19-4023; Rev 0; 4/06

High-Efficiency, 5x Output, Main Power-Supply Controllers for Notebook Computers

General Description

The MAX1533A/MAX1537A are dual step-down, switch-mode power-supply (SMPS) controllers with synchronous rectification, intended for main 5V/3.3V power generation in battery-powered systems. Fixed-frequency operation with optimal interleaving minimizes input ripple current from the lowest input voltages up to the 26V maximum input. Optimal 40/60 interleaving allows the input voltage to go down to 8.3V before duty-cycle overlap occurs, compared to 180° out-of-phase regulators where the duty-cycle overlap occurs when the input drops below 10V. Output current sensing provides accurate current limit using a sense resistor. Alternatively, power dissipation can be reduced using lossless inductor current sensing.

Internal 5V and 3.3V linear regulators power the MAX1533A/MAX1537A and their gate drivers, as well as external keep-alive loads, up to a total of 100mA. When the main PWM regulators are in regulation, automatic bootstrap switches bypass the internal linear regulators, providing currents up to 200mA from each linear output. An additional 5V to 23V adjustable internal 150mA linear regulator is typically used with a secondary winding to provide a 12V supply.

The MAX1533A/MAX1537A include on-board power-up sequencing, a power-good (PGOOD) output, digital soft-start, and internal soft-shutdown output discharge that prevents negative voltages on shutdown. The MAX1533A is available in a 32-pin 5mm x 5mm thin QFN package, and the MAX1537A is available in a 36-pin 6mm x 6mm thin QFN package. The exposed backside pad improves thermal characteristics for demanding linear keep-alive applications.

Applications

2 to 4 Li+ Cells Battery-Powered Devices

Notebook and Subnotebook Computers

PDAs and Mobile Communicators

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX1533AETJ	-40°C to +85°C	32 Thin QFN 5mm x 5mm
MAX1533AETJ+	-40°C to +85°C	32 Thin QFN 5mm x 5mm
MAX1537AETX	-40°C to +85°C	36 Thin QFN 6mm x 6mm
MAX1537AETX+	-40°C to +85°C	36 Thin QFN 6mm x 6mm

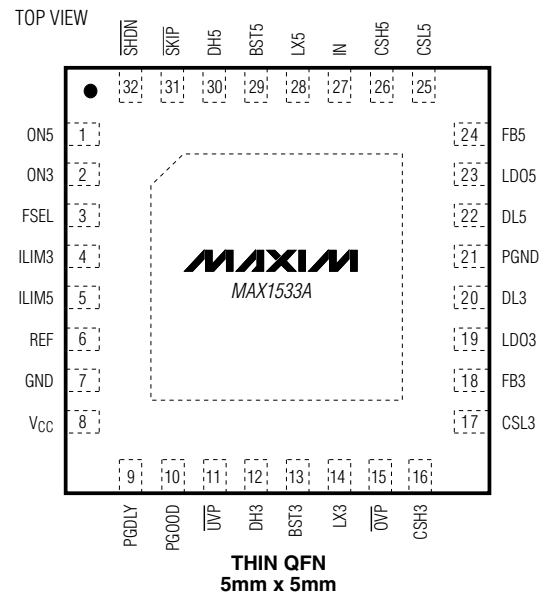
+Denotes lead-free package.

Dual Mode is a trademark of Maxim Integrated Products, Inc.

Features

- ♦ **Fixed-Frequency, Current-Mode Control**
- ♦ **40/60 Optimal Interleaving**
- ♦ **Accurate Differential Current-Sense Inputs**
- ♦ **Internal 5V and 3.3V Linear Regulators with 100mA Load Capability**
- ♦ **Auxiliary 12V or Adjustable 150mA Linear Regulator (MAX1537A Only)**
- ♦ **Dual Mode™ Feedback—3.3V/5V Fixed or Adjustable Output (Dual Mode) Voltages**
- ♦ **200kHz/300kHz/500kHz Switching Frequency**
- ♦ **Versatile Power-Up Sequencing**
- ♦ **Adjustable Overvoltage and Undervoltage Protection**
- ♦ **6V to 26V Input Range**
- ♦ **2V ±0.75% Reference Output**
- ♦ **Power-Good Output**
- ♦ **Soft-Shutdown**
- ♦ **5µA (typ) Shutdown Current**

Pin Configurations



Pin Configurations continued at end of data sheet.

High-Efficiency, 5x Output, Main Power-Supply Controllers for Notebook Computers

ABSOLUTE MAXIMUM RATINGS

IN, $\overline{SHDN}$, INA, LDOA to GND .....-0.3V to +30V
GND to PGND .....-0.3V to +0.3V
LDO5, LDO3, V_{CC} to GND .....-0.3V to +6V
ILIM3, ILIM5, PGDLY to GND .....-0.3V to +6V
CSL3, CSH3, CSL5, CSH5 to GND .....-0.3V to +6V
ON3, ON5, FB3, FB5 to GND .....-0.3V to +6V
$\overline{SKIP}$, $\overline{OVP}$, $\overline{UVP}$ to GND .....-0.3V to +6V
PGOOD, FSEL, ADJA, ONA to GND .....-0.3V to +6V
REF to GND .....-0.3V to (V_{CC} + 0.3V)
DL3, DL5 to PGND .....-0.3V to (V_{LDO5} + 0.3V)
BST3, BST5 to PGND .....-0.3V to +36V
LX3 to BST3 .....-6V to +0.3V
DH3 to LX3 .....-0.3V to (V_{BST3} + 0.3V)
LX5 to BST5 .....-6V to +0.3V
DH5 to LX5 .....-0.3V to (V_{BST5} + 0.3V)
LDO3, LDO5 Short Circuit to GND .....Momentary
REF Short Circuit to GND .....Momentary
INA Shunt Current .....+15mA
Continuous Power Dissipation (T_A = +70°C)
32-Pin TQFN (derate 21.3mW/°C above +70°C) 1702mW
36-Pin TQFN (derate 26.3mW/°C above +70°C) 2105mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

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_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = 0°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
INPUT SUPPLIES (Note 1)						
V_{IN} Input Voltage Range	V_{IN}	LDO5 in regulation	6		26	V
		IN = LDO5, V_{OUT5} < 4.43V	4.5		5.5	
V_{IN} Operating Supply Current	I_{IN}	LDO5 switched over to CSL5		15	35	µA
V_{IN} Standby Supply Current	$I_{IN(STBY)}$	V_{IN} = 6V to 26V, both SMPS off, includes $I_{\overline{SHDN}}$		100	170	µA
V_{IN} Shutdown Supply Current	$I_{IN(SHDN)}$	V_{IN} = 6V to 26V, $\overline{SHDN}$ = GND		5	17	µA
Quiescent Power Consumption	P_Q	Both SMPS on, FB3 = FB5 = $\overline{SKIP}$ = GND, V_{CSL3} = 3.5V, V_{CSL5} = 5.3V, V_{INA} = 15V, I_{LDOA} = 0, P_{IN} + P_{CSL3} + P_{CSL5} + P_{INA}		3.5	4.5	mW
V_{CC} Quiescent Supply Current	I_{CC}	Both SMPS on, FB3 = FB5 = GND, V_{CSL3} = 3.5V, V_{CSL5} = 5.3V		1.1	2.1	mA
MAIN SMPS CONTROLLERS						
3.3V Output Voltage in Fixed Mode	V_{OUT3}	V_{IN} = 6V to 26V, $\overline{SKIP}$ = V_{CC} (Note 2)	3.280	3.33	3.380	V
5V Output Voltage in Fixed Mode	V_{OUT5}	V_{IN} = 6V to 26V, $\overline{SKIP}$ = V_{CC} (Note 2)	4.975	5.05	5.125	V
Feedback Voltage in Adjustable Mode	$V_{FB\_}$	V_{IN} = 6V to 26V, FB3 or FB5, duty factor = 20% to 80% (Note 2)	0.990	1.005	1.020	V
Output-Voltage Adjust Range		Either SMPS	1.0		5.5	V
FB3, FB5 Dual-Mode Threshold			0.1		0.2	V
Feedback Input Leakage Current		V_{FB3} = V_{FB5} = 1.1V	-0.1		+0.1	µA
DC Load Regulation		Either SMPS, $\overline{SKIP}$ = V_{CC}, I_{LOAD} = 0 to full load		-0.1		%

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = 0°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Line-Regulation Error		Either SMPS, duty cycle = 10% to 90%		1		%
Operating Frequency (Note 1)	f_{OSC}	FSEL = GND	170	200	230	kHz
		FSEL = REF	270	300	330	
		FSEL = V_{CC}	425	500	575	
Maximum Duty Factor (Note 1)	D_{MAX}	FSEL = GND	91	93		%
		FSEL = REF	91	93		
		FSEL = V_{CC}	91	93		
Minimum On-Time	$t_{ON(MIN)}$	(Note 3)			200	ns
SMPS3 to SMPS5 Phase Shift		SMPS5 starts after SMPS3		40		%
				144		Deg
CURRENT LIMIT						
ILIM_ Adjustment Range			0.5		V_{REF}	V
Current-Sense Input Range		CSH_, CSL_	0		5.5	V
Current-Sense Input Leakage Current		CSH_, $V_{CSH\_}$ = 5.5V	-1		+1	µA
Current-Limit Threshold (Fixed)	$V_{LIMIT\_}$	$V_{CSH\_}$ - $V_{CSL\_}$, ILIM_ = V_{CC}	70	75	80	mV
Current-Limit Threshold (Adjustable)	$V_{LIMIT\_}$	$V_{CSH\_}$ - $V_{CSL\_}$, $V_{ILIM\_}$ = 2.00V	170	200	230	mV
		$V_{CSH\_}$ - $V_{CSL\_}$, $V_{ILIM\_}$ = 1.00V	91	100	109	
		$V_{CSH\_}$ - $V_{CSL\_}$, $V_{ILIM\_}$ = 0.50V	42	50	58	
Current-Limit Threshold (Negative)	V_{NEG}	$V_{CSH\_}$ - $V_{CSL\_}$, $\overline{SKIP}$ = V_{CC}, percent of current limit		-120		%
Current-Limit Threshold (Zero Crossing)	V_{ZX}	V_{PGND} - $V_{LX\_}$, $\overline{SKIP}$ = GND, ILIM_ = V_{CC}		3		mV
Idle Mode™ Threshold	V_{IDLE}	$V_{CSH\_}$ - $V_{CSL\_}$, ILIM_ = V_{CC}	10	16	22	mV
		$V_{CSH\_}$ - $V_{CSL\_}$, With respect to current-limit threshold (V_{LIMIT})		20		%
ILIM_ Leakage Current		ILIM3 = ILIM5 = GND or V_{CC}	-0.1		+0.1	µA
Soft-Start Ramp Time	t_{SS}	Measured from the rising edge of ON_ to full scale		512/f_{OSC}		s
INTERNAL FIXED LINEAR REGULATORS						
LDO5 Output Voltage	V_{LDO5}	ON3 = ON5 = GND, 6V < V_{IN} < 26V, 0 < I_{LDO5} < 100mA	4.80	4.95	5.10	V
LDO5 Undervoltage-Lockout Fault Threshold		Rising edge, hysteresis = 1%	3.75	4.0	4.25	V
LDO5 Bootstrap Switch Threshold		Rising edge of CSL5, hysteresis = 1%	4.41		4.75	V
LDO5 Bootstrap Switch Resistance		LDO5 to CSL5, V_{CSL5} = 5V, I_{LDO5} = 50mA		0.75	3	Ω

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High-Efficiency, 5x Output, Main Power-Supply Controllers for Notebook Computers

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = 0°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LDO3 Output Voltage	V_{LDO3}	Standby mode, 6V < V_{IN} < 26V, 0 < I_{LOAD} < 100mA	3.20	3.35	3.42	V
LDO3 Bootstrap Switch Threshold		Rising edge of CSL3, hysteresis = 1%	2.83		3.10	V
LDO3 Bootstrap Switch Resistance		LDO3 to CSL3, V_{CSL3} = 3.2V, I_{LDO3} = 50mA		1	3	Ω
Short-Circuit Current		LDO3 = LDO5 = GND, CSL3 = CSL5 = GND		150	220	mA
Short-Circuit Current (Switched Over to CSL_)		LDO3 = LDO5 = GND, V_{CSL3} > 3.1V, V_{CSL5} > 4.7V	250			mA
AUXILIARY LINEAR REGULATOR (MAX1537A ONLY)						
LDOA Voltage Range	V_{LDOA}		5		23	V
INA Voltage Range	V_{INA}		6		24	V
LDOA Regulation Threshold, Internal Feedback		ADJA = GND, 0 < I_{LDOA} < 120mA, V_{INA} > 13V	11.4	12.0	12.4	V
ADJA Regulation Threshold, External Feedback	V_{ADJA}	0 < I_{LDOA} < 120mA, V_{LDOA} > 5.0V and V_{INA} > V_{LDOA} + 1V	1.94	2.00	2.06	V
ADJA Dual-Mode Threshold			0.1	0.15	0.2	V
ADJA Leakage Current		V_{ADJA} = 2.1V	-0.1		+0.1	µA
LDOA Current Limit		V_{LDOA} forced to V_{INA} - 1V, V_{ADJA} = 1.9V, V_{INA} > 6V	150			mA
Secondary Feedback Regulation Threshold		V_{INA} - V_{LDOA}	0.65	0.8	0.95	V
DL Duty Factor		V_{INA} - V_{LDOA} < 0.7V, pulse width with respect to switching period		33		%
INA Quiescent Current	I_{INA}	V_{INA} = 24V, I_{LDOA} = no load		50	165	µA
INA Shunt Sink Current		V_{INA} = 28V	10			mA
INA Leakage Current	$I_{INA(SHDN)}$	V_{INA} = 5V, LDOA disabled			30	µA
REFERENCE (REF)						
Reference Voltage	V_{REF}	V_{CC} = 4.5V to 5.5V, I_{REF} = 0	1.985	2.00	2.015	V
Reference Load Regulation		I_{REF} = -10µA to +100µA	1.980		2.020	V
REF Lockout Voltage	$V_{REF(UVLO)}$	Rising edge, hysteresis = 350mV		1.95		V
FAULT DETECTION						
Output Overvoltage Trip Threshold		$\overline{OVP}$ = GND, with respect to error-comparator threshold	8	11	15	%
Output Overvoltage Fault-Propagation Delay	t_{OVP}	50mV overdrive		10		µs

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = 0°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Undervoltage-Protection Trip Threshold		With respect to error-comparator threshold		65	70	75	%
Output Undervoltage Fault-Propagation Delay	t_{UVP}	50mV overdrive			10		µs
Output Undervoltage-Protection Blanking Time	t_{BLANK}	From rising edge of ON_			6144/ f_{OSC}		s
PGOOD Lower Trip Threshold		With respect to error-comparator threshold, hysteresis = 1%		-14	-10	-7.5	%
PGOOD Propagation Delay	$t_{PGOOD\_}$	Falling edge, 50mV overdrive			10		µs
PGOOD Output Low Voltage		I_{SINK} = 4mA				0.4	V
PGOOD Leakage Current	$I_{PGOOD\_}$	High state, PGOOD forced to 5.5V				1	µA
PGDLY Pullup Current		PGDLY = GND		4	5	6	µA
PGDLY Pulldown Resistance					10	25	Ω
PGDLY Trip Threshold				REF- 0.2	REF	REF+ 0.2	V
Thermal-Shutdown Threshold	T_{SHDN}	Hysteresis = 15°C			+160		°C
GATE DRIVERS							
DH_ Gate-Driver On-Resistance	R_{DH}	BST_ - LX_ forced to 5V			1.5	5	Ω
DL_ Gate-Driver On-Resistance	R_{DL}	DL_, high state			1.7	5	Ω
		DL_, low state			0.6	3	
DH_ Gate-Driver Source/Sink Current	I_{DH}	DH_ forced to 2.5V, BST_ - LX_ forced to 5V			2		A
DL_ Gate-Driver Source Current	I_{DL}	DL_ forced to 2.5V			1.7		A
DL_ Gate-Driver Sink Current	$I_{DL\ (SINK)}$	DL_ forced to 2.5V			3.3		A
Dead Time	t_{DEAD}	DL_ rising			35		ns
		DH_ rising			26		
LX_, BST_ Leakage Current		$V_{BST\_}$ = $V_{LX\_}$ = 26V			<2	20	µA
INPUTS AND OUTPUTS							
Logic Input Voltage		$\overline{SKIP}$, hysteresis = 600mV	High	2.4			V
			Low			0.8	
Fault Enable Logic Input Voltage		$\overline{OVP}$, $\overline{UVP}$, ONA	High	0.7 x V_{CC}			V
			Low			0.4	
Logic Input Current		$\overline{OVP}$, $\overline{UVP}$, $\overline{SKIP}$, ONA		-1		+1	µA
$\overline{SHDN}$ Input Trip Level		Rising trip level		1.10	1.6	2.20	V
		Falling trip level		0.96	1	1.04	
ON_ Input Voltage		Clear fault level/SMPS off level				0.8	V
		Delay start level (REF)		1.9		2.1	
		SMPS on level		2.4			

High-Efficiency, 5x Output, Main Power-Supply Controllers for Notebook Computers

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = 0°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
FSEL Three-Level Input Logic		High	V_{CC} - 0.2			V
		REF	1.7		2.3	
		GND			0.4	
Input Leakage Current		$\overline{OVP}$, $\overline{UVP}$, $\overline{SKIP}$, ONA, ON3, ON5 = GND or V_{CC}	-1		+1	µA
		$\overline{SHDN}$, 0V or 26V	-1		+1	
		FSEL = GND or V_{CC}	-3		+3	
CSL_ Discharge-Mode On-Resistance	$R_{DISCHARGE}$			10	25	Ω
CSL_ Synchronous-Rectifier Discharge-Mode Turn-On Level			0.2	0.3	0.4	V

ELECTRICAL CHARACTERISTICS

(Circuit of Figure 1, V_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = -40°C to +85°C**, unless otherwise noted.) (Note 4)

PARAMETER	SYMBOL	CONDITIONS	MIN	MAX	UNITS
INPUT SUPPLIES (Note 1)					
V_{IN} Input Voltage Range	V_{IN}	LDO5 in regulation	6	26	V
		IN = LDO5, V_{OUT5} < 4.4V	4.5	5.5	
V_{IN} Operating Supply Current	I_{IN}	LDO5 switched over to CSL5, either SMPS on		35	µA
V_{IN} Standby Supply Current	$I_{IN(STBY)}$	V_{IN} = 6V to 26V, both SMPS off, includes $I_{\overline{SHDN}}$		170	µA
V_{IN} Shutdown Supply Current	$I_{IN(SHDN)}$	V_{IN} = 6V to 26V		17	µA
Quiescent Power Consumption	P_Q	Both SMPS on, FB3 = FB5 = $\overline{SKIP}$ = GND, V_{CSL3} = 3.5V, V_{CSL5} = 5.3V, V_{INA} = 15V, I_{LDOA} = 0, P_{IN} + P_{CSL3} + P_{CSL5} + P_{INA}		4.5	mW
V_{CC} Quiescent Supply Current	I_{CC}	Both SMPS on, FB3 = FB5 = GND, V_{CSL3} = 3.5V, V_{CSL5} = 5.3V		2.5	mA
MAIN SMPS CONTROLLERS					
3.3V Output Voltage in Fixed Mode	V_{OUT3}	V_{IN} = 6V to 26V, $\overline{SKIP}$ = V_{CC} (Note 2)	3.28	3.38	V
5V Output Voltage in Fixed Mode	V_{OUT5}	V_{IN} = 6V to 26V, $\overline{SKIP}$ = V_{CC} (Note 2)	4.975	5.125	V
Feedback Voltage in Adjustable Mode	V_{FB3}, V_{FB5}	V_{IN} = 6V to 26V, FB3 or FB5, duty factor = 20% to 80% (Note 2)	0.982	1.018	V
Output-Voltage Adjust Range		Either SMPS	1.0	5.5	V
FB3, FB5 Adjustable-Mode Threshold Voltage		Dual-mode comparator	0.1	0.2	V

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = -40°C to +85°C**, unless otherwise noted.) (Note 4)

PARAMETER	SYMBOL	CONDITIONS		MIN	MAX	UNITS
Operating Frequency (Note 1)	f_{OSC}	FSEL = GND		170	230	kHz
		FSEL = REF		240	330	
		FSEL = V_{CC}		375	575	
Maximum Duty Factor (Note 1)	D_{MAX}	FSEL = GND		91		%
		FSEL = REF		91		
		FSEL = V_{CC}		91		
Minimum On-Time	$t_{ON(MIN)}$				250	ns
CURRENT LIMIT						
ILIM_ Adjustment Range				0.5	V_{REF}	V
Current-Limit Threshold (Fixed)	$V_{LIMIT\_}$	$V_{CSH\_}$ - $V_{CSL\_}$, ILIM_ = V_{CC}		67	83	mV
Current-Limit Threshold (Adjustable)	$V_{LIMIT\_}$	$V_{CSH\_}$ - $V_{CSL\_}$	$V_{ILIM\_}$ = 2.00V	170	230	mV
			$V_{ILIM\_}$ = 1.00V	90	110	
			$V_{ILIM\_}$ = 0.50V	40	60	
INTERNAL FIXED LINEAR REGULATORS						
LDO5 Output Voltage	V_{LDO5}	ON3 = ON5 = GND, 6V < V_{IN} < 26V, 0 < I_{LDO5} < 100mA		4.8	5.1	V
LDO5 Undervoltage-Lockout Fault Threshold		Rising edge, hysteresis = 1%		3.75	4.30	V
LDO3 Output Voltage	V_{LDO3}	Standby mode, 6V < V_{IN} < 28V, 0 < I_{LOAD} < 100mA		3.20	3.43	V
AUXILIARY LINEAR REGULATOR (MAX1537A ONLY)						
LDOA Voltage Range	V_{LODA}			5	23	V
INA Voltage Range	V_{INA}			6	24	V
LDOA Regulation Threshold, Internal Feedback		ADJA = GND, 0 < I_{LDOA} < 120mA, V_{INA} > 13V		11.40	12.55	V
ADJA Regulation Threshold, External Feedback	V_{ADJA}	0 < I_{LDOA} < 120mA, V_{LDOA} > 5.0V and V_{INA} > V_{LDOA} + 1V		1.94	2.08	V
ADJA Dual-Mode Threshold		ADJA		0.10	0.25	V
Secondary Feedback Regulation Threshold		V_{INA} - V_{LDOA}		0.63	0.97	V
INA Quiescent Current	I_{INA}	V_{INA} = 24V, I_{LDOA} = no load			165	µA
REFERENCE (REF)						
Reference Voltage	V_{REF}	V_{CC} = 4.5V to 5.5V, I_{REF} = 0		1.97	2.03	V

High-Efficiency, 5x Output, Main Power-Supply Controllers for Notebook Computers

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1, V_{IN} = 12V, both SMPS enabled, V_{CC} = 5V, FSEL = REF, $\overline{SKIP}$ = GND, $V_{ILIM\_}$ = V_{LDO5}, V_{INA} = 15V, V_{LDOA} = 12V, I_{LDO5} = I_{LDO3} = I_{LDOA} = no load, **T_A = -40°C to +85°C**, unless otherwise noted.) (Note 4)

PARAMETER	SYMBOL	CONDITIONS		MIN	MAX	UNITS
FAULT DETECTION						
Output Overvoltage Trip Threshold		$\overline{OVP}$ = GND, with respect to error-comparator threshold		+8	+15	%
Output Undervoltage-Protection Trip Threshold		With respect to error-comparator threshold		+65	+75	%
PGOOD Lower Trip Threshold		With respect to error-comparator threshold, hysteresis = 1%		-14.0	-7.0	%
PGOOD Output Low Voltage		I_{SINK} = 4mA			0.4	V
PGDLY Pulldown Resistance					25	Ω
PGDLY Trip Threshold				REF-0.2	REF+0.2	V
GATE DRIVERS						
DH_ Gate-Driver On-Resistance	R_{DH}	BST_ - LX_ forced to 5V			5	Ω
DL_ Gate-Driver On-Resistance	R_{DL}	DL_, high state			5	Ω
		DL_, low state			3	
INPUTS AND OUTPUTS						
Logic Input Voltage		$\overline{SKIP}$, hysteresis = 600mV	High	2.4		V
			Low		0.8	
Fault Enable Logic Input Voltage		$\overline{OVP}$, $\overline{UVP}$, ONA	High	0.7 x V_{CC}		V
			Low		0.4	
$\overline{SHDN}$ Input Trip Level		Rising trip level		1.1	2.2	V
		Falling trip level		0.95	1.05	
ON_ Input Voltage		Clear fault level			0.8	V
		SMPS off level			1.6	
		Delay start level (REF)		1.9	2.1	
		SMPS on level		2.4		
FSEL Three-Level Input Logic		High		V_{CC} - 0.2		V
		REF		1.7	2.3	
		GND			0.4	

Note 1: The MAX1533A/MAX1537A cannot operate over all combinations of frequency, input voltage (V_{IN}), and output voltage. For large input-to-output differentials and high-switching frequency settings, the required on-time may be too short to maintain the regulation specifications. Under these conditions, a lower operating frequency must be selected. The minimum on-time must be greater than 150ns, regardless of the selected switching frequency. On-time and off-time specifications are measured from 50% point to 50% point at the DH_ pin with LX_ = GND, $V_{BST\_}$ = 5V, and a 250pF capacitor connected from DH_ to LX_. Actual in-circuit times may differ due to MOSFET switching speeds.

Note 2: When the inductor is in continuous conduction, the output voltage has a DC regulation level lower than the error-comparator threshold by 50% of the ripple. In discontinuous conduction ($\overline{SKIP}$ = GND, light load), the output voltage has a DC regulation level higher than the trip level by approximately 1% due to slope compensation.

Note 3: Specifications are guaranteed by design, not production tested.

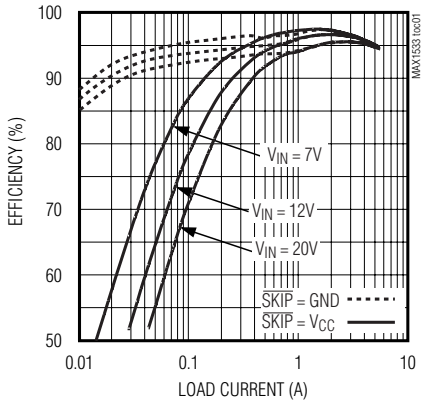
Note 4: Specifications to -40°C are guaranteed by design, not production tested.

High-Efficiency, 5x Output, Main Power-Supply Controllers for Notebook Computers

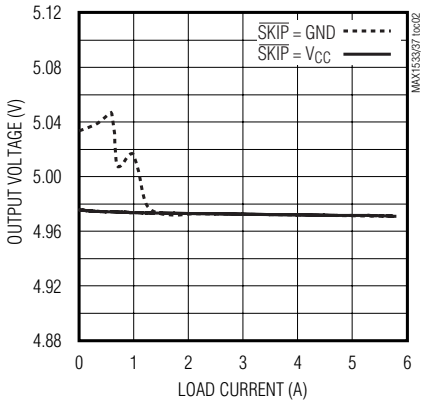
Typical Operating Characteristics

(MAX1537A circuit of Figure 1, V_{IN} = 12V, LDO5 = V_{CC} = 5V, $\overline{SKIP}$ = GND, FSEL = REF, T_A = +25°C, unless otherwise noted.)

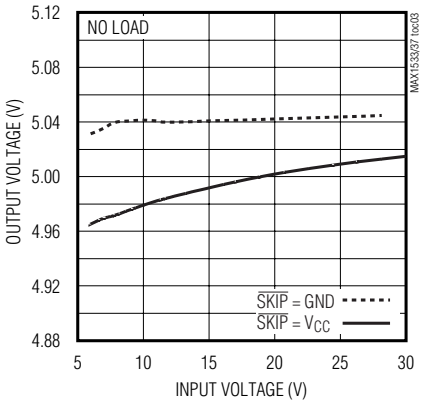
PWM5 EFFICIENCY vs. LOAD CURRENT (V_{OUT5} = 5.0V)



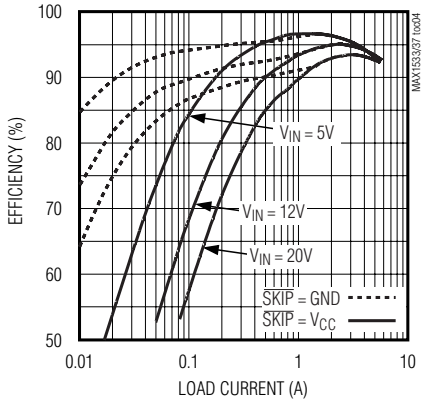
5V OUTPUT VOLTAGE (OUT5) vs. LOAD CURRENT



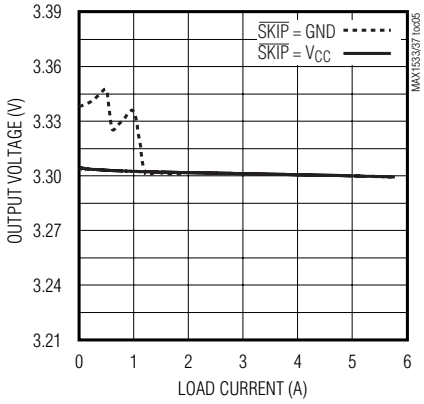
5V OUTPUT VOLTAGE (OUT5) vs. INPUT VOLTAGE



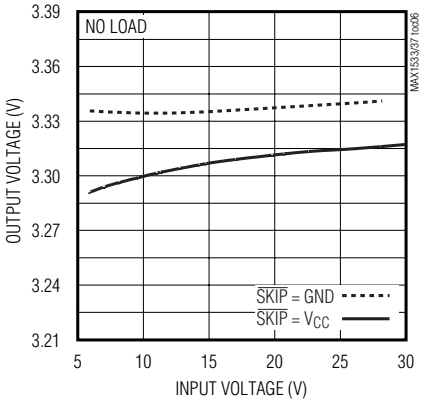
PWM3 EFFICIENCY vs. LOAD CURRENT (V_{OUT3} = 3.3V)



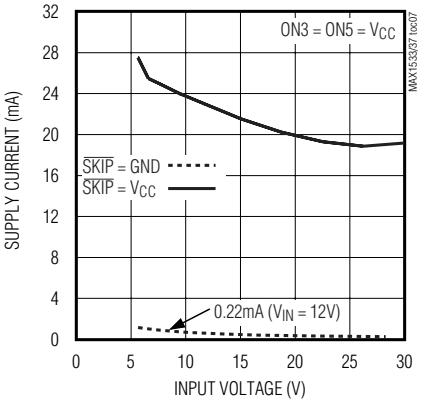
3.3V OUTPUT VOLTAGE (OUT3) vs. LOAD CURRENT



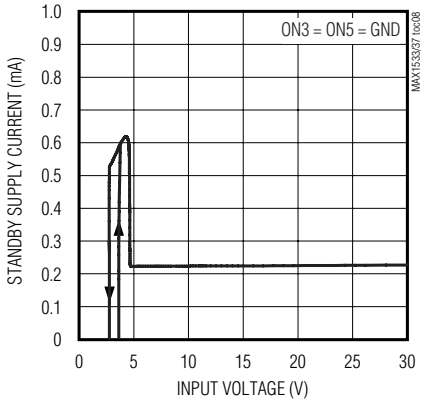
3.3V OUTPUT VOLTAGE (OUT3) vs. INPUT VOLTAGE



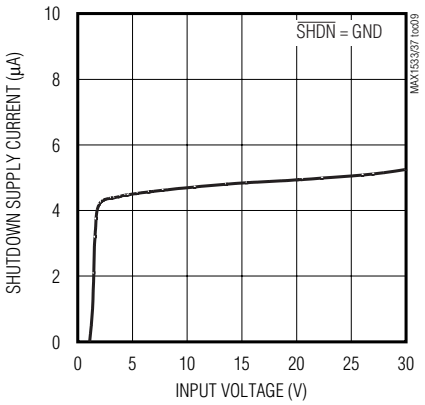
NO-LOAD SUPPLY CURRENT vs. INPUT VOLTAGE (FULLY ENABLED)



NO-LOAD SUPPLY CURRENT vs. INPUT VOLTAGE (STANDBY MODE)



SHUTDOWN SUPPLY CURRENT vs. INPUT VOLTAGE

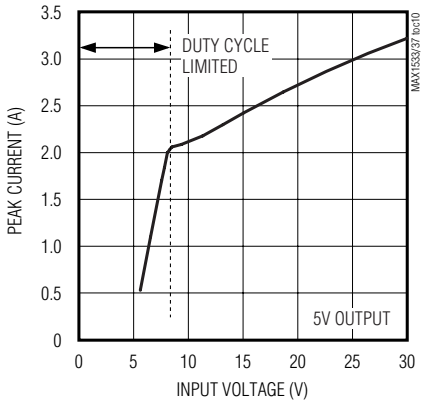


High-Efficiency, 5x Output, Main Power-Supply Controllers for Notebook Computers

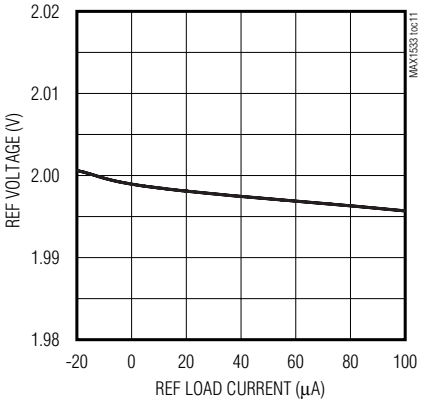
Typical Operating Characteristics (continued)

(MAX1537A circuit of Figure 1, V_{IN} = 12V, LDO5 = V_{CC} = 5V, $\overline{SKIP}$ = GND, FSEL = REF, T_A = +25°C, unless otherwise noted.)

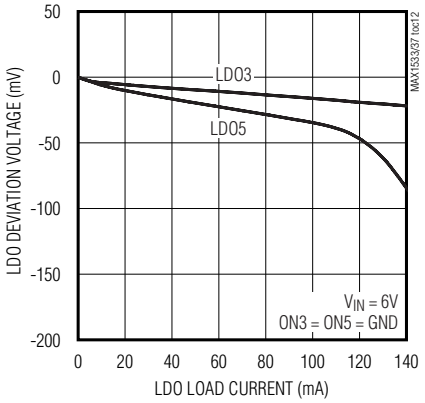
IDLE-MODE CURRENT vs. INPUT VOLTAGE



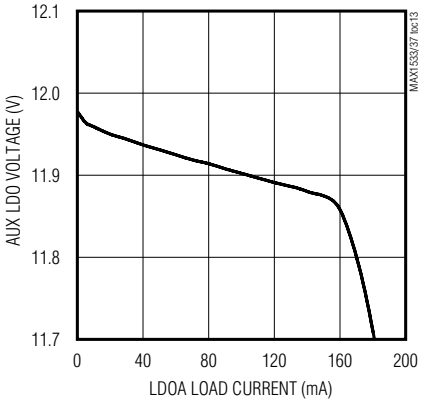
2.0V REFERENCE LOAD REGULATION



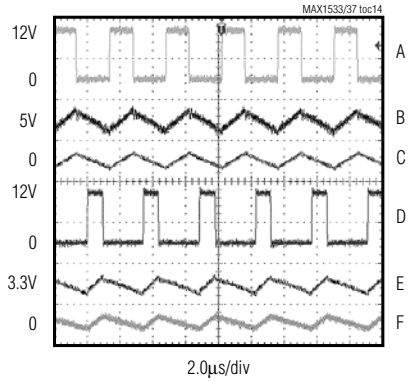
LINEAR-REGULATOR LOAD REGULATION



AUXILIARY LINEAR-REGULATOR LOAD REGULATION

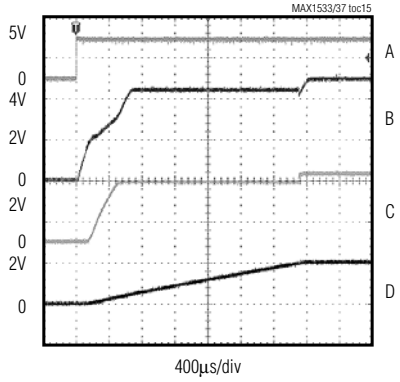


INTERLEAVED OPERATION



A. LX5, 10V/div
B. 5V OUTPUT, 100mV/div
C. PWM5 INDUCTOR CURRENT, 5A/div
D. LX3, 10V/div
E. 3.3V OUTPUT, 100mV/div
F. PWM3 INDUCTOR CURRENT, 5A/div

LINEAR-REGULATOR STARTUP WAVEFORMS



A. $\overline{SHDN}$, 5V/div
B. LDO5, 2V/div
C. LDO3, 2V/div
D. REF, 2V/div
100Ω LOAD ON LDO5 AND LDO3

分销商库存信息:		
MAXIM		
MAX1533AETJ+T	MAX1533AETJ+	