19-4781; Rev 1; 7/00

EVALUATION KIT AVAILABLE

High-Speed, Digitally Adjusted Step-Down Controllers for Notebook CPUs

General Description

The MAX1710/MAX1711 step-down controllers are intended for core CPU DC-DC converters in notebook computers. They feature a triple-threat combination of ultra-fast transient response, high DC accuracy, and high efficiency needed for leading-edge CPU core power supplies. Maxim's proprietary Quick-PWM™ quick-response, constant-on-time PWM control scheme handles wide input/output voltage ratios with ease and provides 100ns "instant-on" response to load transients while maintaining a relatively constant switching frequency.

High DC precision is ensured by a 2-wire remote-sensing scheme that compensates for voltage drops in both the ground bus and supply rail. An on-board, digital-to-analog converter (DAC) sets the output voltage in compliance with Mobile Pentium II® CPU specifications.

The MAX1710 achieves high efficiency at a reduced cost by eliminating the current-sense resistor found in traditional current-mode PWMs. Efficiency is further enhanced by an ability to drive very large synchronous-rectifier MOSFETs.

Single-stage buck conversion allows these devices to directly step down high-voltage batteries for the highest possible efficiency. Alternatively, 2-stage conversion (stepping down the +5V system supply instead of the battery) at a higher switching frequency allows the minimum possible physical size.

The MAX1710/MAX1711 are identical except that the MAX1711 have 5-bit DACs and the MAX1710 has a 4-bit DAC. Also, the MAX1711 has a fixed overvoltage protection threshold at V_{OUT} = 2.25V and undervoltage protection at V_{OUT} = 0.8V whereas the MAX1710 has variable thresholds that track V_{OUT}. The MAX1711 is intended for applications where the DAC code may change dynamically.

Applications

Notebook Computers

Docking Stations

CPU Core DC-DC Converters

Single-Stage (BATT to V_{CORE}) Converters

Two-Stage (+5V to V_{CORE}) Converters

Quick-PWM is a trademark of Maxim Integrated Products.

Mobile Pentium II is a registered trademark of Intel Corp.

Pin Configurations appear at end of data sheet.

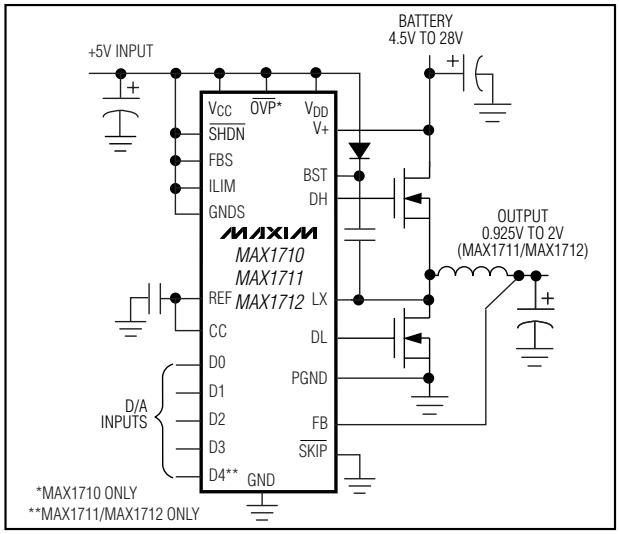
Features

- **Ultra-High Efficiency**
- **No Current-Sense Resistor (Lossless I_{LIMIT})**
- **Quick-PWM with 100ns Load-Step Response**
- **±1% V_{OUT} Accuracy over Line and Load**
- **4-Bit On-Board DAC (MAX1710)**
- **5-Bit On-Board DAC (MAX1711/MAX1712)**
- **0.925V to 2V Output Adjust Range (MAX1711/MAX1712)**
- **2V to 28V Battery Input Range**
- **200/300/400/550kHz Switching Frequency**
- **Remote GND and V_{OUT} Sensing**
- **Over/Undervoltage Protection**
- **1.7ms Digital Soft-Start**
- **Drive Large Synchronous-Rectifier FETs**
- **2V ±1% Reference Output**
- **Power-Good Indicator**
- **Small 24-Pin QSOP Package**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX1710EEG	-40°C to +85°C	24 QSOP
MAX1711EEG	-40°C to +85°C	24 QSOP

Minimal Operating Circuit



High-Speed, Digitally Adjusted Step-Down Controllers for Notebook CPUs

ABSOLUTE MAXIMUM RATINGS

V+ to GND .....-0.3V to +30V
V_{CC}, V_{DD} to GND .....-0.3V to +6V
PGND to GND .....±0.3V
$\overline{SHDN}$, PGOOD to GND .....-0.3V to +6V
$\overline{OVP}$, ILIM, FB, FBS, CC, REF, D0–D4, GNDS, TON to GND .....-0.3V to (V_{CC} + 0.3V)
$\overline{SKIP}$ to GND (Note 1) .....-0.3V to (V_{CC} + 0.3V)
DL to PGND .....-0.3V to (V_{DD} + 0.3V)
BST to GND .....-0.3V to +36V
DH to LX .....-0.3V to (BST + 0.3V)
LX to BST .....-6V to +0.3V
REF Short Circuit to GND .....Continuous
Continuous Power Dissipation (T_A = +70°C)
24-Pin QSOP (derate 9.5mW/°C above +70°C) 762mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +165°C
Lead Temperature (soldering, 10s) .....+300°C

Note 1: $\overline{SKIP}$ may be forced below -0.3V, temporarily exceeding the absolute maximum rating, for the purpose of debugging prototype breadboards using the no-fault test mode. Limit the current drawn to -5mA maximum.

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

(Circuit of Figure 1, V_{BATT} = 15V, V_{CC} = V_{DD} = 5V, $\overline{SKIP}$ = GND, **T_A = 0°C to +85°C**, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNIT
Input Voltage Range	Battery voltage, V+		2		28	V
	V_{CC}, V_{DD}		4.5		5.5	
DC Output Voltage Accuracy	V_{BATT} = 4.5V to 28V, includes load regulation error	DAC codes from 1.3V to 2V	-1		1	%
		DAC codes from 0.925V to 1.275V	-1.2		1.2	
Load Regulation Error	I_{LOAD} = 0 to 7A			9		mV
Remote-Sense Voltage Error	FB - FBS or GNDS - GND = 0 to 25mV			3		mV
Line Regulation Error	V_{CC} = 4.5V to 5.5V, V_{BATT} = 4.5V to 28V			5		mV
FB Input Bias Current	FB (MAX1710 only) or FBS		-0.2		0.2	µA
FB Input Resistance (MAX1711/MAX1712)			130	180	240	kΩ
GNDS Input Bias Current			-1		1	µA
Soft-Start Ramp Time	Rising edge of $\overline{SHDN}$ to full I_{LIM}			1.7		ms
On-Time	V_{BATT} = 24V, FB = 2V (Note 2)	TON = GND (550kHz)	140	160	180	ns
		TON = REF (400kHz)	175	200	225	
		TON = open (300kHz)	260	290	320	
		TON = V_{CC} (200kHz)	380	425	470	
Minimum Off-Time	(Note 2)			400	500	ns
Quiescent Supply Current (V_{CC})	Measured at V_{CC}, FB forced above the regulation point			600	950	µA
Quiescent Supply Current (V_{DD})	Measured at V_{DD}, FB forced above the regulation point			<1	5	µA
Quiescent Battery Supply Current	Measured at V+			25	40	µA
Shutdown Supply Current (V_{CC})	$\overline{SHDN}$ = 0			<1	5	µA
Shutdown Supply Current (V_{DD})	$\overline{SHDN}$ = 0			<1	5	µA
Shutdown Battery Supply Current	$\overline{SHDN}$ = 0, measured at V+ = 28V, V_{CC} = V_{DD} = 0 or 5V			<1	5	µA
Reference Voltage	V_{CC} = 4.5V to 5.5V, no external REF load		1.98	2	2.02	V
Reference Load Regulation	I_{REF} = 0 to 50µA				0.01	V
REF Sink Current	REF in regulation		10			µA
REF Fault Lockout Voltage	Falling edge, hysteresis = 40mV			1.6		V

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{BATT} = 15V, V_{CC} = V_{DD} = 5V, $\overline{SKIP}$ = GND, **T_A = 0°C to +85°C**, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Overvoltage Trip Threshold	With respect to unloaded output voltage (MAX1710)	10.5	12.5	14.5	%
	(MAX1711/MAX1712)	2.21	2.25	2.29	V
Overvoltage Fault Propagation Delay	FB forced 2% above trip threshold		1.5		µs
Output Undervoltage Protection Threshold	With respect to unloaded output voltage (MAX1710)	65	70	75	%
	(MAX1711/MAX1712)	0.76	0.8	0.84	V
Output Undervoltage Protection Time	From $\overline{SHDN}$ signal going high	10		30	ms
Current-Limit Threshold (Positive Direction, Fixed)	LX to PGND, ILIM tied to V_{CC}	90	100	110	mV
Current-Limit Threshold (Positive Direction, Adjustable)	LX to PGND, R_{LIM} = 100kΩ	40	50	60	mV
	LX to PGND, R_{LIM} = 400kΩ	170	200	230	mV
Current-Limit Threshold (Negative Direction)	LX to PGND, T_A = +25°C	-150	-120	-80	mV
Current-Limit Threshold (Zero Crossing)	LX to PGND		3		mV
PGOOD Propagation Delay	FB forced 2% below PGOOD trip threshold, falling edge		1.5		µs
PGOOD Output Low Voltage	I_{SINK} = 1mA			0.4	V
PGOOD Leakage Current	High state, forced to 5.5V			1	µA
Thermal Shutdown Threshold	Hysteresis = 10°C		150		°C
V_{CC} Undervoltage Lockout Threshold	Rising edge, hysteresis = 20mV, PWM disabled below this level	4.1		4.4	V
DH Gate-Driver On-Resistance	BST-LX forced to 5V			5	Ω
DL Gate-Driver On-Resistance (Pullup)	DL, high state			5	Ω
DL Gate-Driver On-Resistance (Pulldown)	DL, low state		0.5	1.7	Ω
DH Gate-Driver Source/Sink Current	DH forced to 2.5V, BST-LX forced to 5V		1		A
DL Gate-Driver Sink Current	DL forced to 2.5V		3		A
DL Gate-Driver Source Current	DL forced to 2.5V		1		A
Dead Time	DL rising		35		ns
	DH rising		26		ns
$\overline{SKIP}$ Input Current Logic Threshold	To enable no-fault mode, T_A = +25°C	-1.5		-0.1	mA
PGOOD Trip Threshold	Measured at FB with respect to unloaded output voltage, falling edge, hysteresis = 1%	-8	-5	-3	%
Logic Input High Voltage	D0–D4, $\overline{SHDN}$, $\overline{SKIP}$, $\overline{OVP}$	2.4			V
Logic Input Low Voltage	D0–D4, $\overline{SHDN}$, $\overline{SKIP}$, $\overline{OVP}$			0.8	V
Logic Input Current	$\overline{SHDN}$, $\overline{SKIP}$, $\overline{OVP}$	-1		1	µA
Logic Input Pullup Current	D0–D4, each forced to GND	3	5	10	µA

High-Speed, Digitally Adjusted Step-Down Controllers for Notebook CPUs

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{BATT} = 15V, V_{CC} = V_{DD} = 5V, $\overline{SKIP}$ = GND, **T_A = 0°C to +85°C**, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
TON V_{CC} Level	TON logic input high level	V_{CC} - 0.4			V
TON Float Voltage	TON logic input upper-midrange level	3.15		3.85	V
TON Reference Level	TON logic input lower-midrange level	1.65		2.35	V
TON GND Level	TON logic input low level			0.5	V
TON Logic Input Current	TON only, forced to GND or V_{CC}	-3		3	µA

ELECTRICAL CHARACTERISTICS

(Circuit of Figure 1, V_{BATT} = 15V, V_{CC} = V_{DD} = 5V, $\overline{SKIP}$ = GND, **T_A = -40°C to +85°C,** unless otherwise noted.) (Note 3)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNIT
Input Voltage Range	Battery voltage, V+		2		28	V
	V_{CC}, V_{DD}		4.5		5.5	
DC Output Voltage Accuracy	V_{BATT} = 4.5V to 28V, for all D/A codes, includes load regulation error	DAC codes from 1.32V to 2V	-1.5		1.5	%
		DAC codes from 0.925V to 1.275V	-1.7		1.7	%
On-Time	V_{BATT} = 24V, FB = 2V (Note 2)	TON = GND (550kHz)	140		180	ns
		TON = REF (400kHz)	175		225	
		TON = open (300kHz)	260		320	
		TON = V_{CC} (200kHz)	380		470	
Minimum Off-Time	(Note 2)				500	ns
Quiescent Supply Current (V_{CC})	Measured at V_{CC}, FB forced above the regulation point				950	µA
Reference Voltage	V_{CC} = 4.5V to 5.5V, no external REF load		1.98		2.02	V
Overvoltage Trip Threshold	With respect to unloaded output voltage (MAX1710)		10		15	%
	(MAX1711/MAX1712)		2.20		2.30	V
Output Undervoltage Protection Threshold	With respect to unloaded output voltage (MAX1710)		65		75	%
	(MAX1711/MAX1712)		0.75		0.85	V
Current-Limit Threshold (Positive Direction, Fixed)	LX to PGND, ILIM tied to V_{CC}		85		115	mV
Current-Limit Threshold (Positive Direction, Adjustable)	LX to PGND	R_{LIM} = 100kΩ	35		65	mV
		R_{LIM} = 400kΩ	160		240	
V_{CC} Undervoltage Lockout Threshold	Rising edge, hysteresis = 20mV, PWM disabled below this level		4.1		4.4	V
Logic Input High Voltage	D0–D4, $\overline{SHDN}$, $\overline{SKIP}$, $\overline{OVP}$		2.4			V
Logic Input Low Voltage	D0–D4, $\overline{SHDN}$, $\overline{SKIP}$, $\overline{OVP}$				0.8	V
Logic Input Current	$\overline{SHDN}$, $\overline{SKIP}$, $\overline{OVP}$		-1		1	µA
Logic Input Pullup Current	D0–D4, each forced to GND		3		10	µA

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{BATT} = 15V, V_{CC} = V_{DD} = 5V, $\overline{SKIP}$ = GND, **T_A = -40°C to +85°C,** unless otherwise noted.) (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
PGOOD Trip Threshold	Measured at FB with respect to unloaded output voltage, falling edge, hysteresis = 1%	-8.5		-2.5	%
PGOOD Output Low Voltage	I_{SINK} = 1mA			0.4	V
PGOOD Leakage Current	High state, forced to 5.5V			1	µA

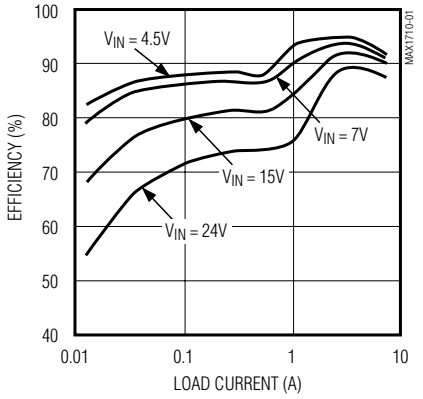
Note 2: On-Time and Off-Time specifications are measured from 50% point to 50% point at the DH pin with LX forced to 0V, BST forced to 5V, and a 250pF capacitor connected from DH to LX. Actual in-circuit times may differ due to MOSFET switching speeds.

Note 3: Specifications from -40°C to 0°C are guaranteed but not production tested.

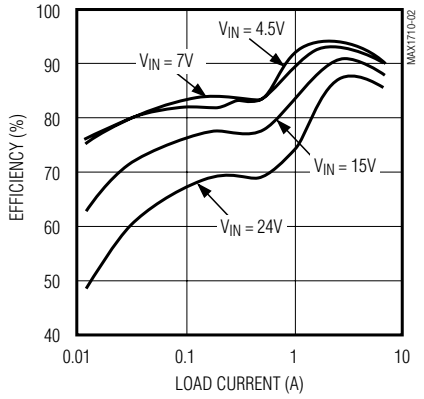
Typical Operating Characteristics

(7A CPU supply circuit of Figure 1, T_A = +25°C, unless otherwise noted.)

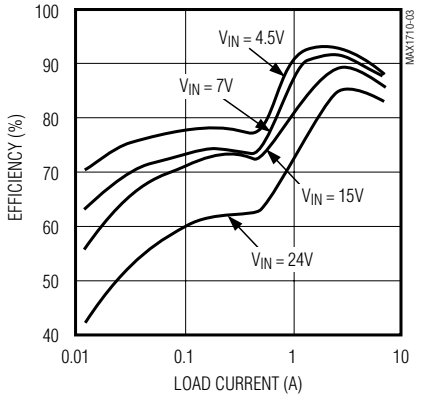
EFFICIENCY vs. LOAD CURRENT (V_O = 2.0V, f = 300kHz)



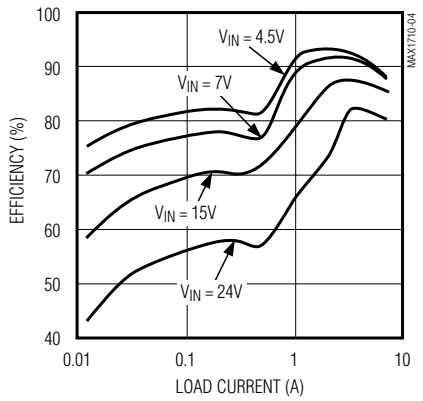
EFFICIENCY vs. LOAD CURRENT (V_O = 1.6V, f = 300kHz)



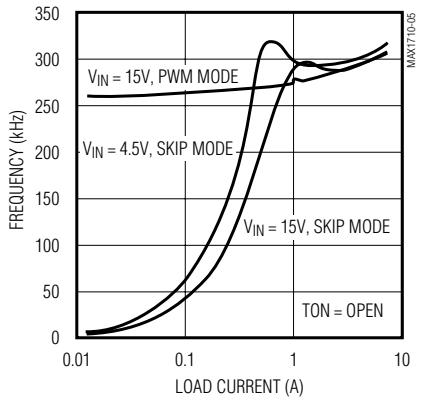
EFFICIENCY vs. LOAD CURRENT (V_O = 1.3V, f = 300kHz)



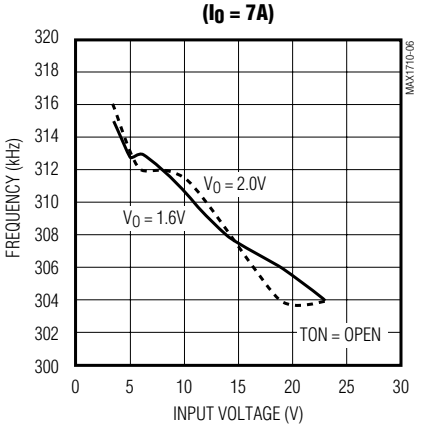
EFFICIENCY vs. LOAD CURRENT (V_O = 1.6V, f = 550kHz)



FREQUENCY vs. LOAD CURRENT (V_O = 1.6V)



FREQUENCY vs. INPUT VOLTAGE (I_O = 7A)



DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.