

Linear Technology Chronicle

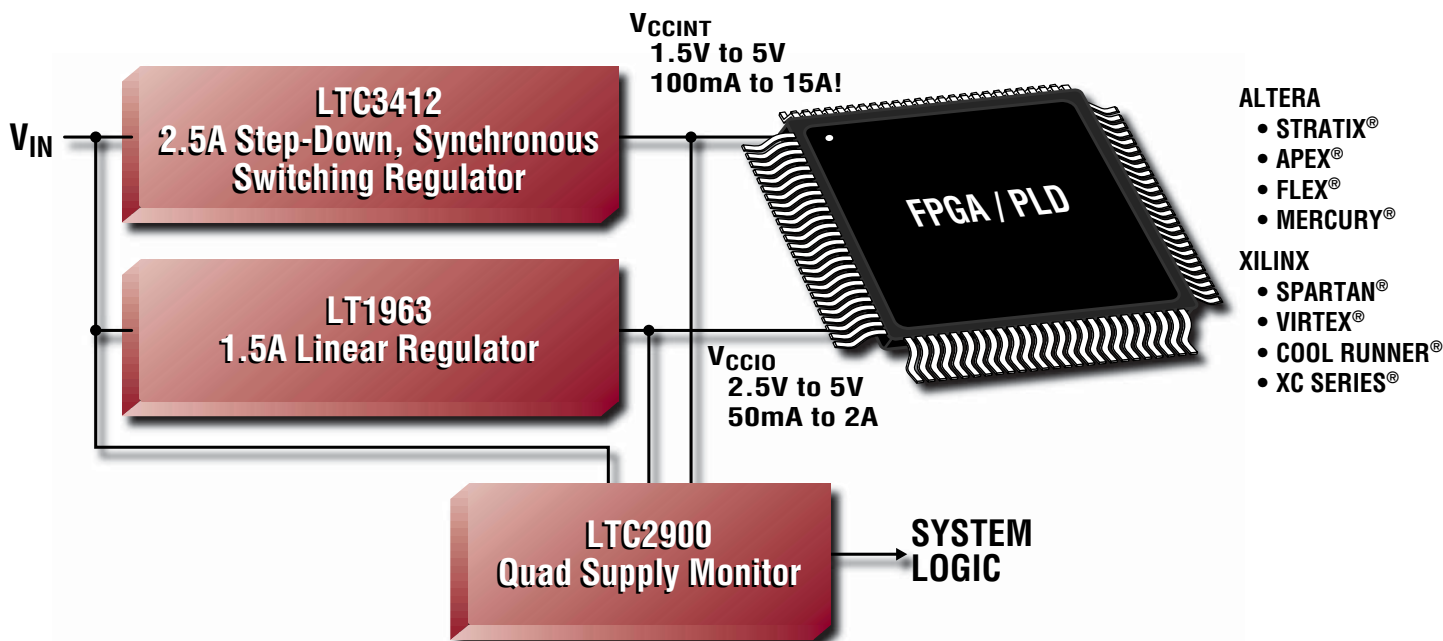
October 2002

High Performance Analog Solutions from Linear Technology

Vol. 11 No. 10

October Focus...

Power Management Solutions for Programmable Logic ICs



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Programmable logic ICs such as Field Programmable Gate Arrays (FPGAs) and Complex Programmable Logic Devices (CPLDs) are the building blocks of today's high performance communications systems. Programmable logic ICs are moving toward ever increasing size and complexity, resulting in more stringent power requirements. Smaller device geometries mean lower core supply voltages. Increased gate count and clock speed result in higher current requirements. Each programmable logic device may require several voltages to properly power the core logic and the I/O sections of the chip.

No matter what family of logic devices you're using, what power level you need, or what your input voltage may be, Linear Technology has a full range of voltage regulator solutions.

- *Linear regulators* provide a simple step down solution best suited for low power applications or where the input voltage and output voltage are close.
- *Switching regulators* provide a highly efficient solution for delivering high power in both step down (buck) and step up (boost) applications. Switching regulators can also maintain efficiencies as high as 90%, even when the input and output voltages differ by a large amount.
- *Synchronous switching regulators* provide the most efficient solution. Efficiencies of over 95% for a wide range of current levels and input/output voltages are achievable using these devices.

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Power Management Solutions for Altera and Xilinx FPGAs

System Requirements

- Core voltage of 1.5V or 1.8V
- I/O voltage of 2.5V or 3.3V

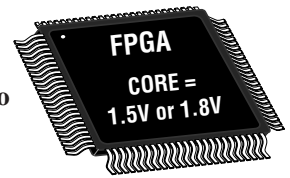
Solutions on this page apply to the following families:

Altera

- Stratix
- Apex II
- Apex 20K and 20KC
- EPXA1 –EPXA10
- Mercury

Xilinx

- Virtex II Pro
- Virtex II
- Spartan IIE



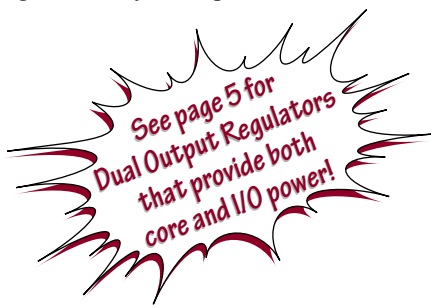
Solutions for Core Voltage = 1.5V or 1.8V

Input Supply	< 200mA	< 500mA	< 1.5A	> 1.5A
1.8V to 2.5V	LT [®] 1962 300mA linear regulator	LT1763 500mA linear regulator	LT1963A 1.5A linear regulator	LT3150 low input voltage linear regulator controller
				LTC3713 sync. controller for up to 20A
2.5V to 6V	LT1962 300mA linear regulator	LT1763 500mA linear regulator	LT1963A 1.5A linear regulator	LT1764A 3A linear regulator
	LTC [®] 3405A 300mA sync. switcher	LTC3406 600mA sync. switcher	LTC3411 1.25A sync. switcher	LTC3412 2.5A sync. switching regulator
				LTC1773 sync. controller for up to 5A
				LTC1778 sync. controller for up to 20A (V _{IN} > 4V)
6V and Above	LT1962 300mA linear regulator	LT1763 500mA linear regulator	LT1963A 1.5A linear regulator	LT1764A 3A linear regulator
	LT1616 500mA switching regulator	LT1616 500mA switching regulator	LT1767 1.2A switching regulator	LT1765 3A switching regulator
				LTC1778 sync. controller for up to 20A

For input voltages or current levels not found on this selector guide, visit the Linear Technology web site or call your local sales representative.

Solutions for I/O Voltage

In addition to the core voltage supply, FPGAs typically require at least one other voltage supply to power the I/O. If the supply voltage for the I/O differs from the voltage required by the core, a second, lower power voltage regulator may be required.



I/O Voltage = 2.5V

Input Voltage	< 200mA	< 500mA	< 1.5A
1.8V to 2.5V	LTC3400 boost	LTC3401 boost	LTC3402 boost
2.5V to 6V	LT1962 linear LTC3405A switcher	LT1763 linear LTC3406 switcher	LT1963A linear LT3411 switcher
Above 6V	LT1962 linear LT1616 switcher	LT1763 linear LT1616 switcher	LT1963A linear LT1767 switcher

I/O Voltage = 3.3V

Input Voltage	< 200mA	< 500mA	< 1.5A
1.8V to 2.5V	LTC3401 boost	LTC3402 boost	LT1619 boost controller
2.5V to 3.3V	LTC3400 boost	LTC3402 boost	LTC3402 boost
3.3V to 6V	LT1962 linear LTC3405A switcher	LT1763 linear LTC3406 switcher	LT1963A linear LTC3411 switcher
Above 6V	LT1962 linear LT1616 switcher	LT1763 linear LT1616 switcher	LT1963A linear LT1767 switcher

Contact your local Linear Technology sales office for a data sheet and evaluation samples. For more information, visit our web site at www.linear.com.

Power Management Solutions for Altera and Xilinx FPGAs

System Requirements

- Core voltage of 2.5V
- I/O voltage of 2.5V, 3.3V or 5V

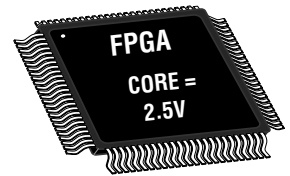
Solutions on this page apply to the following families:

Altera

- Max7000
- Flex 10k
- Acex 1k, 20k

Xilinx

- Spartan II
- XC9500XV CPLD
- Cool Runner



Solutions for Core Voltage = 2.5V

Input Supply	<200mA	<500mA	<1.5A	>1.5A
1.8V to 2.5V	LTC3400 600mA boost regulator	LT3401 1A boost regulator	LTC3402 2A boost regulator	LT1619 boost controller for up to 10A
2.5V to 6V	LT1962 300mA linear regulator	LT1763 500mA linear regulator	LT1963A 1.5A linear regulator	LT1764A 3A linear regulator
	LTC3405A 300mA sync. switching regulator	LTC3406 600mA sync. switching regulator	LTC3411 1.25A sync. switching regulator	LTC3412 2.5A sync. switching regulator
				LTC1773 sync. controller for up to 5A LTC1778 sync. controller for up to 20A
6V and Above	LT1962 300mA linear regulator	LT1763 500mA linear regulator	LT1963A 1.5A linear regulator	LT1764A 3A linear regulator
	LT1616 500mA switching regulator	LT1616 500mA switching regulator	LT1767 1.2A switching regulator	LT1765 3A switching regulator LTC1778 sync. controller for up to 20A

For input voltages or current levels not found on this selector guide, visit the Linear Technology web site or call your local sales representative.

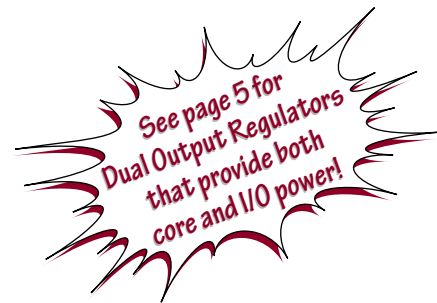
Solutions for I/O Voltage

I/O Voltage = 3.3V

Input Voltage	< 200mA	< 500mA	< 1.5A
1.8V to 2.5V	LTC3401 boost	LTC3402 boost	LT1619 boost controller
2.5V to 3.3V	LTC3400 boost	LTC3402 boost	LTC3402 boost
3.3V to 6V	LT1962 linear LTC3405A switcher	LT1763 linear LTC3406 switcher	LT1963A linear LTC3411 switcher
Above 6V	LT1962 linear LT1616 switcher	LT1763 linear LT1616 switcher	LT1963A linear LT1767 switcher

I/O Voltage = 5V

Input Voltage	< 200mA	< 500mA	< 1.5A
1.8V to 2.5V	LTC3401 boost	LTC3402 boost	LT1619 boost controller
2.5V to 3.3V	LTC3400 boost	LTC3402 boost	LTC3402 boost
Above 5V	LT1962 linear LTC3405A switcher LT1616 switcher	LT1763 linear LTC3406 switcher LT1616 switcher	LT1963A linear LTC3411 switcher LT1767 switcher



Contact your local Linear Technology sales office for a data sheet and evaluation samples. For more information, visit our web site at www.linear.com.

Power Management Solutions for Altera and Xilinx FPGAs

System Requirements

- Core voltage of 3.3V
- I/O voltage of 3.3V or 5V

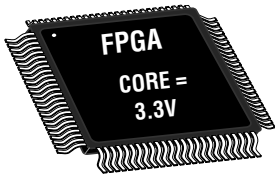
Solutions on this page apply to the following families:

Altera

- Max3000
- Flex 10k
- Flex 6000

Xilinx

- Cool Runner
- XC500XL
- XC3000



Solutions for Core Voltage = 3.3V

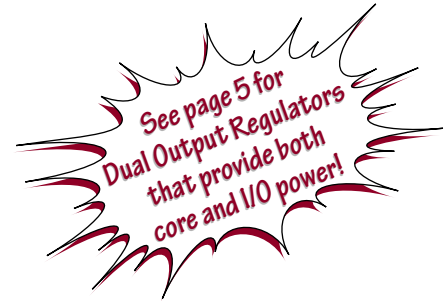
Input Supply	<200mA	<500mA	<1.5A	>1.5A
1.8V to 2.5V	LTC3400 600mA boost regulator	LT3401 1A boost regulator	LTC3402 2A boost regulator	LT1619 boost controller for up to 10A
2.5V to 3.3V	LTC3400 600mA boost regulator	LTC3401 1A boost regulator	LTC3402 boost regulator	LTC1871 boost controller for up to 10A
3.3V to 6V	LTC3405A 300mA sync. switching regulator	LTC3406 600mA sync. switching regulator	LTC3411 1.25A sync. switching regulator	LTC3412 2.5A sync. switching regulator
				LTC1773 sync. controller for up to 5A
				LTC1778 sync. controller for up to 20A
6V and Above	LT1962 300mA linear regulator	LT1763 500mA linear regulator	LT1963A 1.5A linear regulator	LT1764A 3A linear regulator
	LT1616 500mA switching regulator	LT1616 500mA switching regulator	LT1767 1.2A switching regulator	LT1765 3A switching regulator
				LTC1778 sync. controller for up to 20A

For input voltages or current levels not found on this selector guide, visit the Linear Technology web site or call your local sales representative.

Solutions for I/O Voltage

I/O Voltage = 5V

Input Voltage	< 200mA	< 500mA	< 1.5A
1.8V to 2.5V	LTC3401 boost	LTC3402 boost	LT1619 boost controller
2.5V to 3.3V	LTC3400 boost	LTC3402 boost	LTC3402 boost
Above 5V	LT1962 linear LTC3405A switcher LT1616 switcher	LT1763 linear LTC3406 switcher LT1616 switcher	LT1963A linear LTC3411 switcher LT1767 switcher



Power Supply Requirements on Power Up

When power is first applied to an FPGA, the device can draw current several times its normal operating current. This power-on surge current is due to the programmable nature of FPGAs. When the FPGA powers up, before initialization, the RAM cells are briefly in a random state. This results in contention at the interconnect and significant power dissipation.

The surge current typically occurs just as the transistors on the device are powering on, typically between 0.6V to 0.8V. Current requirements will vary from device to device. For example, Xilinx's Spartan II

and IIE devices specify a power-on surge current of 500mA, increasing to 2A at junction temperatures near 0°C. Other devices exhibit little or no power-on surge current. Consult the data sheet for your particular device for more details.

The duration of the power-on surge current is typically quite brief but can cause problems for power supply design. Many high performance switching regulators are designed to view currents that are outside the normal operation range as possible short circuits. If care is not taken in the design of the power supply, the high surge current

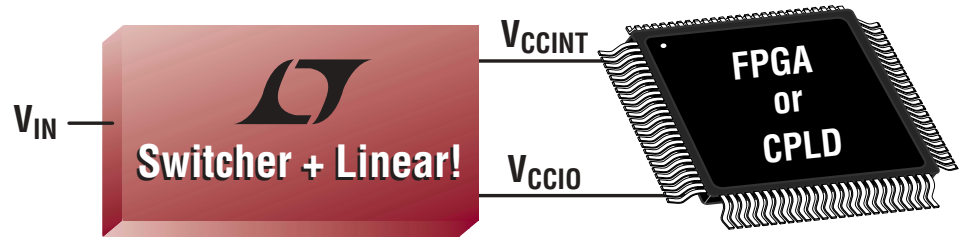
during power on could cause the voltage regulator to restrict the current flow or shut itself down. Any power supply design must account for not only the normal operating current of the programmable logic design but also the possibly much larger power-on surge current.

The applications engineers at Linear Technology have designed power supplies for every conceivable application. For applications support, contact your local FAE or visit our web site at www.linear.com.

Dual Output Regulators for Core and I/O Power

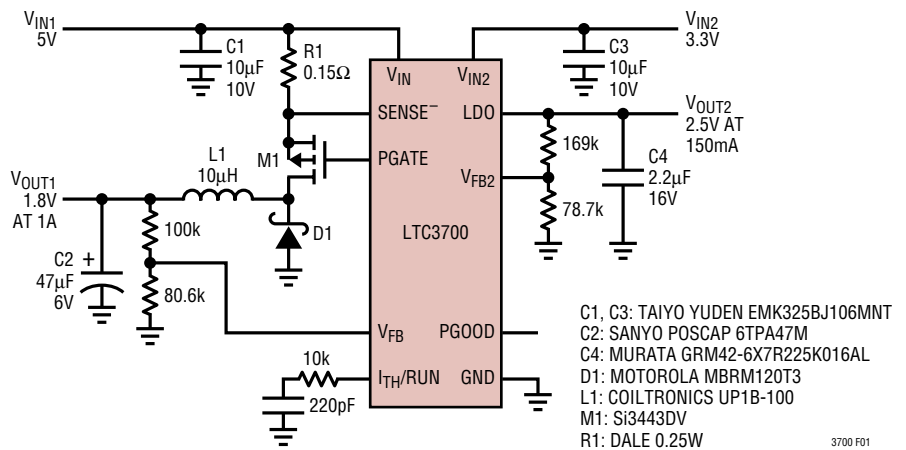
The typical FPGA requires much lower current for the I/O supply than for the core supply. The ideal solution for these applications is a high efficiency switching regulator to handle the high power core supply and a simple linear regulator to provide the low power I/O supply. Linear Technology offers a pair of devices that combine both switching and linear regulators into a single package, providing the ideal solution for FPGA power requirements.

Core and IO Power Supplies with One IC



- Combines switching regulator for core supply and linear regulator for I/O supply in a single IC
- Switching regulator provides high efficiency (>90%) for core supplies
- Integrated linear regulator provides lower power supply for I/O
- LTC1704 provides a synchronous switching controller good for up to 20A with a linear regulator controller that can provide up to 2.5A
- The LTC3700 combines a switching regulator controller that can provide up to 4A with an integrated LDO that can provide 150mA—all in a small MS10 package

High Efficiency 5V to 1.8V/1A Buck with 3.3V to 2.5V/150mA LDO



Dual Output Voltage Regulators for Core and I/O

Part Number	Input Voltage Range	Switching Regulator Output Current	Linear Regulator Output Current	Switching Frequency	Package
LTC1704	3.15V to 5.5V	20A (synchronous)	2.5A	550kHz	SSOP-16
LTC3700	2.4V to 9.8V	4A	150mA	550kHz	MSOP-10

Dual Integrated Switching Regulator

A pair of switching regulators provide the highest efficiency solution for generating core and I/O voltages. The LT1940 has two integrated 2A switches each capable of providing up to 1.4A of output current.

- High output currents in a small solution size are made possible by the thermally enhanced TSSOP-16E package
- A switching frequency of 1.1MHz results in tiny external components that further reduce the solution size
- High efficiency (>90%) for both core and I/O supplies

Dual Monolithic Switching Regulator

Part Number	Input Voltage Range	Switching Regulator Output Current	Switching Frequency	Package
LT1940	3.6V to 25V	2 × 1.4A monolithic	1.1MHz	TSSOP-16E

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Power Supplies for SSTL and LVTTTL Bus Termination

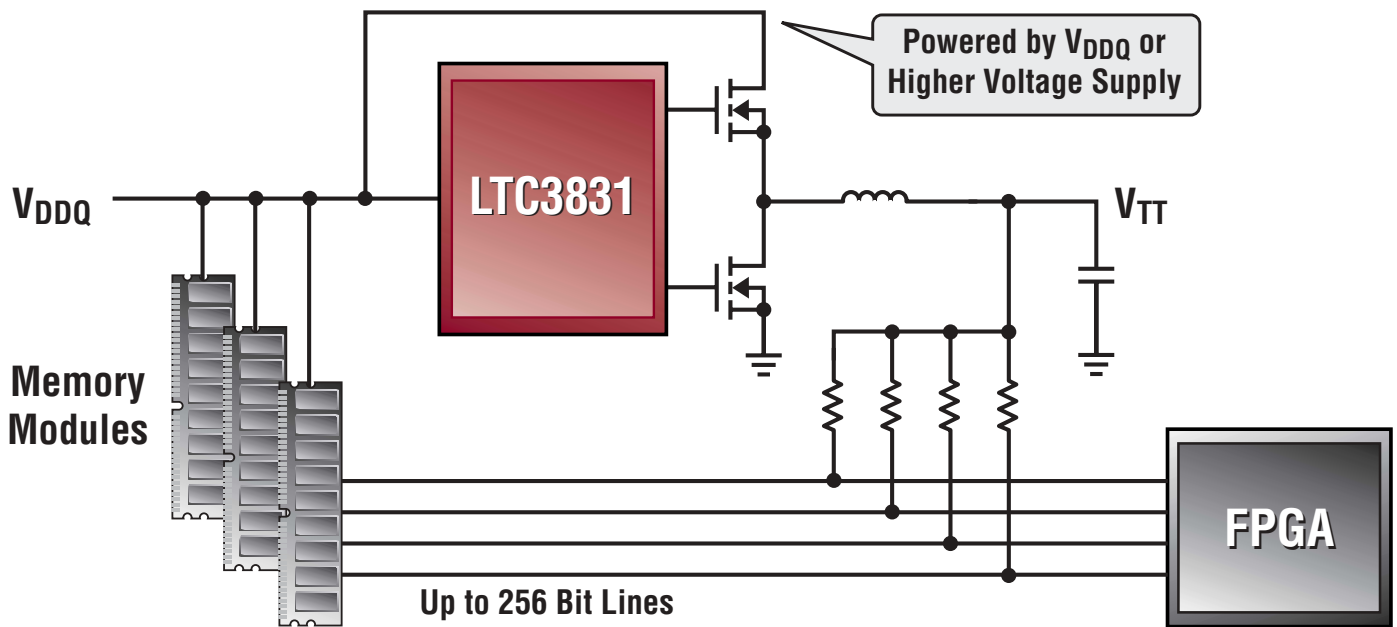
FPGAs require a fast interface to the surrounding memory chips. Typically, standards such as SSTL, HSTL or LVTTTL are used to speed up the data transfer from off chip memory. These data buses require special termination voltage that can both sink and source currents.

- Termination voltage tracks 1/2 memory supply voltage
- Source and sink currents up to 20A
- Input voltages up to 36V
- Termination voltages down to 0.8V

Solutions for Data Bus Termination

Part Number	V _{DDQ}	IC V _{IN}	Current	Package	Comments
LTC3831	0.8V to 8V	3V to 8V	1A to 8A	SSOP-16	No R _{SENSE} [™] , 3V operation
LTC3717	0.8V to 36V	4V to 36V	1A to 20A	SSOP-16	No R _{SENSE}
LTC3718	0.8V to 36V	1.1V to 36V	1A to 20A	SSOP-24	Low voltage operation without requiring external 5V supply
LTC3413	0.5V to 5.5V	2.25V to 5.5V	Up to 3A	TSSOP-16	2MHz monolithic synchronous switching regulator

SSTL Bus Termination

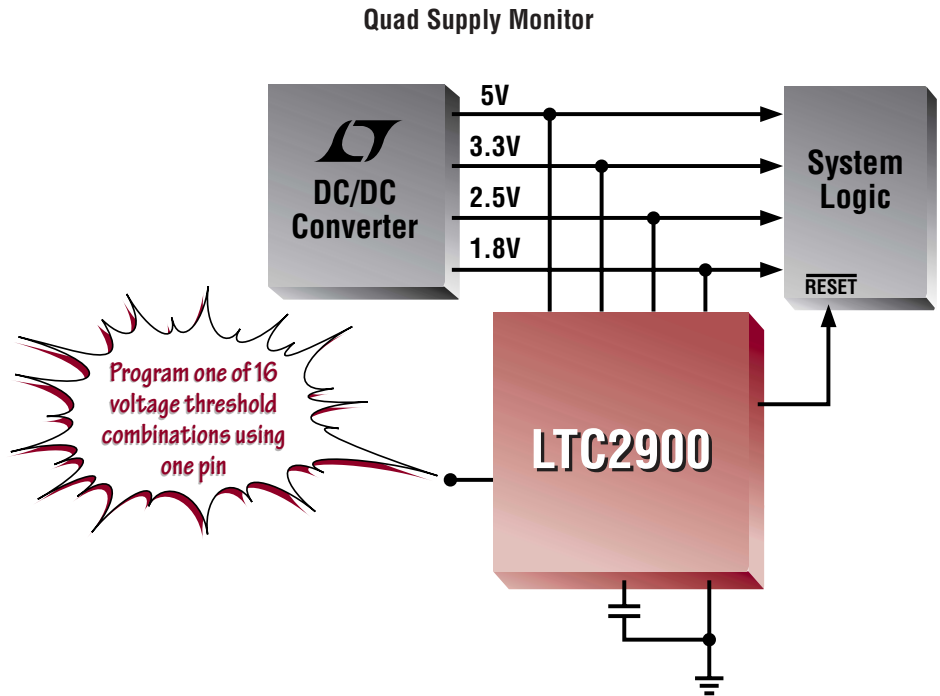


Supply Monitors

FPGAs typically require multiple voltages (core and I/O) for proper operation. Additional logic or different families of programmable logic on the same board may require yet more voltages, resulting in a system with three, four or more supply voltages. For proper system functionality and reliability, each of these supplies should be monitored to ensure that it falls within a tight voltage tolerance.

Linear Technology offers the most complete family of voltage monitors for applications with up to four supply voltages. Integrating up to four monitors in a single package, they require minimal space, low power and guarantee the tightest threshold accuracy in the industry.

- Monitor up to four different voltages with one IC
- Low power
- Small package
- Tight threshold accuracy
- Resistor divider programs the part for any of 16 voltage threshold combinations
- Stock a single IC for any combination of supply voltages



Quad Supply Monitors

Part Number	Voltage	Accuracy	I _{CC}	Package	Features
LTC2900	16 user-selectable combinations of	±1.5%	43µA	MS10	Quad supply monitor
LTC2901	5V, 3.3V, 3V, 2.5V, 1.8V, 1.5V and	±1.5%	43µA	SSOP-16	Adjustable watchdog timer
LTC2902	adjustable down to 0.5V or negative voltages	±1.5%	43µA	SSOP-16	Threshold adjustable by 5%, 7.5%, 10% or 12.5% and RST disable for margining testing

Triple Supply Monitors

Part Number	Voltage	Accuracy	I _{CC}	Package	Features
LTC1985-1.8	3V, 1.8V, Adj.	±1.5%	20µA	SOT-23	Push-pull RESET output
LTC1728-5	5V, 3.3V, Adj.	±1.5%	20µA	SOT-23	
LTC1728-2.5	3.3V, 2.5V, Adj.				
LTC1728-1.8	3V, 1.8V, Adj.				
LTC1727-5	5V, 3.3V, Adj.	±1.5%	20µA	MS8, SO-8	Comparator outputs for each supply voltage
LTC1727-2.5	3.3V, 2.5V, Adj.				
LTC1726-5	5V, 3.3V, Adj.	±1.5%	30µA	MS8, SO-8	Adjustable watchdog and adjustable RESET timeout
LTC1726-2.5	3.3V, 2.5V, Adj.				
LTC1536	5V, 3.3V, Adj.	±1.5%	200µA	MS8, SO-8	PCI-compliant fail timing
LTC1326	5V, 3.3V, Adj.	±0.75%	40µA	MS8, SO-8	Pushbutton RESET output and soft-reset output
LTC1326-5	3.3V, 2.5V, Adj.				

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Programmable Oscillators in SOT-23

The LTC6900 and LTC1799 are precision, low power oscillators that are easy to use and occupy very little PC board space. The oscillator frequency is programmed by a single external resistor (R_{SET})—no timing capacitor is needed. Both parts have been designed for high accuracy operation (<1.5% frequency error) without the need for external trim components.

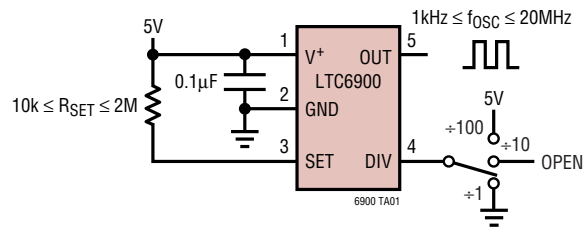
Using these devices to create local clocks close to logic devices can greatly simplify the complex routing and performance issues associated with board layouts.

- **One external resistor sets the frequency**
- **Insensitive to vibrations**
- **1kHz to 30MHz frequency range (LTC1799)**
- **500 μ A typical supply current (LTC6900)**
- **3V to 5V operation**
- **SOT-23 package**

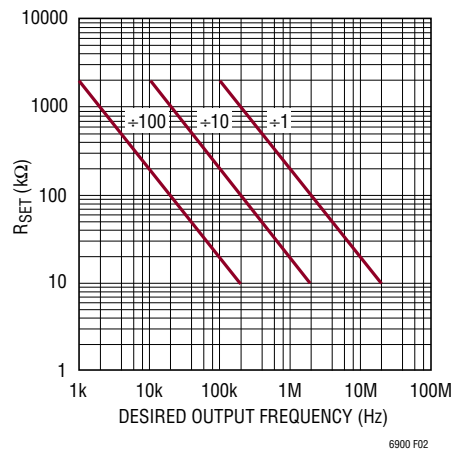
Programmable SOT-23 Oscillators

Part Number	Frequency	Accuracy	Supply Current	Comments
LTC1799	1kHz to 33MHz	1.5% (Max)	1 mA (at 3MHz)	Higher maximum frequency
LTC6900	1kHz to 20MHz	1.5% (Max)	500 μ A (at 3MHz)	Low power

Basic Connection



R_{SET} vs Desired Output Frequency



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