19-4507; Rev. 1; 3/92

EVALUATION KIT AVAILABLE

MAXIM

Battery-Powered Supply Systems

General Description

The MAX714/715/716 battery-powered supply systems combine multiple regulated voltage outputs with microprocessor supervisory functions that are optimized for battery-powered supplies. High-level integration and low-power CMOS simplify high-efficiency power-supply design in portable and battery-operated instruments.

The MAX716 combines circuitry for four low-dropout linear regulators, three DC-DC switching regulators, and power-supervisory functions on a single IC. All but one regulator output is logic controlled so that loads may be shut down to extend battery life. Linear-regulator outputs are pre-trimmed to +5V and operate with only 0.1V input-output differential. In addition, three DC-DC switching regulators generate a fixed negative output (-5V, -12V, or -15V), a software-adjustable negative output (-5V to -26V) to power LCD displays, and a positive boosted output voltage (+12 or +15). Other functions include backup-battery switchover, low-voltage warning, and power-fail reset.

The MAX716 is supplied in 28-pin plastic DIP and wide SO packages. The MAX715, in 24-pin narrow plastic DIP and CERDIP packages, eliminates one linear-regulator output. The MAX714, in 16-pin packages, includes two linear regulators and the LCD display DC-DC converter.

Applications

Portable Computers

Battery-Powered, Microprocessor-Based Systems

Handheld Instruments, Terminals

Bar-Code Readers

Remote Data-Acquisition Systems

Features

- ♦ **Four Logic-Controlled +5V Regulators**
- ♦ **Three Switching Regulators**
- ♦ **35µA Quiescent Current in Standby Mode**
- ♦ **100mV Dropout on Linear Regulators**
- ♦ **CMOS RAM Battery-Switchover Circuit**
- ♦ **Microprocessor Reset and Interrupt Outputs**
- ♦ **Hardware-On Signal**
- ♦ **Evaluation Kit Available – MAX716EVKIT**

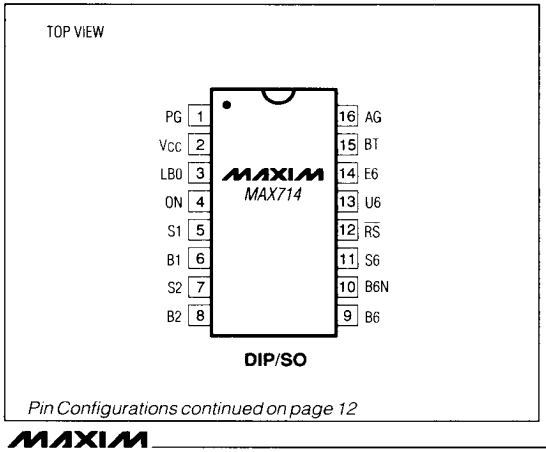
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX714CPE	0°C to +70°C	16 Plastic DIP
MAX714CWE	0°C to +70°C	16 Wide SO
MAX714C/D	0°C to +70°C	Dice*
MAX714EPE	-40°C to +85°C	16 Plastic DIP
MAX714EWE	-40°C to +85°C	16 Wide SO
MAX714MJE	-55°C to +125°C	16 CERDIP
MAX715CNG	0°C to +70°C	24 Narrow Plastic DIP
MAX715CWG	0°C to +70°C	24 Wide SO
MAX715C/D	0°C to +70°C	Dice*
MAX715ENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX715EWG	-40°C to +85°C	24 Wide SO
MAX715MRG	-55°C to +125°C	24 Narrow CERDIP

Ordering Information continued on page 12.

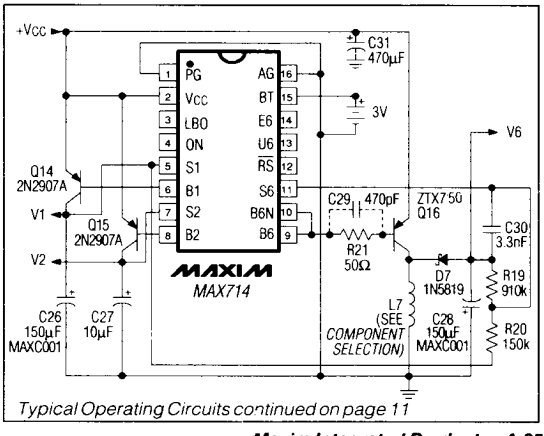
Contact factory for dice specifications.

Pin Configurations



Pin Configurations continued on page 12

Typical Operating Circuits



Typical Operating Circuits continued on page 11

Call toll free 1-800-998-8800 for free samples or literature.

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ABSOLUTE MAXIMUM RATINGS

Input Supply Voltages
- V_{CC}, BT ..... -0.3V to +12V
- S1-S7, B1-B7, ON, E3-E7, U6 ..... -0.3V to the higher of V_{CC}+0.3V or BT+0.3
- LB0, $\overline{RS}$ ..... -0.3V to V1+0.3V

Maximum $\Delta V/\Delta T$ on V_{CC} 1V/µs
Maximum $\Delta V/\Delta T$ on BT ..... Infinite
Continuous Power Dissipation
- Plastic DIP
  - 16-Pin (derate 7.41mW/°C above +70°C) 593mW
  - 24-Pin Narrow (derate 8.7mW/°C above +70°C) .. 696mW
  - 28-Pin (derate 9.09mW/°C above +70°C) 727mW
- Wide SO
  - 16-Pin (derate 9.52mW/°C above +70°C) 762mW
  - 24-Pin (derate 11.76mW/°C above +70°C) 941mW
  - 28-Pin (derate 12.50mW/°C above +70°C) 1000mW

CERDIP
- 16-Pin (derate 10mW/°C above +70°C) 800mW
- 24-Pin Narrow (derate 12.5mW/°C above +70°C) ... 1000mW
- 28-Pin (derate 16.67mW/°C above +70°C) 1333mW

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(AG = PG = 0V, V_{CC} = +5.05V to +11V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage Range	V_{CC}	Regulated output	5.05		11.00	V
Low Battery Indicator Threshold (Note 1)	LBO	MAX71_C_ _	5.05	5.16	5.27	V
Shutdown Voltage Range		MAX71_C_ _	4.81	4.92	5.05	V
Delta Between LB0 and $\overline{RS}$ (Note 1)		MAX71_C_ _	0.19	0.24	0.29	V
Low Battery Indicator Threshold (Note 1)	LBO	MAX71_E/M_ _	4.94	5.16	5.27	V
Shutdown Voltage Range		MAX71_E/M_ _	4.70	4.92	5.05	V
Delta Between LBO and $\overline{RS}$ (Note 1)		MAX71_E/M_ _	0.17	0.24	0.31	V
Battery Input	BT		2.3		4.0	V
Supply Current in Backup State		V_{CC} = 0V, BT = 3V, MAX71_C_ _		7	15	µA
		V_{CC} = 0V, BT = 3V, MAX71_E/M_ _		7	20	
Supply Current in Standby State (ON = 0V)		V_{CC} = 11V, BT = 3V		35	55	µA
Supply Current in Operating State (ON = V1)		V_{CC} = 11V, BT = 3V, V1 and V2 on only, I_{OUT} = 0µA		300	500	µA
$\overline{RS}$ Pulse Width			160	230	350	ms
V_{CC} to BT Power-Supply Switchover (Note 2) BT to V_{CC} Power-Supply Switchover (Note 2)			-200		-50	mV
			50		200	
BT Input Current (Note 3)		BT = 3V, V_{CC} = 5.05-11V	-1.00	0.01	1.00	µA
Digital Input Levels; ON, E3-E7, U6	V_{IH}		V1•0.7			V
	V_{IL}				V1•0.3	
	I_{IH}	Digital input current			5	µA
Digital Outputs; $\overline{RS}$, LB0	V_{OH}	I_{OUT} = -500µA	V1-0.5			V
	V_{OL}	I_{OUT} = 500µA			0.5	

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ELECTRICAL CHARACTERISTICS (continued)

(AG = PG = 0V, V_{CC} = +5.05V to +11V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LINEAR REGULATORS V1 - V4						
Output Voltage (Note 4)	V_{OUT}	5.05 < V_{CC} < 11	4.75		5.25	V
		V_{CC} = 5.05, I_{OUT} = 100mA	4.75		5.25	
Load Regulation (Note 4)		I_{OUT} = 1mA to 100mA, V_{CC} = 9V		35	100	mV
Line Regulation (Note 4)		V_{CC} = 5.05V to 11V, I_{OUT} = 1mA		20	100	mV
Additional Operating Supply Current when each V3, V4 Input is Enabled		V_{CC} = 11V		100	200	µA
Output Voltage Tracking Maximum Difference Between V1, V2, V3, V4		V_{CC} = 5.05V to 11V, I_{OUT} ≤ 100mA	-300		300	mV
B1-B4 Maximum Sink Capability		V_{CC} = 9V, B1-B4 = 5V	10	50	85	mA
B1 Sink Capability		During standby mode		100		µA
DC-DC CONVERTERS V5 - V7						
Additional Operating Supply Current when each V5, V6, V7 Input is Enabled		V_{CC} = 11V		125	200	µA
Extra Operating Supply Current when RC Oscillator Enabled (Note 5)		V_{CC} = 11V		225	300	µA
Oscillator Timing High Period Low Period	T_{ON} (Note 6)	V_{CC} = 5.5V, MAX71_C_ _	10.22	11.36	12.45	µs
		V_{CC} = 11V, MAX71_C_ _	4.56	5.70	6.84	
	T_{OFF}	V_{CC} = 5.5V to 11V, MAX71_C_ _	11.25	12.50	13.75	
Oscillator Timing High Period Low Period	T_{ON} (Note 6)	V_{CC} = 5.5V, MAX71_E/M_ _	9.09	11.36	13.63	µs
		V_{CC} = 11V, MAX71_E/M_ _	4.56	5.70	6.84	
	T_{OFF}	V_{CC} = 5.05V to 11V, MAX71_E/M_ _	10	12.50	15	
Input Leakage Current S5-S7		V_{CC} = 11V, S5-S7 = 1V	-1		1	µA
S5 Voltage		E5 = V1	-30		30	mV
S6 Voltage		E6 = V1, controlled by DAC, Code = 00000	-70		70	mV
		E6 = V1, controlled by DAC, Code = 11111	1.18		1.32	V
S7 Voltage		E7 = V1	1.18	1.25	1.32	V
B5, B6, B7 Drive Voltages	V_{OL}	V_{CC} = 5.5V, I_{SINK} = 10mA		0.5	1.0	V
	V_{OH}	V_{CC} = 5.5V, I_{SOURCE} = 10mA	4.0	4.5		
Efficiency				85 (Note 7)		%

Note 1: Typical ramp rate 1V/ms.
Note 2: Tested with less than 1V/ms on V_{CC} and BT separately.
Note 3: To minimize test time, a larger max spec was chosen. The typical value indicates the mean value.
Note 4: A Motorola 2N2907A PNP was used as the output transistor in Figure 1.
Note 5: RC oscillator is enabled whenever any one of the DC-DC convertors is enabled.
Note 6: T_{ON} varies proportionally to 1/V_{CC}.
Note 7: The efficiency depends on external components and can be increased or decreased from this typical value.

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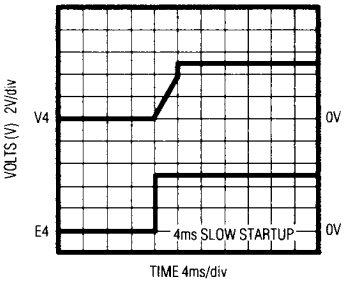
Typical Operating Characteristics

BACKUP-BATTERY SWITCHING AND WARNING FLAGS



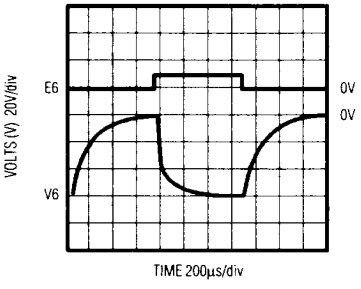
NOTE: THE BACKUP BATTERY IS AT 3V

REGULATOR 4 TURN-ON TIME



REGULATOR 4 V_{OUT} 0V TO +5V
WITH LOAD OF 390Ω AND 150µF

REGULATOR 7 TURN-ON TIME

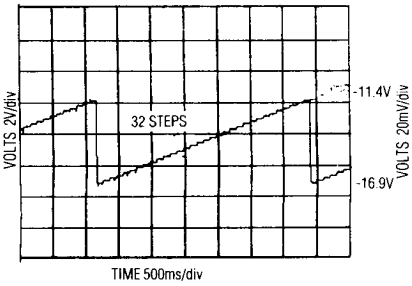


REGULATOR V_{OUT} 0V TO -30V
I_{OUT} 0mA TO -30mA 10V/div

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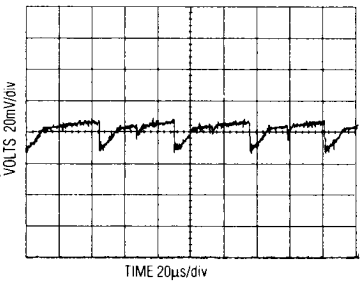
Typical Operating Characteristics (continued)

REGULATOR 7 V_{OUT} STEPPING



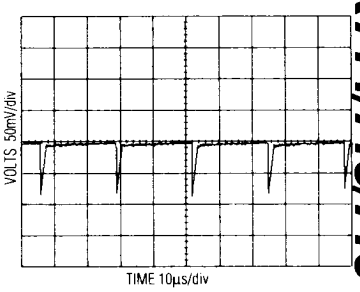
REGULATOR 7 V_{OUT} -11.4 TO -16.9 V WITH 10kΩ LOAD

REGULATOR 6 OUTPUT RIPPLE UNFILTERED



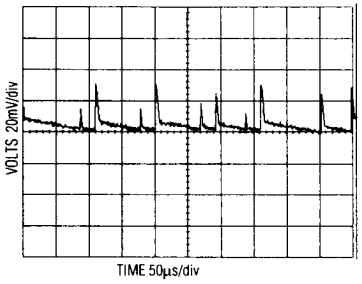
REGULATOR 6 V_{OUT} = -5V WITH 250Ω LOAD

REGULATOR 7 OUTPUT RIPPLE UNFILTERED



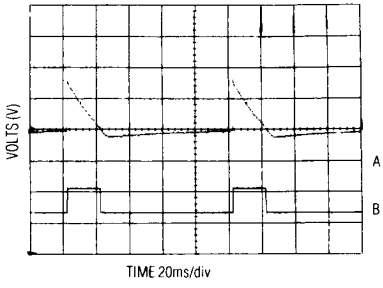
REGULATOR 7 V_{OUT} = -30V WITH 150kΩ LOAD

REGULATOR 8 OUTPUT RIPPLE UNFILTERED



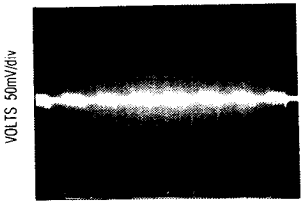
REGULATOR 8 V_{OUT} = +15V WITH 1.5kΩ LOAD

V2 LINE TRANSIENT RESPONSE



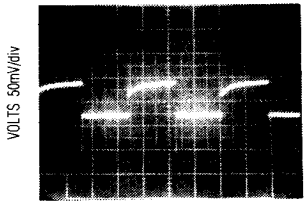
A = V2 VOLTAGE OUT, 2V/div
B = LINE TRANSIENT SWITCH 5V/div

V5 LOAD-TRANSIENT RESPONSE



0mA TO -40mA LOAD
V_{CC} = +9V, V_{OUT} = -5V
ZTX749 OUTPUT TRANSISTOR

V4 LOAD-TRANSIENT/DROPOUT RESPONSE



0mA TO 100mA LOAD
V_{CC} = +9V, V_{OUT} = -5V
2N2907 OUTPUT TRANSISTOR

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Pin Description

MAX714 PIN	MAX715 PIN	MAX716 PIN	NAME	FUNCTION
15	1	1	BT	Backup-Battery Input
16	2	2	AG	Analog Ground
1	3	3	PG	High-Power Ground
2	4	4	V_{CC}	Main Supply Input: +5.05V to +11V
3	5	5	LBO	Low Battery Warning Output. High when V_{CC} > 5.16V.
4	6	6	ON	Hardware-On Input. Logic-high level activates V2-V7. V1 is always on.
–	–	7	S4	V4, Feedback-Sense Input
–	–	8	B4	V4, Base drive for linear regulator output transistor
5	7	9	S1	V1, Feedback-Sense Input
6	8	10	B1	V1, Base drive for linear regulator output transistor
7	9	11	S2	V2, Feedback-Sense Input
8	10	12	B2	V2, Base drive for linear regulator output transistor
–	11	13	B3	V3, Base drive for linear regulator output transistor
–	12	14	S3	V3, Feedback-Sense Input
–	13	15	B5	V5, Base drive for the inverting output transistor
–	14	16	S5	V5, Feedback-Sense Input
9	15	17	B6	V6, Base drive for LCD inverting output transistor (MAX714 - B6P)
10	–	–	B6N	V6, MAX714 only
11	16	18	S6	V6, Feedback-Sense Input – for adjustable (LCD) switching regulator
–	17	19	B7	V7, Base-/Gate-Drive Output – step-up switching transistor/MOSFET
–	18	20	S7	V7, Feedback-Sense Input – step-up switching regulator
12	19	21	$\overline{RS}$	$\overline{Reset}$ Output – low during power-up, battery-backup, and standby states
–	20	22	E3	V3, Enable Input
–	–	23	N.C.	No Connect
–	–	24	E4	V4, Enable Input
13	21	25	U6	Pulsing this input increments V6 negative output
–	22	26	E5	V5, Enable Input
14	23	27	E6	V6, Enable Input
–	24	28	E7	V7, Enable Input

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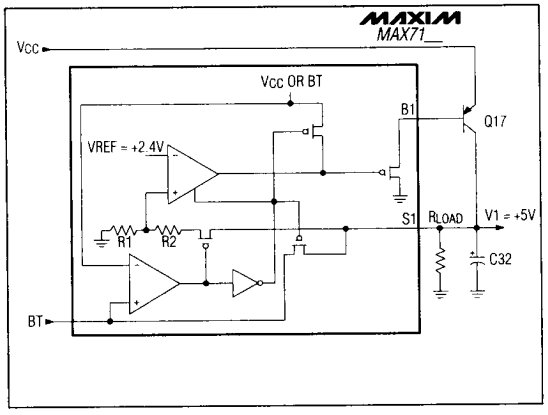


Figure 1. Functional Diagram and Circuit for Linear Regulator V1

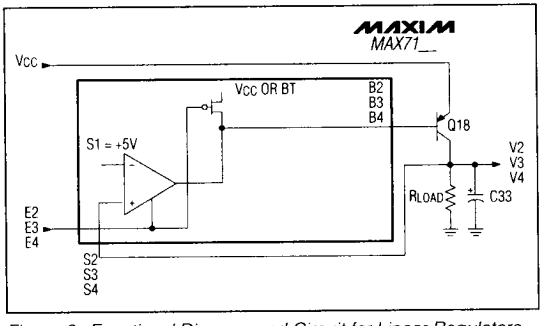


Figure 2. Functional Diagram and Circuit for Linear Regulators V2-V4

Detailed Description

External PNP pass transistors provide low-dropout linear outputs while minimizing regulator interaction and maximizing line and load rejection. The switching regulators employ external switching transisitors to maximize efficiency at low input voltages.

DC-DC convertor output current is primarily determined by the selected inductors and transistors. Inductors and transistors for several voltage and current outputs are listed in Table 1.

A "speed-up" capacitor (C29) (see *Typical Operating Characteristics*, page 1) appears in dotted lines across the base resistor of the DC-DC converter's output transistor. This capacitor reduces switching time and increases efficiency by about 2%. It may be omitted if efficiency improvement is not needed. Linear-regulator (V1-V4) output current is determined by the current capability of the selected output PNP pass transistors. The 2N2907A transistors in Figure 1 can provide load currents up to approximately 600mA.

TABLE 1: COMPONENT SELECTION

REGULATOR	TRANSISTOR	INDUCTOR*	VOUT (V)	IOUT (mA)
V5	2N2907A	470µH CB 7070-33	-5	-30
V5	2N2907A	390µH CB 7070-32	-5	-36
V5	ZTX750	100µH CB 7070-25	-5	-100
V6	2N2907A	220µH CB 7070-29	-18	-17
V6	ZTX750	82µH CB 7070-24	-26	-30
V6	ZTX750	100µH CTX100-3	-26	-28
V7	2N2222A	470µH CB 7070-33	15	14
V7	2N2222A	220µH CB 7070-29	15	30

* CB = Caddell-Burns, CTX = Coiltronics, ZTX = Zetex

The Caddell-Burns (CB) inductors are ferrite-bobbin cylindrical coils and the Coiltronics (CTX) is a surface-mount toroidal inductor.

Linear Regulators

Linear-regulator output current is a function of the selected PNP pass transistors. As the input voltage rises, power dissipation in the transistor limits the safe output current. Very little power is dissipated in the MAX714/715/716 devices, but each transistor must dissipate (V_{CC}-V_{OUT}) x I_{OUT}. Consult the pass-transistor data sheets for power-dissipation and thermal-resistance limits.

To maintain stability, 10µF output capacitors are required at the V2-V4 linear regulator outputs. 150µF is recommended at V1, as it serves as the V2-V4 reference, and V1 output ripple may feed through to other regulator outputs.

For V2-V4, use these minimum capacitor values:
I_{LOAD} 500mA – 100µF
I_{LOAD} 50mA – 10µF

Outputs B1-B4 drive the bases of external PNP pass transistors and sink a minimum of 10mA. The output voltage at the collector of the external PNP transistor is sensed at S1-S4 to maintain regulation. When an output is turned off, the base-drive output rises to VCC (or BT whichever is higher), turning off the pass transistor.

Short-circuit current limiting and thermal shutdown are not implemented in the regulator outputs. Consequently,

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short-circuit current is limited only by the maximum B1-B4 sink current (85mA) and the transistor current gain (beta).

During standby, when the ON input is low or V_{CC} < 4.95V, B1 is limited to 100µA to reduce power consumption during dropout (dropout occurs when V_{CC} falls below 5V). During start-up, V2-V4 base currents limit at approximately 0.5mA for about 4ms to prevent large load-current transients. The external PNP transistors should have betas above 100 and f_t above 200MHz. Typical transistors are 2N2907A and 2N3905.

All 5V outputs have a tolerance of ±5% over the specified V_{CC} input voltage, output current, and temperature ranges. V1 serves as the reference for all other 5V outputs to maintain optimum tracking between outputs.

Switching Regulators

Inverters

Figures 3 and 4 show typical operating circuits for the V5 and V6 inverting regulators. V5's feedback input (S5) is kept at 0V in regulator 5. In regulator 6, S6 is digitally adjusted from 0V to +1.25V, providing a variable negative supply for LCD power.

When V5 (Figure 3) becomes less negative than the level set by the R23 and R24 resistor dividers, B5 toggles at the oscillator frequency (f_{OSC} varies with V_{CC}; see *Electrical Characteristics*), turning on Q19 when B5 is low. When Q19 turns on, current increases in the L8 inductor, storing energy in its magnetic field. When Q19 is off, current flows through L8 in the same direction, flowing from C35 through D8, making V5 more negative. As inductor energy is transferred to C35, the inductor current decays linearly to zero and its magnetic field collapses. V6 (Figure 4) operates similarly to V5, except its output is varied by a digital input signal at V6.

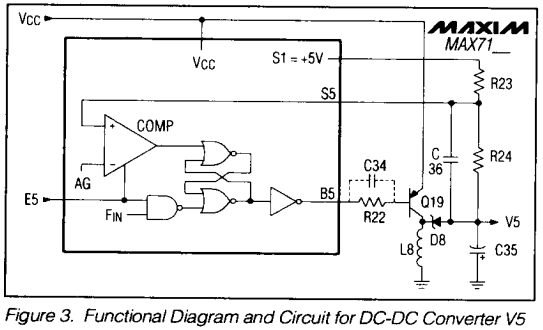


Figure 3. Functional Diagram and Circuit for DC-DC Converter V5

The B5 and B6 outputs are suitable for driving external PNP or logic-level P-channel MOSFET switching transistors (such as the Siliconix SMD10PO5L); however, PNP transistors are less expensive for input voltages below 7V. Likewise, the B7 output can drive a logic-level N-channel MOSFET such as the Siliconix Si9956DY.

The output voltages of V5 and V6 are set by these equations:

$$R24 = -V5 \times (R23/5)$$
$$R27 = -R26 \times (V6-V_{TH})/(5-V_{TH}),\ V_{TH} = 0V \text{ to } +1.25V$$

The V6 output (Figure 4) is generated in the same fashion as V5, except that the S6 threshold can be varied from 0V to +1.25V with an internal 5-bit (32 step) DAC. The DAC is incremented by pulsing U6 and can only be incremented in one direction (more negative). To reduce the voltage (less negative), the DAC must loop completely around; to decrement by one step, U6 must be clocked 31 times. The DAC is set to 0V during standby and whenever V6 is turned off.

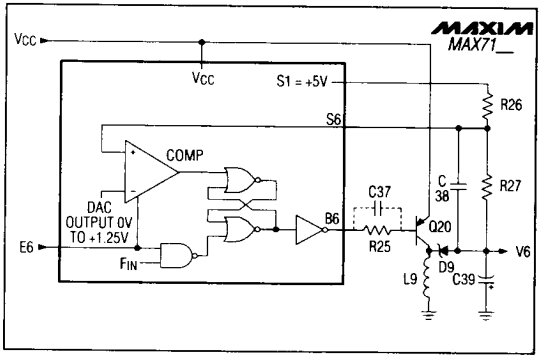


Figure 4. Functional Diagram and Circuit for DC-DC Converter V6

V6's output voltage range is set by an external resistor divider connected between V1 (used as a reference) and V6 (see Table 2). A good typical value for R26 is 150kΩ. The ratio of the resistors to each other sets the voltage ranges as follows. Choose the high value to be within the absolute maximum of the display.

TABLE 2: V6 (LCD POWER) VOLTAGE RANGE

R27/R26 RATIO	V6 OUTPUT VOLTAGE RANGE (V)
6:1	-30 to -21.3
5:1	-25 to -17.5
4:1	-20 to -13.8
3:1	-15 to -10
2:1	-10 to -6.3
1:1	-5 to -2.5

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Step-Up Converter

Regulator V7 operates similiarly to V5, except that it steps up rather than inverts. In Figure 5, the feedback input (S7) is kept at 1.25V. B7 swings from 0V to V_{CC}, and can drive either the gate of an N-channel power MOSFET or the base of an NPN transistor. When V7 is at the desired voltage, B7 remains low, keeping Q21 off. When V7 falls below the preset level, B7 switches Q21 on and off at the clock frequency. When Q21 turns off, inductor current flows through D10 into C41, and V_{OUT} rises. R30 is set by:

$$R30 = R29 \times 1.25/(V7-1.25)$$

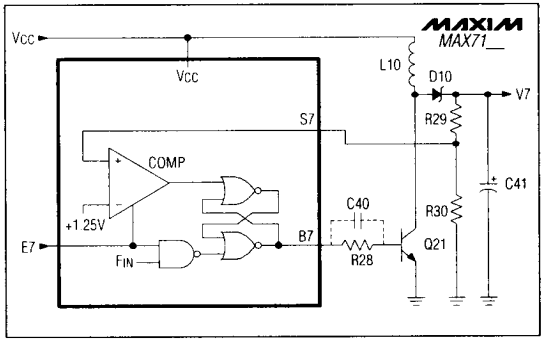


Figure 5. Functional Diagram and Circuit for DC-DC Converter V7

Switching Frequency and Soft Start

The switching frequency is set by an internal oscillator. The oscillator high period (switch-on time) is inversely proportional to V_{CC} and peak inductor current remains constant over variations in input voltage. The high period is typically 11.36µs with V_{CC} = 5.5V, and 5.7µs with V_{CC} = 11V. The low period (off time) is typically 12.5µs and is independent of V_{CC}.

A soft-start circuit limits the oscillator duty cycle at start-up by enabling the switch during every 8th oscillator cycle only. The soft-start duration is approximately 4ms. This prevents large current drain at turn-on.

Board Layout and Grounding

Since the V5-V7 DC-DC converters use feedback control circuitry, it is important to minimize the lengths of GND connections and feedback points. Minimize the size of the connections between S5, S6, S7, and the respective resistors, and place the transistors' output bases as close as possible to the respective B5, B6, and B7 base pins. The traces connecting the V_{CC} pins to the input capacitor (C28 or C31 in *Typical Operating Circuits*) must be separate from the high current traces of the linear switching circuits.

Switching-Regulator Components

Inductor Selection

The output power of each switching regulator depends on the selected inductor and switching transistor. Table 1 lists components for two ranges of output current (see *Typical Operating Characteristics*). Other inductor types may also be used, but be sure to observe their peak current ratings.

For the output power levels given in Table 1, Caddell-Burns 7070 inductors were used. However, smaller size inductors may be used in low output-current applications. In general, higher internal resistance and lower current ratings reduce efficiency and increase the chance of inductor saturation. Be sure to observe the manufacturer's ratings on substitute coils. Coiltronics produces surface-mount inductors that have relatively high-power capacity compared to their size. For alternate output voltage, current values, or coil selection, contact Maxim's applications department.

Coil saturation is the most likely cause of poor efficiency, overheating, and component damage in switching-regulator circuits. Test for saturation by applying the maximum load over the full input voltage range while monitoring the inductor current with a current probe. The normal inductor-current waveform is a sawtooth with a linear increase and decrease of current. Saturation creates a nonlinear current waveform where current slope increases as the current level rises.

Capacitor Selection

The V5-V7 output ripple contains two elements. One is the result of change in the stored charge on the filter capacitor with each current pulse. The other element is the effect of the capacitor's charge/discharge current and its equivalent series resistance (ESR). With low-cost aluminum electrolytic capacitors, ESR-produced ripple may sometimes be greater than that caused by the change in charge. Consequently, high-quality aluminum or tantalum filter capacitors minimize output ripple, even when smaller capacitance values are used. Best results at reasonable cost are achieved with a high-quality aluminum electrolytic capacitor in parallel with a 0.1µF ceramic capacitor. For V5-V7, the MAXC001 or equivalent capacitor is recommended for an output filter.

The Typical Operating Circuit on page 11 shows capacitors C8-C10 as dashed lines connected in parallel with the base resistors of transistors Q5-Q7. These capacitors improve efficiency by about 2% by reducing switching time, but can be omitted if component count is critical.

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Rectifier Selection

Since the current in the external rectifiers switches abruptly, they must have a fast turn-on time to minimize losses. For low-power circuits with peak inductor currents less than 100mA, signal diodes such as 1N4148s perform well. In higher-power applications, or for maximum efficiency at low power, Schottky rectifiers are recommended. Although 1N4001s and other general-purpose rectifiers are rated for high currents, they are unacceptable because their slow turn-on times result in excessive losses. Since Schottky rectifiers tend to have limited breakdown voltage, be careful to observe this limit, especially in the V6 and V7 inverting regulators. When the switch turns on, the voltage at the inductor-diode junction is pulled to V_{CC}. When the switch turns off, this junction "flies back" to the negative output. If the V7 output is -26V, the diode reverse voltage is +11V - (-26V), or +37V, which is why the higher rated (40V) 1N5819 is used.

System Operating Modes

There are three system operating modes:

Battery Backup
Standby
Operating

Battery-Backup Mode

In battery-backup mode, V1 provides a low current output to maintain CMOS RAM and/or a real-time clock. The input to V1 is supplied by the backup battery when V_{CC} is less than the backup-battery voltage. This will happen when the main battery is discharged, the line power switch is disconnected, or the main battery is being replaced. Battery-backup mode is entered whenever the voltage at BT is higher than V_{CC}. Supply current in this state is less than 15µA maximum with a 3V backup-battery voltage.

In battery-backup mode:

1) V1 connects to BT via an internal 500Ω switch.
2) All other outputs (V2-V7) turn off.
3) S2-S4 connect to GND via internal 5kΩ resistors.
4) ON and $\overline{RS}$ outputs are low.
5) All digital inputs are ignored. The allowed digital input range is 0V to V1.

Changing Batteries

The V1 regulator picks the higher of either V_{CC} or BT. Either the main battery (at V_{CC}) or the backup battery (but not both) may be removed without loss of backup power. The V_{CC} rate-of-rise must be limited to 1V/µs during power-up. The BT rate-of-rise need not be controlled.

The BT input must be connected to GND if a backup battery is not used. If BT is left unconnected, leakage currents may raise the BT-terminal voltage to a level that causes erroneous switchover to the battery backup. The BT input range is 2.3V to 4.0V. BT voltage above 4V may damage external transistors.

Standby Mode

Standby is entered from the operating mode when the ON input is low. The purpose of standby is to minimize power consumption between periods of normal operation. The MAX714/715/716 also enter standby if V_{CC} falls to approximately 4.95V (4.70V min). Operating circuitry must be shut down by the system processor before standby is entered; this prevents data loss that might result from power supplies turning off without warning. The low battery output provides early warning so that data can be saved.

In standby mode:

1) V1 = 5V (or V_{CC}, whichever is lower).
2) B1 output current is limited to 100µA typ.
3) V2-V7 are off.

Standby mode is also entered from the battery-backup mode whenever V_{CC} rises above BT.

The MAX714/715/716 power up in standby mode. The V1 output current is limited to 100µA times the beta of the pass transistor. If V1's load current is too high on power-up, there may be insufficient output current to regulate at 5V. For a transistor beta of 200, the load on V1 during power-up should be no more than 20mA.

Operating Mode

Operating mode is entered from standby by driving the ON input high. V_{CC} MUST be above the low battery warning threshold to enter the operating mode. V2 turns on, but the other regulators (V3-V7) are controlled by E3-E7 regulator enable inputs.

LBO Warning and $\overline{RS}$ Outputs

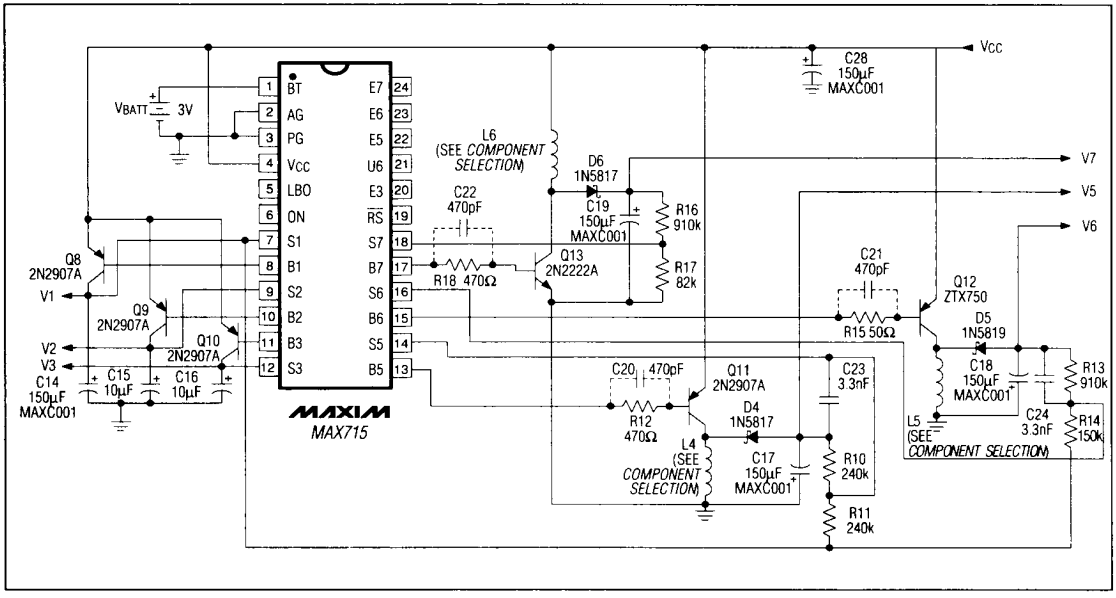
The low battery output (LBO) is normally a logic high (the V1 voltage). When V_{CC} falls to approximately 5.16V, LBO goes low. In a typical application, LBO drives the non-maskable interrupt ($\overline{NMI}$) input of a microprocessor (µP). When LBO goes low, the µP should perform an orderly shutdown of the system, including turning off all MAX714/715/716 regulators. This shutdown should be completed before V_{CC} falls more than 240mV below the low-battery warning threshold. When V_{CC} falls to approximately 4.92V, standby mode begins whether or not standby has been commanded by the µP. All supplies except V1 are turned off.

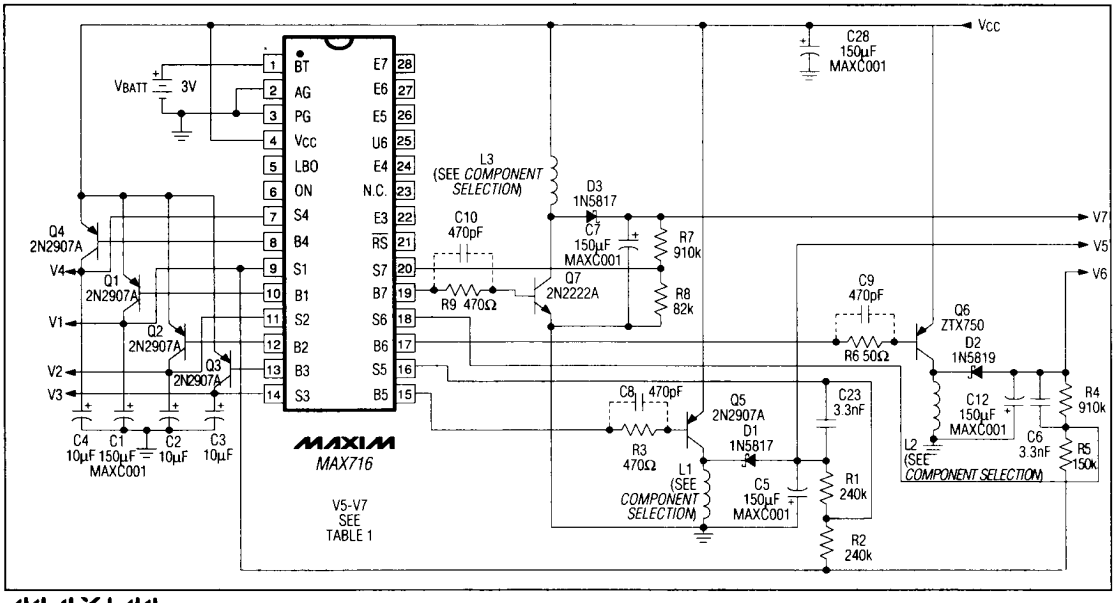
$\overline{RS}$ goes low during battery-backup and standby modes. It remains low for approximately 230ms after the ON input rises, and V_{CC} is above the warning threshold.

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Typical Operating Circuits (continued)

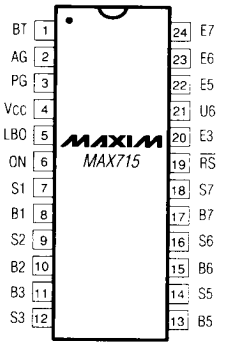




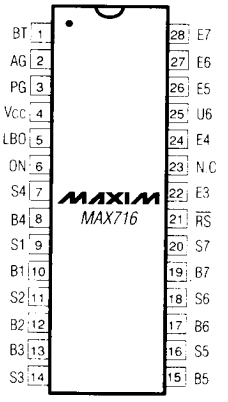
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Pin Configurations (continued)

TOP VIEW



DIP/SO



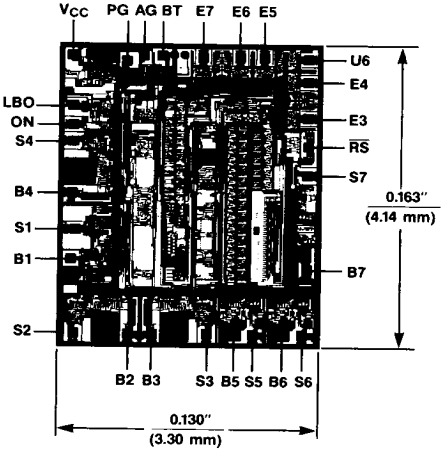
DIP/SO

Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX716CPI	0°C to +70°C	28 Plastic DIP
MAX716CWI	0°C to +70°C	28 Wide SO
MAX716C/D	0°C to +70°C	Dice*
MAX716EPI	-40°C to +85°C	28 Plastic DIP
MAX716EWI	-40°C to +85°C	28 Wide SO
MAX716MJI	-55°C to +125°C	28 CERDIP
MAX716EVKIT Evaluation Kit		

*Contact factory for dice specifications.

Chip Topography



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