EVALUATION KIT AVAILABLE

MAXIM

High-Efficiency, PWM, Step-Down DC-DC Controllers in 16-Pin QSOP

MAX1652–MAX1655

General Description

The MAX1652–MAX1655 are high-efficiency, pulse-width-modulated (PWM), step-down DC-DC controllers in small QSOP packages. The MAX1653/MAX1655 also come in 16-pin narrow SO packages that are pin-compatible upgrades to the popular MAX797. Improvements include higher duty-cycle operation for better dropout, lower quiescent supply currents for better light-load efficiency, and an output voltage down to 1V (MAX1655).

The MAX1652–MAX1655 achieve up to 96% efficiency and deliver up to 10A using a unique Idle Mode™ synchronous-rectified PWM control scheme. These devices automatically switch between PWM operation at heavy loads and pulse-frequency-modulated (PFM) operation at light loads to optimize efficiency over the entire output current range. The MAX1653/MAX1655 also feature logic-controlled, forced PWM operation for noise-sensitive applications.

All devices operate with a selectable 150kHz/300kHz switching frequency, which can also be synchronized to an external clock signal. Both external power switches are inexpensive N-channel MOSFETs, which provide low resistance while saving space and reducing cost.

The MAX1652 and MAX1654 have an additional feedback pin that permits regulation of a low-cost second output tapped from a transformer winding. The MAX1652 provides an additional positive output. The MAX1654 provides an additional negative output.

The MAX1652–MAX1655 have a 4.5V to 30V input voltage range. The MAX1652/MAX1653/MAX1654's output range is 2.5V to 5.5V while the MAX1655's output range extends down to 1V. An evaluation kit (MAX1653EVKIT) is available to speed designs.

Applications

Notebook Computers

PDAs

Cellular Phones

Hand-Held Computers

Handy-Terminals

Mobile Communicators

Distributed Power

Pin Configurations appear at end of data sheet.

Idle Mode is a trademark of Maxim Integrated Products.

Features

♦ **96% Efficiency**
♦ **Small, 16-Pin QSOP Package (half the size of a 16-pin narrow SO)**
♦ **Pin-Compatible with MAX797 (MAX1653/MAX1655)**
♦ **Output Voltage Down to 1V (MAX1655)**
♦ **4.5V to 30V Input Range**
♦ **99% Duty Cycle for Lower Dropout**
♦ **170µA Quiescent Supply Current**
♦ **3µA Logic-Controlled Shutdown**
♦ **Dual, N-Channel, Synchronous-Rectified Control**
♦ **Fixed 150kHz/300kHz PWM Switching, or Synchronized from 190kHz to 340kHz**
♦ **Programmable Soft Start**
♦ **Low-Cost Secondary Outputs (MAX1652/MAX1654)**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX1652EEE	-40°C to +85°C	16 QSOP
MAX1653ESE	-40°C to +85°C	16 Narrow SO
MAX1653EEE	-40°C to +85°C	16 QSOP
MAX1654EEE	-40°C to +85°C	16 QSOP
MAX1655ESE	-40°C to +85°C	16 Narrow SO
MAX1655EEE	-40°C to +85°C	16 QSOP

Selection Guide

PART	FEEDBACK VOLTAGE (V)	SPECIAL FEATURE	COMPATIBILITY
MAX1652	2.5	Regulates positive secondary voltage (such as +12V)	Same pin order as MAX796, but smaller package
MAX1653	2.5	Logic-controlled, low-noise mode	Pin-compatible with MAX797
MAX1654	2.5	Regulates negative secondary voltage (such as -5V)	Same pin order as MAX799, but smaller package
MAX1655	1	Low output voltages (1V to 5.5V); logic-controlled, low-noise mode	Pin compatible with MAX797 (except for feedback voltage)

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High-Efficiency, PWM, Step-Down DC-DC Controllers in 16-Pin QSOP

ABSOLUTE MAXIMUM RATINGS

V+ to GND ....-0.3V to +36V
GND to PGND ....-0.3V to +0.3V
VL to GND ....-0.3V to +6V
BST to GND ....-0.3V to +36V
DH to LX ....-0.3V to (BST + 0.3V)
LX to BST..-6V to +0.3V
$\overline{SHDN}$ to GND..-0.3V to (V+ + 0.3V)
SYNC, SS, REF, SECFB, $\overline{SKIP}$, FB to GND...-0.3V to (VL + 0.3V)
DL to PGND ....-0.3V to (VL + 0.3V)
CSH, CSL to GND ....-0.3V to +6V
VL Short Circuit to GND...Momentary

REF Short Circuit to GND..Continuous
VL Output Current ....+50mA to -1mA
REF Output Current...+5mA to -1mA
Continuous Power Dissipation (T_A = +70°C)
  SO (derate 8.70mW/°C above +70°C) 696mW
  QSOP (derate 8.3mW/°C above +70°C) 667mW
Operating Temperature Range
  MAX165_E_E ....-40°C to +85°C
Storage Temperature Range ....-65°C to +160°C
Lead Temperature (soldering, 10sec) ....+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

(V+ = +15V, GND = PGND = 0V, SYNC = REF, I_{VL} = I_{REF} = 0A, **T_A = 0°C to +85°C**, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
3.3V AND 5V STEP-DOWN CONTROLLERS						
Input Supply Range			4.5		30	V
5V Output Voltage (CSL)	0 < (CSH - CSL) < 80mV, FB = VL, 6V < V+ < 30V, includes line and load regulation		4.85	5.06	5.25	V
3.3V Output Voltage (CSL)	0 < (CSH - CSL) < 80mV, FB = 0V, 4.5V < V+ < 30V, includes line and load regulation		3.20	3.34	3.46	V
Nominal Adjustable Output Voltage Range	External resistor divider	MAX1655	1		5.5	V
		MAX1652/MAX1653/ MAX1654	2.5		5.5	
Feedback Voltage	CSH - CSL = 0V, CSL = FB, $\overline{SKIP}$ = 0V, 4.5V < V+ < 30V	MAX1655	0.97	1.00	1.03	V
		MAX1652/MAX1653/ MAX1654	2.43	2.50	2.57	
Load Regulation	0 < (CSH - CSL) < 80mV			2		%
	25mV < (CSH - CSL) < 80mV			1.2		
Line Regulation	6V < V+ < 30V			0.03	0.06	%/V
Current-Limit Voltage	CSH - CSL, positive		80	100	120	mV
	CSH - CSL, negative		-50	-100	-160	
SS Source Current	V_{SS} = 0V		2.5	4.0	6.5	µA
SS Fault Sink Current	V_{SS} = 4V		2.0			mA
FLYBACK/PWM CONTROLLER						
SECFB Regulation Setpoint	Falling edge, rising edge, hysteresis = 22mV (MAX1652)		2.45	2.50	2.55	V
	Rising edge, falling edge, hysteresis = 22mV (MAX1654)		-0.05	0	0.05	
INTERNAL REGULATOR AND REFERENCE						
VL Output Voltage	$\overline{SHDN}$ = 2V, 0 < I_{VL} < 25mA, 5.5V < V+ < 30V		4.7	5.0	5.3	V
VL Fault Lockout Voltage	Rising edge, falling edge hysteresis = 50mV		3.8	3.9	4.0	V
VL/CSL Switchover Voltage	Rising edge, falling edge hysteresis = 60mV		4.2	4.5	4.7	V

ELECTRICAL CHARACTERISTICS (continued)

(V+ = +15V, GND = PGND = 0V, SYNC = REF, I_{VL} = I_{REF} = 0A, **T_A = 0°C to +85°C,** unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Reference Output Voltage	No external load (Note 1)	2.46	2.50	2.54	V
Reference Fault Lockout Voltage	Falling edge	2.0		2.4	V
Reference Load Regulation	0 < I_{REF} < 100µA			15	mV
CSL, CSH Shutdown Leakage Current	$\overline{SHDN}$ = 0V, CSL = 5.5V, CSH = 5.5V, V+ = 0 or 30V, VL = 0V		0.1	1	µA
V+ Shutdown Current	$\overline{SHDN}$ = 0V, V+ = 30V, CSL = 0 or 5.5V		3	7	µA
V+ Off-State Leakage Current	FB = CSH = CSL = 5.5V, VL switched over to CSL		5	15	µA
Dropout Power Consumption	V+ = 4.5V, CSH = CSL = 4.0V (Note 2)		1	8	mW
Quiescent Power Consumption	CSH = CSL = 5.5V		1	2	mW
OSCILLATOR AND INPUTS/OUTPUTS					
Oscillator Frequency	SYNC = REF	270	300	330	kHz
	SYNC = 0 or 5V	125	150	175	
SYNC High Pulse Width		200			ns
SYNC Low Pulse Width		200			ns
SYNC Rise/Fall Time	Guaranteed by design, not tested			200	ns
Oscillator Sync Range		190		340	kHz
Dropout-Mode Maximum Duty Cycle	SYNC = REF	97	98		%
	SYNC = 0 or 5V	98	99		
Input High Voltage	SYNC	VL - 0.5			V
	$\overline{SHDN}$, $\overline{SKIP}$	2.0			
Input Low Voltage	SYNC			0.8	V
	$\overline{SHDN}$, $\overline{SKIP}$			0.5	
Input Current	$\overline{SHDN}$, 0 or 30V			3.0	µA
	SECFB, 0 or 4V			0.1	
	SYNC, $\overline{SKIP}$			1.0	
	CSH, CSL, CSH = CSL ≤ 4V			70	
	FB, FB = REF			±0.1	
DL Sink/Source Current	DL forced to 2V		1		A
DH Sink/Source Current	DH forced to 2V, BST - LX = 4.5V		1		A
DL On-Resistance	High or low		1.5	5	Ω
DH On-Resistance	High or low, BST - LX = 4.5V		1.5	5	Ω

Note 1: Since the reference uses VL as its supply, V+ line-regulation error is insignificant.
Note 2: At very low input voltages, quiescent supply current may increase due to excessive PNP base current in the VL linear regulator. This occurs if V+ falls below the preset VL regulation point (5V nominal).

High-Efficiency, PWM, Step-Down DC-DC Controllers in 16-Pin QSOP

ELECTRICAL CHARACTERISTICS (continued)

(V+ = +15V, GND = PGND = 0V, SYNC = REF, I_{VL} = I_{REF} = 0A, **T_A = -40°C to +85°C,** unless otherwise noted.) (Note 3)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
3.3V and 5V STEP-DOWN CONTROLLERS						
Input Supply Range			4.5		30	V
5V Output Voltage (CSL)	0 < (CSH - CSL) < 70mV, FB = VL, 6V < V+ < 30V, includes line and load regulation		4.80		5.30	V
3.3V Output Voltage (CSL)	0 < (CSH - CSL) < 70mV, FB = VL, 4.5V < V+ < 30V, includes line and load regulation		3.16		3.50	V
Feedback Voltage	CSH - CSL = 0V, 5V < V+ < 30V, CSL = FB, $\overline{SKIP}$ = 0V	MAX1655	0.96		1.04	V
		MAX1652/MAX1653/MAX1654	2.40		2.60	
Line Regulation	6V < V+ < 30V				0.06	%/V
Current-Limit Voltage	CSH - CSL, positive		70		130	mV
	CSH - CSL, negative		-40		-160	
FLYBACK/PWM CONTROLLER						
SECFB Regulation Setpoint	Falling edge, hysteresis = 22mV (MAX1652)		2.40		2.60	V
	Falling edge, hysteresis = 22mV (MAX1654)		-0.08		0.08	
INTERNAL REGULATOR AND REFERENCE						
VL Output Voltage	$\overline{SHDN}$ = 2V, 0 < I_{VL} < 25mA, 5.5V < V+ < 30V		4.7		5.3	V
VL Fault Lockout Voltage	Rising edge, hysteresis = 50mV		3.75		4.05	V
VL/CSL Switchover Voltage	Rising edge, hysteresis = 60mV		4.2		4.7	V
Reference Output Voltage	No external load (Note 1)		2.43		2.57	V
Reference Load Regulation	0 < I_{REF} < 100µA				15	mV
V+ Shutdown Current	$\overline{SHDN}$ = 0V, V+ = 30V, CSL = 0 or 5.5V				10	µA
V+ Off-State Leakage Current	FB = CSH = CSL = 5.5V, VL switched over to CSL				15	µA
Quiescent Power Consumption					2	mW
OSCILLATOR AND INPUTS/OUTPUTS						
Oscillator Frequency	SYNC = REF		250		350	kHz
	SYNC = 0 or 5V		120		180	
SYNC High Pulse Width			250			ns
SYNC Low Pulse Width			250			ns
Oscillator Sync Range			210		320	kHz
Maximum Duty Cycle	SYNC = REF		97			%
	SYNC = 0 or 5V		98			
DL On-Resistance	High or low				5	Ω
DH On-Resistance	High or low, BST - LX = 4.5V				5	Ω

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

_____*Typical Operating Circuits*

MAX1652–MAX1655
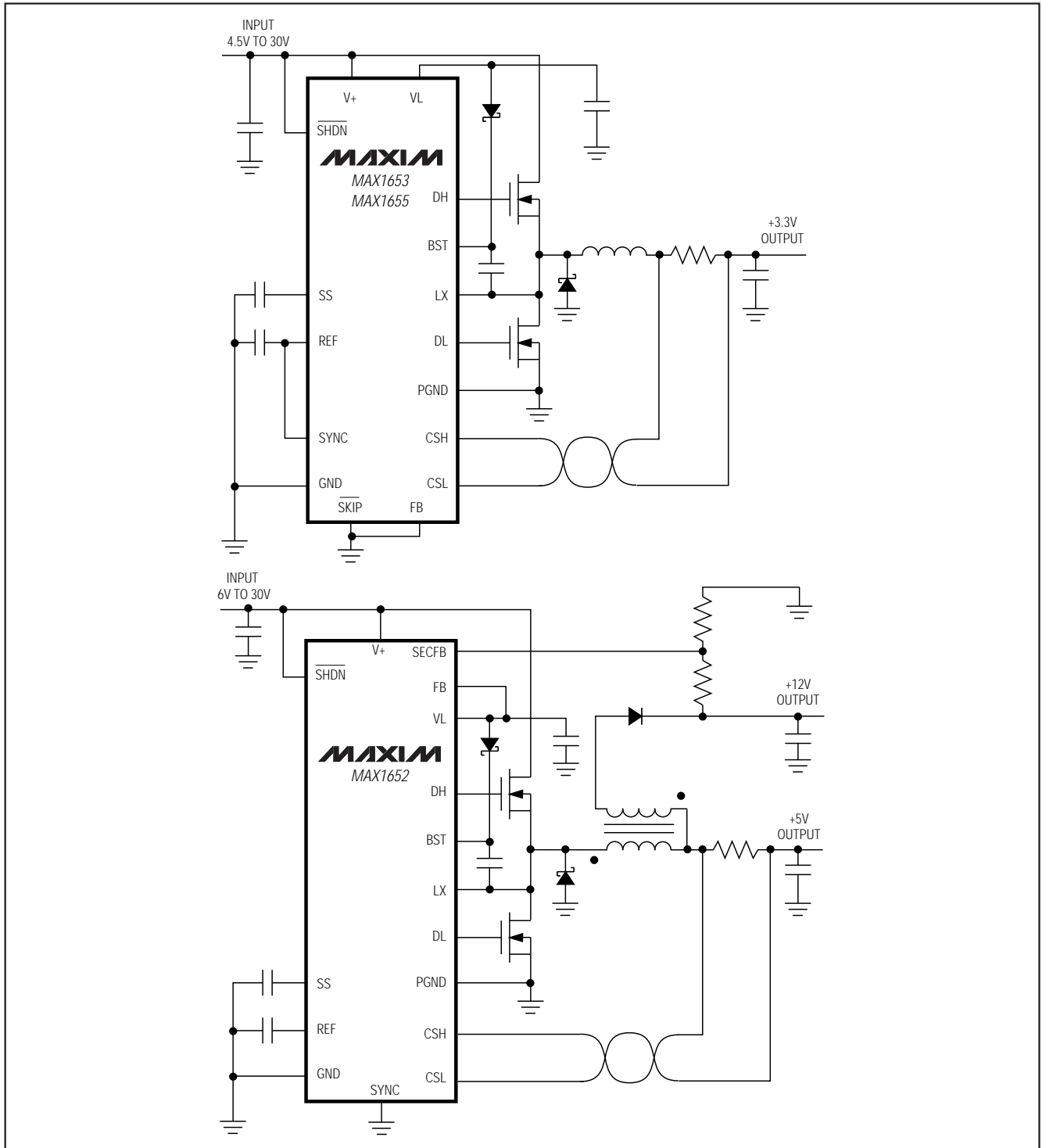
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