with a linear regulator enables the combination to maintain a nominal regulated output for inputs that range above and below that level. The circuit of **Figure 1**, for example, maintains a regulated 5V for inputs from 3V to 10V. For inputs above 3.2V, the circuit can start up under a full load of 1A.

The boost regulator (IC1) is a switching type that produces a regulated output of approximately 5.3V for V_{IN} less than 5.7V. For V_{IN} above 5.7V it does not maintain switching action, so Q2 shuts off and dc current flows from V_{IN} through L1 and D1. (This behavior is typical for boost regulators when V_{IN} is greater than the nominal output voltage.) With high input voltages, the boost-regulator output rises above 5.3V, but the linear regulator (IC2B) assures a constant 5V output.

This configuration is suitable for 5V supplies derived from batteries of three to five cells, and for dual-input applications in which either a battery or an external dc source provides the input voltage. (Some systems, for example, let you remove the battery while applying power with an external charger.)

Boost regulators powered by their own output voltage (bootstrapped regulators) often have trouble starting under load. The difficulty centers on the external switching MOSFET—it can't substantially boost V_{OUT} until it sees a full-amplitude gate drive, and the gate drive can't achieve full amplitude until V_{OUT} is substantially boosted.

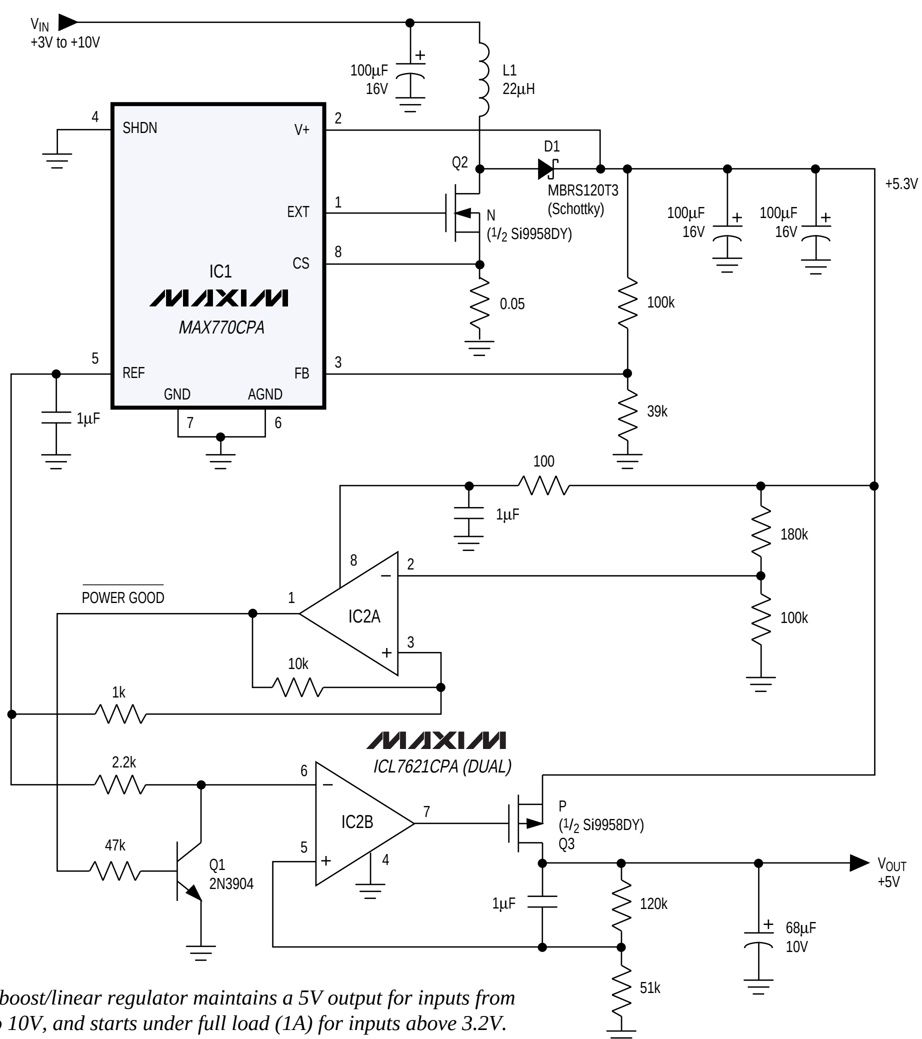


Figure 1. This boost/linear regulator maintains a 5V output for inputs from 3V to 10V, and starts under full load (1A) for inputs above 3.2V.

This difficulty is overcome by the $\overline{\text{POWER GOOD}}$ line. During turn-on the line is high, which disconnects the load from the boost regulator by turning on Q1 and disabling the linear regulator. The linear regulator then resumes normal operation after the boost regulator is up and running.

The dual MOSFET Si9958DY (n-channel and p-channel) is well suited for this application. When the p-channel device is in heavy use the n-channel is inactive, and when the n-channel device is active (boosting) the p-channel drops less than 0.5V. Thus, the SO-8 package rating (2W at room temperature) allows an output current of 1A for inputs from 3.2V to 7V. Above 7V or at higher temperature, the package rating limits the output current.

This circuit topology is useful over wide ranges of output current and input voltage, and yields reasonable efficiency over much of those ranges (**Figure 2**).

A version of this idea has appeared in EDN.

(Circle 5)

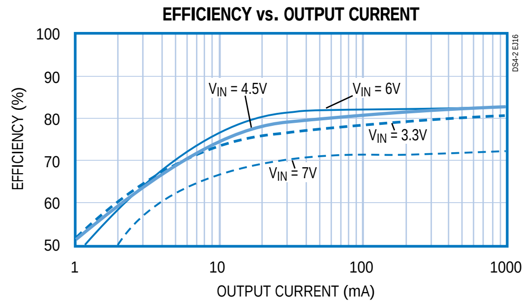


Figure 2. Efficiency for the Figure 1 circuit increases with V_{IN} until the boost regulator shuts down, and then drops with the rise of dissipation in Q3.

LC oscillator has 1% THD

At the heart of many oscillators is a parallel-resonant LC tank circuit whose impedance is infinite at the resonant frequency of $1/(2\pi\sqrt{LC})$Hz. Infinite impedance implies an absence of parallel damping resistance, so once it starts, an ideal tank circuit should continue oscillating indefinitely.

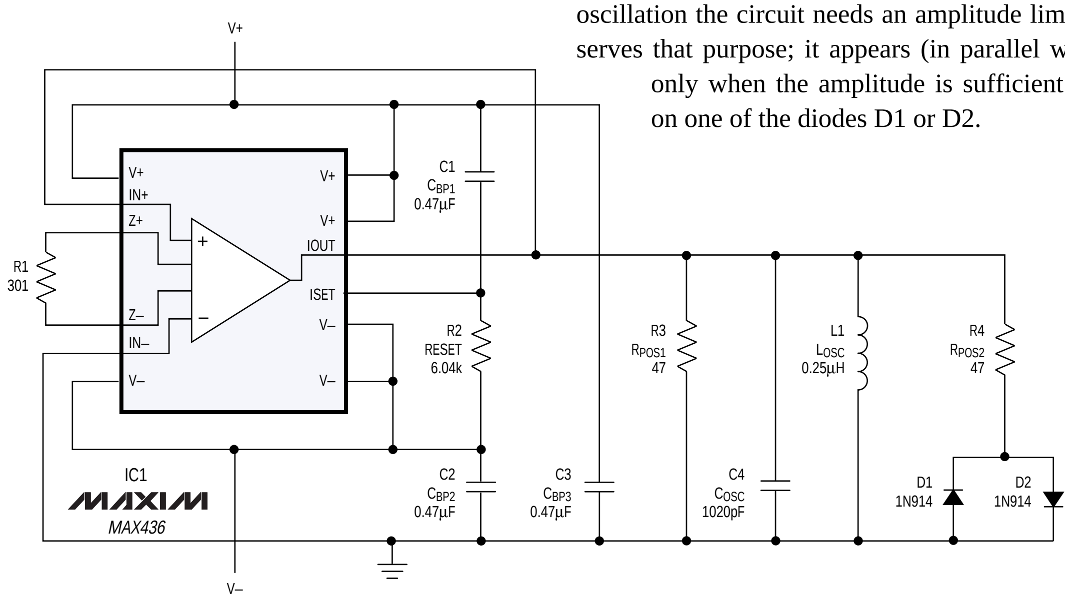
The actual tank circuit, of course, has parasitic resistances that dissipate energy, causing the oscillations to die out. You can counteract this effect by adding a "negative" resistance, which cancels the net parallel parasitic resistance. Negative resistance is easily synthesized with a wideband transconductance amplifier (WTA).

Connect the WTA's positive input to its output and its negative input to ground (**Figure 1**). Then, a positive voltage applied to the output causes current to flow *out* of the amplifier, in proportion to the applied voltage. The circuit acts like a resistor whose current flows in the opposite direction; hence the negative value. (Note the equivalent circuit in Figure 1.)

The source impedance of IC1's current-source output (2.5kΩ minimum) is compatible with the 50Ω-to-300Ω load resistance in applications for which the IC is intended. The load resistance in this circuit (R3) also resembles that in a typical application. R3 should be much smaller than the tank-circuit parasitics, yet larger (in absolute value) than the WTA's negative resistance. R1 sets the negative resistance in terms of the amplifier's transconductance: $g_m = 8/R1$, where the factor of eight is inherent in the IC.

The negative resistance value is therefore (R1)/8, which must be less than R3: (R1)/8 < R3. Choosing 47Ω for R3 yields R1 < 8R3 = 376Ω. A reasonable value for R1, therefore, is 301Ω. As intended, the parallel combination of negative resistance (-(R1)/8 = -37.6Ω) and positive R3 (47Ω) yields a negative resistance (-189Ω) that shifts the oscillator's complex-conjugate pole pair to the right half plane.

By itself, the combination of tank circuit and regenerative element (negative resistance) simply drives the output amplitude to saturation. To achieve steady oscillation the circuit needs an amplitude limiter. R4 serves that purpose; it appears (in parallel with R3) only when the amplitude is sufficient to turn on one of the diodes D1 or D2.



EQUIVALENT CIRCUIT:

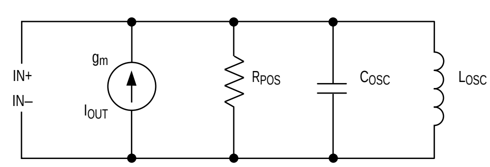


Figure 1. This 9.3MHz oscillator includes a wideband transconductance amplifier (IC1), whose negative resistance counters losses in the L1/C4 tank circuit.

Then, the net parallel resistance (excluding diode resistance) is a positive value (-37.6 || 47 || 47 = 63Ω) that damps oscillation by shifting the pole pair to the left half plane. Thus, the circuit achieves amplitude stability by allowing the pole pair to toggle between positions slightly to either side of the jω axis.

The oscillator, whose tank circuit consists of a mica capacitor and air-core inductor, has an output frequency of 9.3MHz. You can trim the output frequency to any reasonable value, but above 10MHz the layout should include short connections and a ground plane. The major source of THD is the third harmonic, down about 40dB (**Figure 2**).

A version of this idea has appeared in EDN.

(Circle 6)

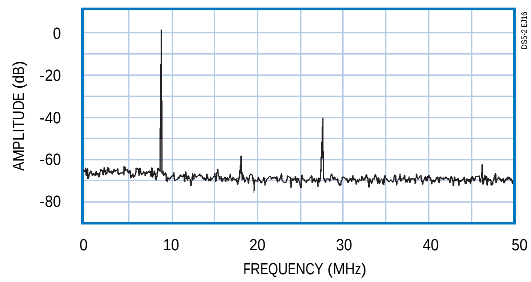


Figure 2. The output power spectrum for Figure 1 shows an output of 9.3MHz and a third harmonic below -40dB (less than 1%).

NEW PRODUCTS

Two-channel, 15-bit, serial-output ADCs cost only $4.80

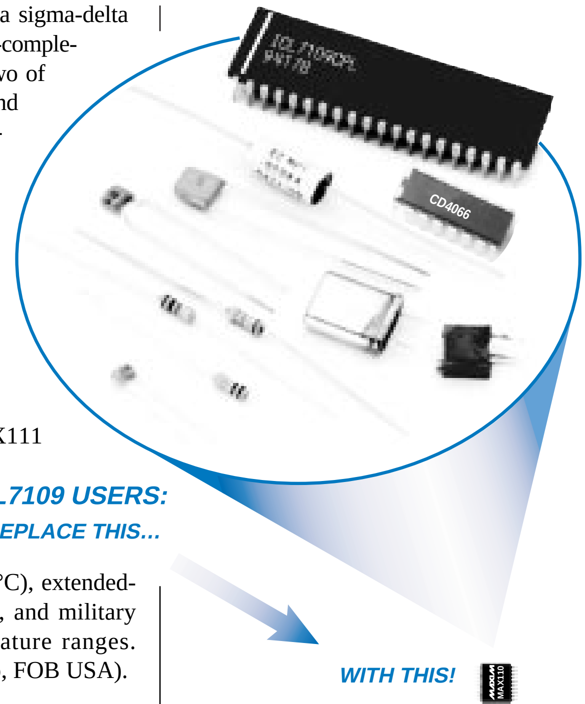
The MAX110/MAX111 auto-calibrated A/D converters (ADCs) achieve 12-bit-plus-sign accuracy and 15-bit resolution (plus overrange) without external components. The MAX110 has a ±3V input range and operates on ±5V, and the MAX111 has a 0V to 2V input range and operates on 5V. The MAX110 draws 550µA supply current; the MAX111 draws 640µA. In power-down mode the supply current is only 1µA, making the converters ideal for use in high-resolution battery-powered and remote-sensing applications.

Each chip includes a differential multiplexer that accommodates two high-impedance, fully differential analog inputs. The parts feature a fast serial interface that simplifies signal routing and isolation while saving microcontroller pins. It provides compatibility with the SPI™, QSPI™, and Microwire™ synchronous serial-interface standards.

Each converter employs a sigma-delta loop, producing a 16-bit twos-complement output code in which two of the bits serve as a sign bit and an overrange bit. A separate 4-bit control word lets you program the clock cycles per conversion, which determines the conversion time and resolution in bits. It also lets you adjust the converters' operation for maximum rejection of 50Hz or 60Hz interference.

The MAX110 and MAX111 come in 20-pin SSOPs, 16-pin DIPs, and 16-pin wide-SO packages, in versions tested for the commercial (0°C to +70°C), extended-industrial (-40°C to +85°C), and military (-55°C to +125°C) temperature ranges. Prices start at $4.80 (1000 up, FOB USA).

™ *SPI and QSPI are trademarks of Motorola Inc. Microwire is a trademark of National Semiconductor Corp.*



(Circle 7)

10-bit, 8-channel, serial ADC operates on 100µA at 5V

The low-cost MAX192 data-acquisition IC combines an 8-channel multiplexer, high-bandwidth track/hold, and 4.096V voltage reference with a 10-bit successive-approximation A/D converter (ADC). The device guarantees ±½LSB INL and ±1LSB DNL. It draws 1.5mA typical at 5V for the maximum rate of 133k samples per second (ksps), or 100µA (including reference) at 1ksps.

Shutdown current is 2µA. Quick turn-on time enables the MAX192 to achieve sub-10µA supply currents at reduced sampling rates by powering down between conversions. Two sub-LSB data bits reduce quantization errors.

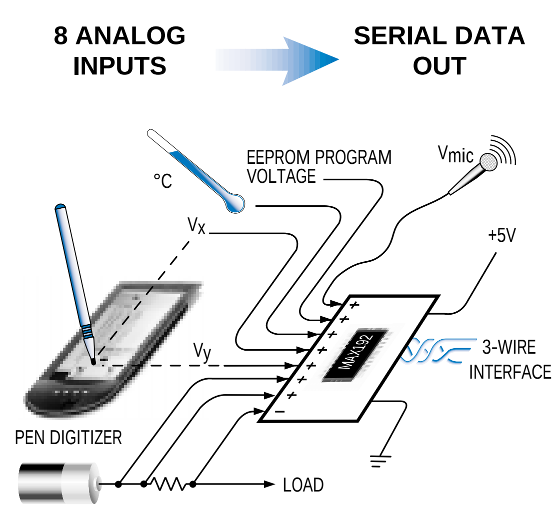
All data and control signals pass through a fast serial interface (four wires including $\overline{CS}$) that connects directly to SPI™, QSPI™, and Microwire™ devices without external logic. An additional strobe output allows direct connections between the MAX192 and members of the TMS320 family of digital signal processors. When the internal clock drives the ADC, the chip produces a result that can be read out later, at a time and rate convenient to the system.

For highest throughput you can clock the SAR externally—an approach that also shifts out the data bits immediately and provides precise control of the sampling instant. The wide frequency range (0.1MHz to 2MHz) ensures that an existing system clock can be used for this purpose.

The 20-pin SSOP package is 30% smaller than an 8-pin DIP. Thus, small size and low-power operation suit the MAX192 for use in micropower applications such as scanners, pen digitizers, consumer portables, and battery management for portable equipment.

The MAX192 data-acquisition chip comes in 20-pin DIP, SO, and SSOP packages, in versions tested for the the commercial (0°C to +70°C), extended-industrial (-40°C to +85°C), and military (-55°C to +125°C) temperature ranges. Prices start at $2.95 (25,000 up, FOB USA).

(Circle 8)



NEW PRODUCTS

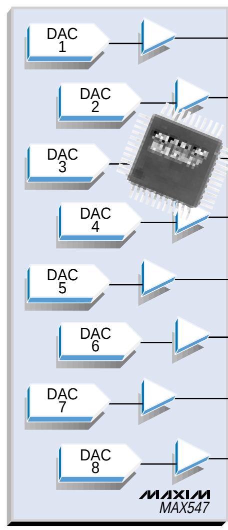
First monolithic, octal, 13-bit DAC has on-chip op amps

The MAX547 is a monolithic IC that contains eight 13-bit D/A converters (DACs). The converters' R-2R ladders produce voltage outputs that are buffered by eight gain-of-two amplifiers, and each converter input is double-buffered by two latches that enable independent or simultaneous updates via the parallel data interface. Each converter guarantees full 13-bit performance without adjustment. Each is 13-bit monotonic over temperature and settles to ±½LSB in 5µs.

The MAX547 operates on ±5V, with unipolar or bipolar outputs that swing to ±4.5V. Bipolar operation requires no external components. The converters are grouped in four pairs served by four separate V_{REF} inputs, which allows each pair to operate with a different full-scale range. All converter outputs can be reset to analog ground, either at power-up by the internal reset circuitry or via an external command to the asynchronous $\overline{CLR}$ input.

The MAX547 comes in a 44-pin PLCC or plastic flatpack, in versions tested for the commercial (0°C to +70°C) and extended-industrial (-40°C to +85°C) temperature ranges. Prices start at $29.60 (1000 up, FOB USA).

(Circle 9)



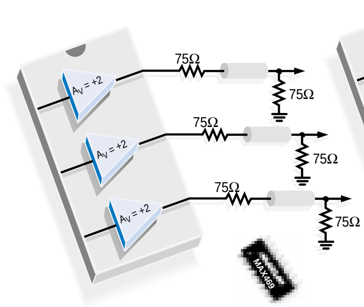
Low-cost, 100MHz, triple and quad video buffers eliminate cable-drive amplifiers

MAX467–MAX470 video buffers have the lowest differential gain/phase errors available (0.01%/0.03°). They operate on ±5V and guarantee ±2.5V into 75Ω back-terminated cables (150Ω loads), or ±2V into 75Ω loads. MAX469/MAX470 buffers can drive 50Ω and 75Ω double-terminated coaxial cables directly. Because their 2V/V gain is achieved without external feedback resistors, the MAX469/ MAX470 are easier to use than conventional, multi-channel video amplifiers that require feedback.

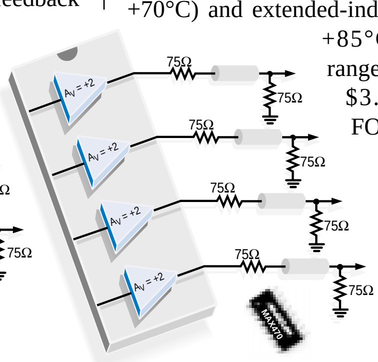
The MAX467 and MAX469 are triple buffers; the MAX468 and MAX470 are quad buffers. The gain-of-one MAX467/ MAX468 buffers have 100MHz bandwidths and 200V/µs slew rates, and the gain-of-two MAX469/MAX470 buffers have 90MHz bandwidths and 300V/µs slew rates. Typical input capacitance is only 5pF.

The MAX467–MAX470 come in 16-pin plastic DIP and SO packages, in versions tested for the commercial (0°C to +70°C) and extended-industrial (-40°C to +85°C) temperature ranges. Prices start at $3.70 (1000 up, FOB USA).

(Circle 10)



TRIPLE, +2 GAIN



QUAD, +2 GAIN

100MHz, 8x4 video crosspoint switches include 75Ω cable drivers

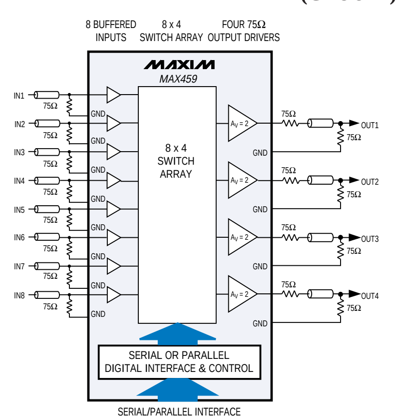
The monolithic MAX458 and MAX459 video crosspoint switches are broadcast-quality devices that save tremendous amounts of board space and design time by replacing conventional video switches, amplifiers, and logic. Internal switches connect any of the eight inputs to any or all of the four outputs. Each MAX458 output amplifier has a 100MHz bandwidth and a fixed gain of one, and each MAX459 output amplifier accommodates double-terminated applications with a 90MHz bandwidth and a fixed gain of two.

Both devices can drive 75Ω loads. The output buffers have high slew rates (300V/µs for the MAX459) and low differential gain and phase errors (only 0.01% and 0.05° for the MAX458). Separately controlled three-state outputs let you form larger switching networks by connecting multiple MAX458 and MAX459 devices in parallel. Actual switching times are only 60ns.

Each device offers shutdown capability along with a serial and parallel data interface. In serial mode the MAX458/MAX459 are compatible with SPI™, QSPI™, and Microwire™ synchronous serial-interface standards. In parallel mode they are compatible with most microprocessor buses.

The MAX458/MAX459 come in 40-pin plastic DIPs and 44-pin PLCCs, screened for the commercial (0°C to +70°C) or extended-industrial (-40°C to +85°C) temperature ranges. Prices start at $24.00 (1000 up, FOB USA).

(Circle 11)



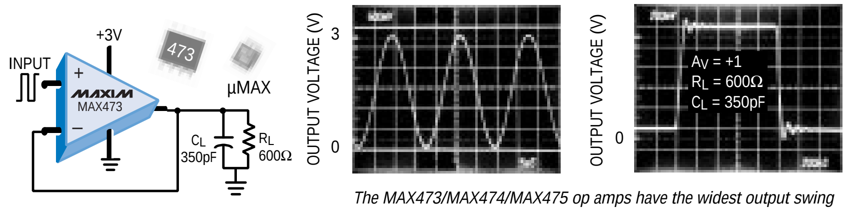
NEW PRODUCTS

10MHz, 15V/µs, rail-to-rail op amps operate down to 2.7V

The MAX473/MAX474/MAX475 wideband op amps are the first low-voltage devices to guarantee 10MHz unity-gain bandwidths and 15V/µs slew rates while operating from single supplies as low as 3.0V. Their output voltage range (rail-to-rail) is wider than that of any comparable op amp. The MAX473 (single), MAX474 (dual), and MAX475 (quad) are unity-gain stable and operate on a single supply of 2.7V to 5.25V. Typically, they remain stable while driving capacitive loads as high as 390pF.

Supply current is typically 2mA per op amp, yet each output guarantees a 10MHz unity-gain bandwidth, 15V/µs slew rate, short-circuit protection, and 600Ω drive capability. The input range includes the negative rail, and outputs swing within 50mV of each rail. Fast slewing and quick settling (400ns typical to ±0.1%) enable these op amps to save power in large-signal applications by replacing op amps that draw higher supply currents.

WIDEST OUTPUT SWING ...AND DRIVES CAPACITIVE LOADS!



The MAX473/MAX474/MAX475 op amps have the widest output swing in their class (5MHz to 10MHz).

Ideal applications include wireless, test & measurement, and all portable systems that operate on single 3V or 5V supplies. The single MAX473 comes in 8-pin DIP, SO, and µMAX packages; the dual MAX474 comes in 8-pin DIP and SO packages; the quad MAX475 comes in 14-pin DIP and SO packages. All are available in versions tested for the commercial (0°C to +70°C), extended-industrial (-40°C to +85°C), and military (-55°C to +125°C) temperature ranges. Prices start at $1.45 (1000 up, FOB USA).

(Circle 12)

500kHz, 2.7V precision op amps guarantee rail-to-rail input and output

The MAX492/MAX494/MAX495 op amps (dual/quad/single devices) simplify the design of low-voltage, precision applications. Ideal for battery-powered 3V or 5V systems, they operate from either a single supply of 2.7V to 6V, or a bipolar supply of ±1.35V to ±3V. Each amplifier draws less than 150µA of supply current.

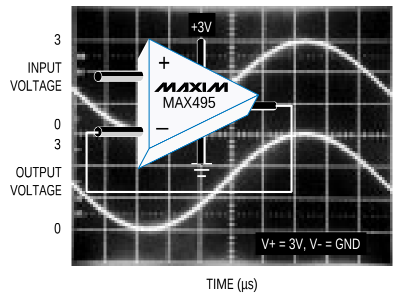
Despite their low supply current, the op amps exhibit a 500kHz unity-gain bandwidth, an input-referred voltage noise of only 25nV/$\sqrt{Hz}$, and the ability to drive 1kΩ loads. At A_V = 1, they remain stable while driving capacitive loads in excess of 500pF. Precision specifications include an input offset voltage of less than 200µV, an input bias current of less than 60nA, and a guaranteed open-loop gain (for R_L = 100kΩ) of 90dB.

To insure a wide dynamic range—particularly important in low-voltage systems—the outputs swing within 40mV of each supply rail and the input range extends 0.25V *beyond* each rail. These capabilities often eliminate the need for a negative supply or pseudo ground. And unlike conventional amplifiers, these op amps guarantee an absence of latchup or phase reversal for input voltages that extend beyond the specified common-mode range.

The dual MAX492 op amp comes in 8-pin DIP and SO packages. The single MAX495 also comes in 8-pin DIP and SO, as well as an 8-pin µMAX package. The quad MAX494 comes in 14-pin DIPs and SOs. All are available in versions tested for the commercial (0°C to +70°C), extended-industrial (-40°C to +85°C), and military (-55°C to +125°C) temperature ranges. Prices start at $1.40 (1000 up, FOB USA).

(Circle 13)

WARNING:
NO PSEUDO GROUND OR NEGATIVE SUPPLY REQUIRED… MAY BE TOO EASY TO USE!



Charge-pump dc-dc converter programs flash memories without inductors

The MAX662A regulated charge-pump converter produces 12V ±5% at 30mA, as required for programming byte-wide flash memories—without the troublesome inductors associated with switching converters. As pin-compatible upgrades for the popular MAX662, MAX662A converters have added military and extended-temperature versions while offering lower quiescent and shutdown currents. The MAX662A is recommended for new designs.

An all-surface-mount MAX662A circuit is the smallest and lowest-cost flash memory programmer available, covering less than 0.1in.^{2} of board space. External components include about 30¢ worth of capacitors. Normal quiescent current is 185µA, and the logic-controlled shutdown lowers this current to 1µA. A pre-assembled surface-mount evaluation kit, available from Maxim, saves you hours of component gathering, board layout, assembly, and design time.

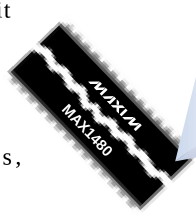
The MAX662A is ideal for byte-at-a-time firmware updates. It comes in 8-pin DIP and narrow-SO packages, in versions tested for the commercial (0°C to +70°C), extended-industrial (-40°C to +85°C), and military (-55°C to +125°C) temperature ranges. Prices start at $1.81 (10,000 up, FOB USA).

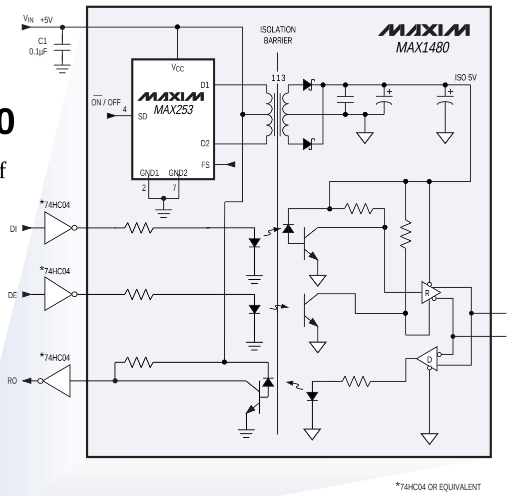
(Circle 14)

NEW PRODUCTS

Isolated, single-package RS-485 interface costs less than $10

Members of the MAX1480 family of data-communications transceivers provide an isolated RS-485 interface in a single package. Operating from a single 5V supply on the logic side of the isolation barrier, each provides a fully isolated RS-485 transmitter and receiver on the other side. The entire circuit comes in a 28-pin DIP—including transformer, optocouplers, diodes, and ICs.





The MAX1480A operates at data rates as high as 2.5M bits per second (bps), and the MAX1480B has slew-rate-limited drivers that minimize EMI (electromagnetic interference) while reducing any reflections caused by improperly terminated cables. The result is error-free transmissions to 250kbps.

Both devices offer half-duplex operation with a single 5V supply, with isolated outputs that meet all RS-485 and RS-422 specifications. They typically withstand $1600V_{RMS}$ across the isolation barrier for one minute, or $130V_{RMS}$ continuously.

Each device draws a typical quiescent current of 28mA. The MAX1480B's low-power shutdown draws only 0.2µA (1µW). The outputs have short-circuit current limiting and thermal-shutdown circuitry, which prevents excessive power dissipation by placing the outputs in a high-impedance state. MAX1480A/B receivers guarantee fail-safe logic-high outputs when the inputs are open-circuited. Their common-mode input range with respect to isolated ground is -7V to +12V.

The MAX1480A and MAX1480B come in 28-pin plastic DIPs, in versions tested for the commercial (0°C to +70°C) and extended-industrial (-40°C to +85°C) temperature ranges. Prices start at $9.95 (1000 up, FOB USA direct).

(Circle 15)

5V dual RS-232 transceivers withstand ±15kV ESD

MAX202E and MAX232E transceivers, each including two transmitters and two receivers, are the only such RS-232 ICs to withstand ESD levels as high as ±15kV (Human Body Model), ±15kV (IEC 801.2, air discharge), and ±8kV (IEC 801.2, contact discharge).

MAX202E/MAX232E devices are designed for RS-232 and V.28 communications in harsh environments, and they meet all EIA/TIA-232E and CCITT V.28 specifications at data rates to 120kbps (when loaded in accordance with the EIA specification). The MAX202E operates with small, inexpensive 0.1µF capacitors, and the MAX232E operates with 1µF capacitors. Five-volt operation and high data rates make these transceivers ideal for use in printers.

Available in 16-pin DIPs, 16-pin wide and narrow SOs, and 20-pin ceramic LCCs, the MAX202E and MAX232E come in versions tested for the commercial (0°C to +70°C), extended-industrial (-40°C to +85°C), and military (-55°C to +125°C) temperature ranges. Prices start at $1.85 (1000 up, FOB USA).

(Circle 16)

Compact dc-dc inverters provide 200mA with 85% efficiency

MAX764/MAX765/MAX766 dc-dc inverters are switch-mode regulators that produce negative outputs of -5V, -12V, and -15V, respectively. With two external resistors, they also produce arbitrary negative outputs between 0V and a maximum V_{IN}-V_{OUT} differential of 20V. The input voltage range is 3V to 16V.

Efficiencies exceed 80% for load currents from 2mA to 200mA—a load range of 100:1. Low quiescent currents (120µA maximum), low shutdown currents (5µA maximum), and compact circuit layouts suit the devices for use in hard-disk drives, bias supplies for LCD contrast, and interface circuitry for portable systems.

High efficiency for a wide range of loads is maintained by a current-limited PFM control circuit that combines the advantages of pulse-frequency modulation (pulse skipping) with pulse-width modulation (continuous pulsing). Each IC includes a p-channel, power-switching MOSFET with a peak-current rating of 0.75A.

The high switching frequency (300kHz) allows the use of small, inexpensive 47µH inductors and 100µF capacitors, resulting in all-surface-mount circuits that occupy less than $0.3in.^2$ of board area. MAX764/MAX765/MAX766 devices come in 8-pin DIP and SO packages, in versions tested for the commercial (0°C to +70°C), extended-industrial (-40°C to +85°C), and military (-55°C to +125°C) temperature ranges. Prices start at $2.38 (1000 up, FOB USA).

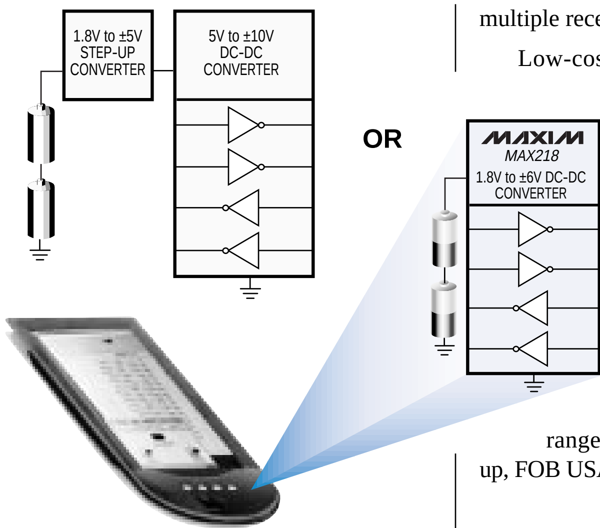
(Circle 17)

NEW PRODUCTS

Two-cell-powered, dual transceiver meets all RS-232 specifications

The MAX218 is the first and only dual RS-232 transceiver that operates directly from two alkaline, NiCd, or NiMH cells—thereby eliminating the step-up converter and level translator otherwise required. Intended as a communications interface for battery-powered EIA/TIA-232E and V.28/V.24 systems, the MAX218 includes two transmitters and two receivers, meets all RS-232 specifications, and guarantees true RS-232 output levels over the input range 1.8V to 4.25V.

The MAX218 also guarantees a minimum data rate of 120kbps, which assures compatibility with popular PC-communications software. A shutdown mode extends battery life by lowering the supply current (3mA maximum) to 1µA. During shutdown, the two receivers can remain active to monitor external signals, or be disabled via the EN input. Three-state receiver outputs let you wire-OR multiple receivers on one line.



Low-cost surface-mount components are available for the external circuit, whose layout is further simplified by a flow-through pinout for the MAX218 package. The MAX218 comes in 20-pin DIP, wide-SO, and SSOP packages, in versions tested for the commercial (0°C to +70°C) and extended-industrial (-40°C to +85°C) temperature ranges. Prices start at $2.10 (1000 up, FOB USA).

(Circle 18)

New proprietary architecture obsoletes all other 3V RS-232 ICs

The MAX3241 RS-232 transceiver has a proprietary output stage whose low dropout voltage allows true RS-232 performance with supply voltages in the range 3.0V to 5.5V. Its internal charge-pump doubler draws far less supply current than does a voltage tripler or a 5V IC respecified for 3V operation. Intended for notebook computers with an EIA/TIA-232 or V.28/V.24 communications interface, the device guarantees a 120kbps data rate that assures compatibility with popular PC-communications software such as LapLink™.

The MAX3241 implements a complete RS-232 serial port (three drivers and five receivers), and includes a 1µA shutdown mode that maintains two receivers active for monitoring external devices such as a modem. It operates with 0.1µA capacitors and draws a maximum supply current of 1mA.

For palmtop computers and other hand-held devices that don't require a full serial interface, the MAX3222/MAX3232 dual transceivers contain two drivers and two receivers. Each device draws a maximum of 500µA during normal operation. The MAX3222 has a 1µA shutdown mode in which both receivers remain active.

MAX3241 comes in 28-pin wide-SO and SSOP packages, tested for the commercial (0°C to +70°C) temperature range. The MAX3222 comes in an 18-pin DIP or SO package, and the MAX3232 comes in a 16-pin DIP or SO package. Both are available in versions tested for the commercial and extended-industrial (-40°C to +85°C) temperature ranges. Please contact the factory for prices.

™ *LapLink is a trademark of Traveling Software.*

(Circle 19)

Precision function generator operates to 20MHz

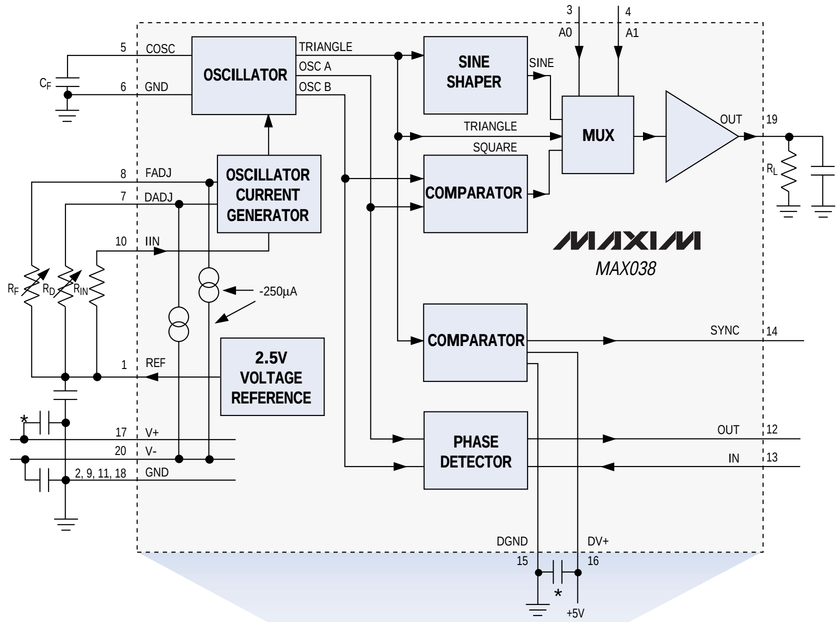
The MAX038 precision function generator produces accurate, high-frequency sine, square, triangle, sawtooth, and pulse waveforms with a minimum of external components. A two-bit digital code selects the sine, square, or triangle function.

The frequency of oscillation is controlled by an internal bandgap reference and an external resistor and capacitor. Varying the resistance can change the output frequency over a range of 0.1Hz to 20MHz. All output waveforms have 2Vp-p amplitudes, symmetrical with respect to ground. The 0.1Ω low-impedance output buffer delivers ±20mA, and the typical sinewave distortion is less than 0.75%.

An external voltage applied to the device can produce pulse-width modulation or sawtooth waveforms by varying the duty cycle between 10% and 90%. Similarly, an independent control voltage can modulate the programmed frequency by ±70%.

The internal oscillator's TTL-compatible SYNC output, intended for synchronizing other devices in the system, maintains a 50% duty cycle regardless of the duty cycle programmed for other waveforms. In turn, an internal phase detector lets you synchronize the oscillator to an external TTL clock.

ALL THIS...



IN THIS!

The MAX038 comes in a 20-pin plastic DIP or wide-SO package, in versions tested for the commercial (0°C to +70°C) and extended-industrial (-40°C to +85°C) temperature ranges. Prices start at $9.50 (1000 up, FOB USA).

(Circle 20)