









TPS65154
SLVSBG2A – SEPTEMBER 2013 – REVISED JUNE 2016

TPS65154 LCD Bias IC with Integrated WLED Driver

1 Device Overview

1.1 Features

- 2.0 V to 5.5 V Input Voltage Range
- Synchronous Boost Converter (AV_{DD})
- Non-Synchronous Boost Converter (V_{GH})
- Low Dropout Linear Regulator (V_{CC})
- Programmable V_{COM} Calibrator with Integrated Buffer Amplifier
- 6-Channel WLED Driver with Direct Dimming and Phase-Shift Dimming Modes
- Gate Voltage Shaping

- Panel Reset Signal (XAO)
- T-CON Reset Signal (RST)
- On-Chip EEPROM with Write Protect
- I²C Interface
- Thermal Shutdown
- 48-Pin, 6 mm × 6 mm, 0.4 mm Pitch VQFN

1.2 Applications

Notebook PCs

Tablet PCs

1.3 Description

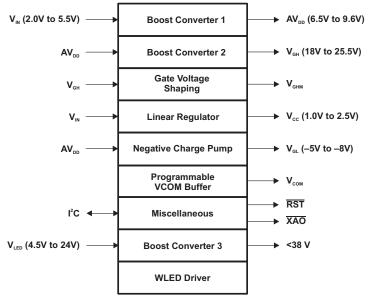
The TPS65154 is a compact LCD bias solution primarily intended for use in Notebook and Tablet PCs. The device comprises two boost converters to supply the LCD panel's source driver and gate driver; a linear regulator to supply the system's logic voltage; a programmable V_{COM} with high-speed amplifier; and a gate voltage shaping function; and a 6-channel WLED driver.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS65154	VQFN (48)	6.00 mm × 6.00 mm

(1) For all available packages, see the orderable addendum at the end of the data manual.

1.4 Simplified System Diagram



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Table of Contents

1	Devi	ce Overview 1		5.5	Programming	26
	1.1	Features <u>1</u>		5.6	Register Map	38
	1.2	Applications 1	6	App	lication and Implementation	63
	1.3	Description 1		6.1	Application Information	63
	1.4	Simplified System Diagram 1		6.2	Typical Application	63
2	Revi	sion History 2	7	Pow	ver Supply Recommendations	75
3		Configuration and Functions3	8		out	
4		cifications 5		8.1	Layout Guidelines	
	4.1	Absolute Maximum Ratings 5		8.2	Layout Example	76
	4.2	ESD Ratings5	9	Devi	ice and Documentation Support	
	4.3	Recommended Operating Conditions 5		9.1	Device Support	78
	4.4	Thermal Information		9.2	Receiving Notification of Documentation Updates	
	4.5	Electrical Characteristics 7		9.3	Community Resources	
	4.6	Timing Requirements 9		9.4	Trademarks	78
5	Deta	niled Description 12		9.5	Electrostatic Discharge Caution	78
	5.1	Overview		9.6	Glossary	
	5.2	Functional Block Diagram 12	10	Mec	hanical, Packaging, and Orderable	
	5.3	Feature Description			rmation	79
	5.4	Device Functional Modes		10.1	Packaging Information	<u>79</u>
2	Rev	vision History				
Ch.		from Oviginal (Santambar 2012) to Povision A				0000

Onan	ges nom original (deptember 2013) to Nevision A	ı age
•	Changed from data sheet to data manual format	1
•	Added Device Information table, ESD Ratings table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and	
	Documentation Support section, and Mechanical, Packaging, and Orderable Information section.	<u>1</u>



3 Pin Configuration and Functions

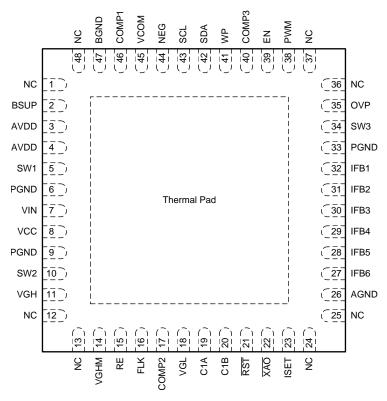


Figure 3-1. RSL Package, 48-Pin VQFN (Top View)

Pin Functions

	FIII FUIICUOIIS					
PII	PIN		DESCRIPTION			
NAME	NO.	IIFE	DESCRIPTION			
NC	1	N/A	No internal connection.			
BSUP	2	Р	Positive supply for the VCOM buffer.			
AVDD	3	Р	Boost converter 1 output voltage sense.			
AVDD	4	Р	Boost converter 1 rectifier output.			
SW1	5	Р	Boost converter 1 switch pin.			
PGND	6	Р	Ground.			
VIN	7	Р	Positive supply.			
VCC	8	Р	Linear regulator output.			
PGND	9	Р	Ground.			
SW2	10	Р	Boost converter 2 switch pin.			
VGH	11	Р	V _{GH} regulation point and positive supply for gate voltage shaping function.			
NC	12	N/A	No internal connection.			
NC	13	N/A	No internal connection.			
VGHM	14	Р	Gate voltage shaping output.			
RE	15	I/O	Gate votlage shaping discharge resistor connection.			
FLK	16	I/O	Gate votlage shaping flicker clock input.			
COMP2	17	I/O	Internal linear regulator compensation network connection.			
VGL	18	Р	Negative charge pump output and V _{GL} regulation point.			
C1A	19	Р	Negative charge pump flying capacitor connection.			
C1B	20	Р	Negative charge pump flying ccapacitor connection.			



Pin Functions (continued)

PIN	ı					
NAME	NO.	TYPE	DESCRIPTION			
RST	21	I/O	Reset generator output.			
XAO	22	I/O	Panel discharge generator output.			
ISET	23	I/O	WLED driver current-setting resistor connection.			
NC	24	N/A	No internal connection.			
NC	25	N/A	No internal connection.			
AGND	26	Р	Ground.			
IFB6	27	I/O	WLED driver channel 6 output.			
IFB5	28	I/O	WLED driver channel 5 output.			
IFB4	29	I/O	WLED driver channel 4 output.			
IFB3	30	I/O	WLED driver channel 3 output.			
IFB2	31	I/O	WLED driver channel 2 output.			
IFB1	32	I/O	WLED driver channel 1 output.			
PGND	33	Р	Ground.			
SW3	34	Р	WLED driver boost converter switch pin.			
OVP	35	I/O	WLED driver boost converter output voltage sensing pin.			
NC	36	N/A	No internal connection.			
NC	37	N/A	No internal connection.			
PWM	38	I/O	WLED driver PWM input.			
EN	39	I/O	WLED driver enable input.			
COMP3	40	I/O	WLED driver boost converter compensation network connection.			
WP	41	I/O	EEPROM write protect input.			
SDA	42	I/O	I ² C data.			
SCL	43	I/O	I ² C clock.			
NEG	44	I/O	VCOM buffer inverting input.			
VCOM	45	I/O	VCOM buffer output.			
COMP1	46	I/O	Boost converter 1 compensation network connection.			
BGND	47	Р	Ground.			
NC	48	N/A	No internal connection.			
GND	Pad	Р	Ground.			



4 Specifications

4.1 Absolute Maximum Ratings⁽¹⁾

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
	VIN, VCC, SCL, SDA, FLK, WP, XAO, COMP1	-0.3	7	V
	AVDD, SW1, VCOM, NEG, BSUP, RST	-0.3	12	V
	EN, PWM	-0.3	20	V
Din voltogo	COMP2, COMP3, ISET	-0.3	3.6	V
Pin voltage	C1A, C1B	-10	12	V
	VGL	-10	0.3	٧
	SW3, OVP	-0.3	40	V
	IFB1, IFB2, IFB3, IFB4, IFB5, IFB6, VGH, VGHM, RE, SW2	-0.3	30	V
Pin current	SW2		TBD	Α
Ambient tempe	erature, T _A	-40	85	ů
Junction tempo	erature, T _J	-40	150	°C
Storage tempe	erature, T _{STG}	-65	150	°C

⁽¹⁾ 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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

4.2 ESD Ratings

			VALUE	UNIT
		Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	2000	
V _(ESD)	Electrostatic discharge	Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	700	V

⁽¹⁾ JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

4.3 Recommended Operating Conditions

			MIN	NOM	MAX	UNIT		
V	lanut voltage range	Normal operation	2.0		5.5	V		
V _{IN}	Input voltage range	EEPROM programming	2.6		5.5	V		
dV _{IN} /dt	V _{IN} rise time		0.45		11	ms		
V_{BSUP}	Input voltage range		6.5		9.6	V		
V_{BAT}	Input voltage range				24	V		
dV _{BAT} /dt	V _{BAT} rise time		0.45		11	ms		
LINEAR REGULATOR (V _{CC})								
V _{CC}	Output voltage		1.0		2.5	V		
I _{ICC}	Output current				300	mA		
C _{OUT}	Output capacitance		4.7	10	22	μF		
BOOST C	ONVERTER 1 (AV _{DD})				•			
AV_{DD}	Boost converter 1 output voltage ra	ange	6.5		9.6	V		
IAV _{DD}	Boost converter 1 output current at	: V _{IN} = 3.7 V			400	mA		
L	Inductance		4.7	10	15	μΗ		
C _{OUT}	Boost converter 1 output capacitar	ice	4.7	10	22	μF		
	BOOST CONVERTER 2 (V _{GH})							
AV_{DD}	Input voltage range		6.5		9.6	V		
V_{GH}	Output voltage range		18		25.5	V		
I _{GH}	Output current				25	mA		

²⁾ JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.



Recommended Operating Conditions (continued)

		MIN	NOM	MAX	UNIT
L	Inductance	4.7	10	15	μΗ
C _{OUT}	Output capacitance	1	4.7	10	μF
NEGATIV	E CHARGE PUMP (V _{GL})	•			
V_{GL}	Output voltage	-5		-8	V
I_{GL}	Output current			25	mA
C _{FLY}	Flying capacitance		0.5		μF
C _{OUT}	Output capacitance	0.5		5	μF
BOOST C	ONVERTER 3 (WLED)				
V _{OUT}	Output voltage			38	V
I _{OUT}	Output current			250	mA
L	Inductance	4.7	10	15	μH
C _{OUT}	Output capacitance	2.2	4.7	10	μF
INTERNA	L REGULATOR				
C _{OUT}	Capacitance connected to the TCOMP pin	1			μF

4.4 Thermal Information

		TPS65154	
	THERMAL METRIC ⁽¹⁾	RSL (VQFN)	UNIT
		48 PIN	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	29.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	15.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	5.2	°C/W
ΨЈТ	Junction-to-top characterization parameter	0.2	°C/W
ΨЈВ	Junction-to-board characterization parameter	5.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	0.8	°C/W

⁽¹⁾ For more information about traditional and new thermal metrics, see Semiconductor and IC Package Thermal Metrics application report.



4.5 Electrical Characteristics

 V_{IN} = 3.3 V, V_{LED} = 12 V, V_{CC} = 2.5 V, AV_{DD} = 8 V, V_{GL} = -6.8 V, V_{GH} = 20 V, T_A = -40°C to 85°C. Typical values are at 25°C (unless otherwise noted).

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER	SUPPLY					
I _{IN}	Supply current into VIN pin	Converters not switching		0.1	1	mA
I _{AVDD}	Supply current into AVDD pins	Pins 2 and 3 connected together		0.75	2.5	mA
I _{BSUP}	Supply current into BSUP pin			2.5	5	mA
I _{GH}	Supply current into VGH pin	No load on VGHM		0.1	1	mA
	OLTAGE LOCKOUT		l		-	
		V _{IN} falling	1.75			
V_{UVLO}	Undervoltage lockout threshold	V _{IN} rising			2.2	V
0120	Hysteresis		90			mV
LINEAR	REGULATOR (V _{CC})					
	Linear regulator output voltage range		1.0		2.5	V
V_{CC}	Tolerance	I _{CC} = 10 mA	-3%		+3%	
V _{UVP}	Undervoltage protection threshold	V _{CC} falling	60%	70%	75%	
V _{SCP}	Short circuit protection threshold	V _{CC} falling	25%	30%	40%	
- 307	C. or on our protoction throughout	$T_{\rm J} = 25^{\circ}\text{C to } 125^{\circ}\text{C}$	300	5570	1370	
I_{LIM}	Current limit	$V_{CC} = 5\%$ below value at 10 mA. $T_{J} = -40$ °C $T_{L} = -40$ °C	250			mA
r _{nove}	Active pull-down resistance	1J = -+0 O	10	21	35	Ω
r _{DS(ON)}	CONVERTER 1 (AV _{DD})		10	21	33	52
B0031 (Output voltage range		6.5		9.6	V
AV_{DD}	Tolerance					V
\ <u>'</u>			-2%	700/	+2%	
V _{UVP}	Undervoltage protection threshold		60%	70%	75%	
V _{SCP}	Short-circuit protection threshold		25%	30%	35%	
r _{DS(ON)}	Switch ON resistance	I _{SW} = 1 A		0.1	0.25	Ω
I _{LIM}	Switch current limit		2.4	3.0	3.6	Α
r _{DS(ON)}	Rectifier ON resistance	I _{SW} = 1 A		0.25	0.4	Ω
f_{SW}	Switching frequency		400		1000	kHz
	Tolerance		-20%		+20%	
NEGATI	VE CHARGE PUMP (V _{GL})					
V_{GL}	Output voltage range		-5		-8	V
- GL	Output voltage tolerance		-3%		3.5%	
V_{UVP}	Undervoltage protection threshold	V _{GL} rising	65%	70%	75%	
V_{SCP}	Short-circuit protection threshold	V _{GL} rising	25%	30%	35%	
ı	Maximum drive current	C1B sinking	50		150	mA
I _{DRVN}	Maximum drive current	C1B sourcing	60		160	ША
V_{DO}	Dropout voltage	f_{SW} = 500 kHz, C_{FLY} = 0.5 μF , I_{GL} = 10 mA		0.6	1.0	V
f _{SW}	Switching frequency		400	500	600	kHz
r _{DS(ON)}	Discharge ON resistance	I _{MEAS} = 2 mA	2.1	3	3.9	kΩ
BOOST	CONVERTER 2 (V _{GH})					
\ <u></u>	Output voltage range		18		25.5	V
V_{GH}	Tolerance		-3%		3%	
V _{UVP}	Undervoltage protection threshold	V _{GH} falling	65%	70%	75%	
	Short-circuit protection threshold	V _{GH} falling	25%	30%	35%	
V_{SCP}				0.3	1.0	Ω
V _{SCP}	Switch ON resistance	$I_{SW} = 1 A$				
	Switch ON resistance Maximum ton time	ISW = 1 A	1	2	2.5	μs
r _{DS(ON)} t _{ON(MAX)}	Maximum t _{ON} time	ISW = 1 A	1 2		+	μs μs
r _{DS(ON)} t _{ON(MAX)} t _{OFF}	$\label{eq:maximum ton} \begin{aligned} & \text{Maximum t}_{\text{ON}} \text{ time} \\ & \text{t}_{\text{OFF}} \text{ time} \end{aligned}$	ISW = TA		2	2.5	
r _{DS(ON)} t _{ON(MAX)} t _{OFF}	Maximum t _{ON} time t _{OFF} time CONVERTER 3	ISW = TA	2	2	2.5	μs
r _{DS(ON)} t _{ON(MAX)} t _{OFF}	$\label{eq:maximum ton} \begin{aligned} & \text{Maximum t}_{\text{ON}} \text{ time} \\ & \text{t}_{\text{OFF}} \text{ time} \end{aligned}$	ISW = TA		2	2.5	



Electrical Characteristics (continued)

 $V_{IN} = 3.3 \text{ V}$, $V_{LED} = 12 \text{ V}$, $V_{CC} = 2.5 \text{ V}$, $AV_{DD} = 8 \text{ V}$, $V_{GL} = -6.8 \text{ V}$, $V_{GH} = 20 \text{ V}$, $T_A = -40 ^{\circ}\text{C}$ to 85 $^{\circ}\text{C}$. Typical values are at 25 $^{\circ}\text{C}$ (unless otherwise noted).

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
	OVP range		30		39	V
V_{OVP}	Tolerance		-5%		+5%	
V _{IL}	EN low input voltage	EN falling			0.6	V
V _{IH}	EN high input voltage	EN rising	1.5			V
V _{IH} – V _{IL}	EN input hysteresis		0.09	0.16	0.27	V
R _{PULL} -	EN pull-down resistance		450	750	1250	kΩ
WLED DIN	MING					
WLLD DIN	Maximum current		40			mA
I_{FB}	Channel-to-channel current matching		-3%		+3%	IIIA
			-3%	10	+3%	hito
D.	Output dimming resolution			10	40/	bits
D _{MIN}	Minimum output duty cycle		0.040		1%	
D _{HYS}	Input PWM jitter hysteresis		-0.048 %		0.048 %	
V_{SET}	ISET regulation voltage		-3%	1.0	+3%	V
K _{SET}	ISET multiplication constant		1260	1296	1332	
V_{IL}	PWM low input voltage	PWM falling			0.6	V
V _{IH}	PWM high input voltage	PWM rising	1.2			V
$V_{IH} - V_{IL}$	PWM input voltage hysteresis		0.09	0.16	0.27	V
R _{PULL}	PWM pull-down resistance		450	750	1250	kΩ
RESET (R	ST)					
V _{OL}	Output voltage	I _{RST} = 1 mA (sinking)		0.2	0.5	V
I _{OH}	Leakage current	$V_{RST} = 1.8 \text{ V}$			1	μA
	MMABLE VCOM	KSI -				<u> </u>
	VCOM DAC set zero-scale error	$V_{MIN} = 07h, V_{MAX} = 07h$	-7		7	
SET _{ZSE}	VMAX DAC set zero-scale error	TIMIN STITE THAT STITE	-1		1 LSE	LSB
01.23E	VMIN DAC set zero-scale error		-1			
	VCOM set full-scale error	$V_{MIN} = 07h, V_{MAX} = 07h$	-7		7	
SET _{FSE}	VMAX set full-scale error	V _{MIN} – STII, V _{MAX} – STII	-1		1	LSB
OLIFSE	VMIN set full-scale error		-1		1	LOD
	VIVIII V Set Tuii-Scale error	V	'			
DNL	Differential poplinearity	V _{COM}			1	LSB
DINL	Differential nonlinearity	V _{MAX}				LSB
		V _{MIN}			1	
BW	Small-signal bandwidth	Closed-loop; A _V = –1; R _F = 1 k Ω , R _{IN} = 1 k Ω , V _{CM} = 4 V; V _{SIGNAL} = 63 mV _{pp} ; R _L = ∞		21		MHz
I _{OUT}	Peak output current	Open-loop; V _{POS} = 4 V, V _{NEG} = 3 V		400		mA
1001	Tour output outron	Open-loop; $V_{POS} = 4 \text{ V}$, $V_{NEG} = -5 \text{ V}$		330		
SR	Slew rate	Open-loop; V _{POS} = 4 V, V _{NEG} = 5 V		36		V/µs
SIX	Siew rate	Open-loop; V _{POS} = 4 V, V _{NEG} = 3 V		33		ν/μ5
I _{IB-}	Input bias current (inverting input)	Closed-loop; $A_V = +1$; $R_F = 1 \text{ M}\Omega$; $V_{POS} = 4 \text{ V}$	-1		1	μΑ
V_{DROP}	Output voltage drop	Open-loop; $V_{POS} = 4 \text{ V}$; $I_{MEAS} = V_{NEG} = 3 \text{ V}$ $V_{NEG} = 5 \text{ V}$		0.06	0.1	V
GATE VO	LTAGE SHAPING	NEG - V V		0.00	J. 1	
	VGH to VGHM ON resistance	V _{GH} = 20 V, I _{GHM} = 10 mA, V _{FLK} = 1.8 V		13	25	Ω
r _{DS(ON)H}	VOLUME ON TESISTATION	V _{GHM} = 20 V, I _{GHM} = 10 mA, V _{FLK} = 0 V		26	50	22
r _{DS(ON)L}	VGHM to RE ON resistance			26	50	Ω
V	ELK low input voltage threshold	$V_{GHM} = 6 \text{ V, } I_{GHM} = 10 \text{ mA, } V_{FLK} = 0 \text{ V}$	0.6	20	50	V
V _{IL}	FLK low input voltage threshold	V _{FLK} falling	0.6		4.0	
V _{IH}	FLK high input voltage threshold	V _{FLK} rising	0.00	0.1-	1.2	V
$V_{IH} - V_{IL}$	FLK input hysteresis		0.09	0.15	0.27	V



Electrical Characteristics (continued)

 V_{IN} = 3.3 V, V_{LED} = 12 V, V_{CC} = 2.5 V, AV_{DD} = 8 V, V_{GL} = -6.8 V, V_{GH} = 20 V, T_A = -40°C to 85°C. Typical values are at 25°C (unless otherwise noted).

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I _{IL}	FLK low input current	V _{FLK} = 0 V	-100		100	nA
I _{IH}	FLK high input current	V _{FLK} = 1.8 V	-100		100	nA
PANEL R	ESET (XAO)					
V _{OL(xxxx)}	Output voltage	I _{XAO} = 1 mA (sinking)		0.16	0.5	V
I _{LK(xxo)}	Leakage current	V _{xxo} = 1.8 V			1	μΑ
	XAO Threshold voltage range	- V _{IN} falling	V _{UVLO}		3.0	V
V_{DET}	Tolerance		-3%		+3%	
	Hysteresis	V _{IN} rising	0.05		0.3	V
I ² C INTER	RFACE					
4000	Configuration parameters slave address			74h		
ADDR	Programmable VCOM slave address			28h		
V _{IL}	Low level input voltage	SCL or SDA falling, standard and fast modes			0.6	V
V _{IH}	High level input voltage	SCL or SDA rising, standard and fast modes	1.0			V
$V_{\text{IH}} - V_{\text{IL}}$	Input hysteresis		0.05			V
V _{OL}	Low level output voltage	Sinking 3 mA			0.36	V
Cı	Input capacitance				10	pF
0	Capacitive load on SDA and SCL	Standard mode			400	pF
C _B		Fast mode			400	þΓ
EEPROM						
V_{IL}	WP low input voltage threshold	V _{WP} falling	0.8			V
V_{IH}	WP high input voltage threshold	V _{WP} rising			1.2	V
$V_{IH}-V_{IL} \\$	WP input voltage hysteresis		0.03	0.05	0.1	V
R _{PULL-UP}	WP internal pull-up resistor		20	60	100	$k\Omega$
N_{WRITE}	Number of write cycles		1000			
	Data retention	Storage temperature = 150 °C	100			1000 hrs
THERMA	L SHUTDOWN			<u>-</u>		
-	Thermal shutdown temperature			150		°C
T _{SD}	Thermal shutdown hysteresis			10		

4.6 Timing Requirements

 $V_{IN} = 3.3 \text{ V}$, $V_{LED} = 12 \text{ V}$, $V_{CC} = 2.5 \text{ V}$, $AV_{DD} = 8 \text{ V}$, $V_{GL} = -6.8 \text{ V}$, $V_{GH} = 20 \text{ V}$, $T_A = -40 ^{\circ}\text{C}$ to $85 ^{\circ}\text{C}$. Typical values are at $25 ^{\circ}\text{C}$ (unless otherwise noted).

		MIN	TYP MAX	UNIT
LINEAR R	REGULATOR (V _{CC})	1	11	
t _{DLY1}	Linear regulator start-up delay time	0	75	ms
	Tolerance	-20%	30%	
BOOST C	ONVERTER 1 (AV _{DD})			
t _{SS2}	Boost converter 1 soft-start duration range	0.5	75	ms
	Tolerance	-20%	30%	
t _{DLY2}	Boost converter 1 start-up delay range	0	75	ms
	Tolerance	-20%	30%	
NEGATIV	E CHARGE PUMP (V _{GL})			
t _{SS3}	Negative charge pump soft-start duration	0	35	ms
	Tolerance	-20%	30%	
	Negative charge pump start-up delay	0	35	ms
t _{DLY3}	Tolerance	-20%	30%	
BOOST C	ONVERTER 2 (V _{GH})	-	1	



Timing Requirements (continued)

 V_{IN} = 3.3 V, V_{LED} = 12 V, V_{CC} = 2.5 V, AV_{DD} = 8 V, V_{GL} = -6.8 V, V_{GH} = 20 V, T_A = -40°C to 85°C. Typical values are at 25°C (unless otherwise noted).

			MIN	TYP	MAX	UNIT
	Boost converter 2 soft-start of	duration range	0		35	ms
t _{SS4}	Tolerance		-20%		30%	
BOOST CO	ONVERTER 3					
,	Switching frequency range		400		1000	kHz
sw	Tolerance		-20%		20%	
WLED DIM	IMING					
t _{PWMIN}	Input pulse width		500			ns
f _{OUT}	Output frequency range	Direct dimming	0.1		15	
		DPWM dimming	15		22	kHz
	Tolerance	9	-20%		20%	
f _{IN}	Input frequency range	PWM and direct dimming modes	0.1		15	kHz
RESET (R		3				
(***	Reset pulse duration range		0		15	ms
t _{RST}		Measured from end of V _{CC} 's ramp to 50% of				71.5
e:	Tolerance	\overline{RST} 's rising edge with a 10 k Ω pull-up resistor.	-20%		20%	
GATE VOL	TAGE SHAPING					
t _{PLH}	Dunnamentian delega	V_{GHM} rising, V_{FLK} = 0 V/1.8 V, 50% thresholds, C_{VGHM} = 150 pF, R_E = 0 Ω		92	200	
PHL	Propagation delay	V_{GHM} falling, V_{FLK} =0 V/1.8 V, 50% thresholds, C_{VGHM} = 150 pF, R_E = 0 Ω		88	200	ns
DLY4	Gate voltage shaping start-u	p delay range	0		35	ms
	Tolerance	-	-20%		30%	
PANEL RE	SET (XAO)	-				
	Panel reset duration range		0		35	ms
DLY6	Tolerance	Measured from $V_{IN} = V_{DET}$ to 50% of \overline{XAO} 's rising edge with a 10-kΩ pull-up resistor.	-20%		30%	
TIMING						
UVP	Undervoltage protection time	eout	40	50	60	ms
² C INTERI	• •					
		Standard mode			100	
SCL	Clock frequency	Fast mode			400	kHz
	Clock low period Clock high period	Standard mode	4.7			
LOW		Fast mode	1.3			μs
		Standard mode	4.0			
HIGH		Fast mode	0.6			μs
	Bus free time between a STOP and a START condition	Standard mode	4.7			
BUF		Fast mode	1.3			μs
	Hold time for a repeated START condition	Standard mode	4.0			
t _{hd:STA}		Fast mode	0.6			μs
	Set-up time for a repeated START condition	Standard mode	4.0			μs
su:STA		Fast mode	0.6			
	Data set-up time	Standard mode	250			ns
su:DAT		Fast mode	100			
		Standard mode	0.05		3.45	
t _{hd:DAT}	Data hold time	Fast mode				μs



Timing Requirements (continued)

 V_{IN} = 3.3 V, V_{LED} = 12 V, V_{CC} = 2.5 V, AV_{DD} = 8 V, V_{GL} = -6.8 V, V_{GH} = 20 V, T_A = -40°C to 85°C. Typical values are at 25°C (unless otherwise noted).

			MIN	TYP MAX	UNIT
	Rise time of SCL after a	Standard mode	20+0.1C _B	1000	
t _{RCL1}	repeated START condition and after an ACK bit	Fast mode	20+0.1C _B	1000	ns
t _{RCL}	Rise time of SCL	Standard mode	20+0.1C _B	1000	ns
		Fast mode	20+0.1C _B	300	
t _{FCL}	Fall time of SCL	Standard mode	20+0.1C _B	300	ns
		Fast mode	20+0.1C _B	300	
	Rise time of SDA	Standard mode	20+0.1C _B	1000	ns
t _{RDA}		Fast mode	20+0.1C _B	300	
	Fall time of SDA	Standard mode	20+0.1C _B	300	
t _{FDA}		Fast mode	20+0.1C _B	300	ns
t _{su:STO}	Set-up time for STOP condition	Standard mode	4.0		
		Fast mode	0.6		μs
EEPROM			·		
t _{WRITE}	Write time			100	ms

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5 Detailed Description

5.1 Overview

The TPS65154 device integrates the bias and backlight functions needed by an active matrix liquid crystal display.

The LCD bias functions comprise

- A synchronous boost converter to generate AV_{DD}
- A non-synchronous boost converter to generate V_{GH}
- An inverting charge pump to generate V_{GL}
- An low dropout linear regulator to generate V_{CC}
- · A gate-voltage shaping function
- A programmable VCOM buffer
- XAO and RST signals
- An I²C programming interface

The backlight driver functions comprise

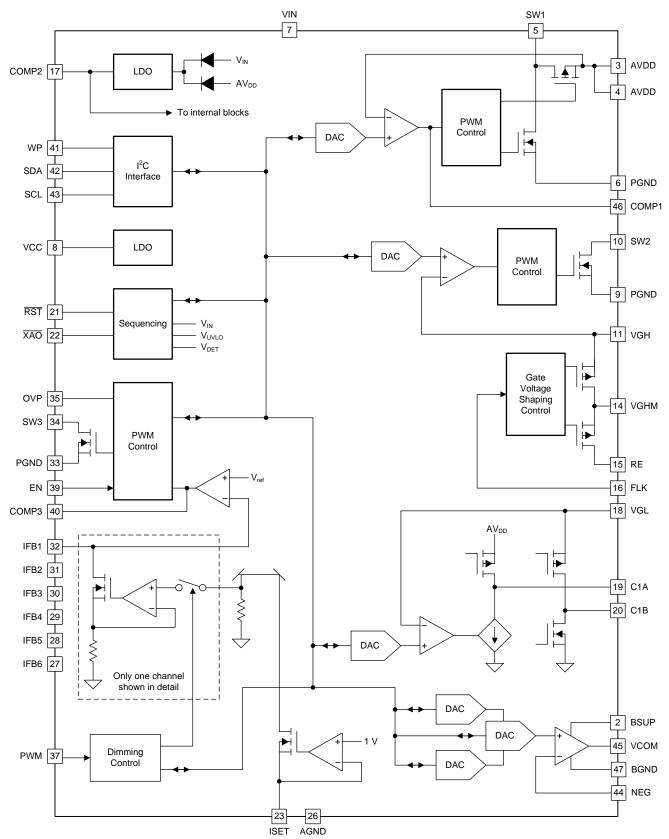
- · A non-synchronous boost converter
- A six-channel WLED driver with PWM dimming

The device configuration is stored in an on-chip nonvolatile memory, which can be programmed via an I²C interface.

5.2 Functional Block Diagram

Figure 5-1 shows a top-level block diagram of the TPS65154.





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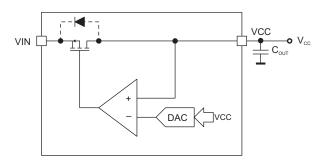
Figure 5-1. Top-Level Block Diagram

5.3 Feature Description

The following sections describe the features of the TPS65154.

5.3.1 Linear Regulator (V_{CC})

The linear regulator is supplied directly from the VIN pin, and its output voltage can be programmed to 1.0 V, 1.2 V, 1.89 V, or 2.5 V using the VCC register.



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Figure 5-2. Linear Regulator Block Diagram

5.3.1.1 Power-Up (Linear Regulator)

The linear regulator starts t_{DLY1} milliseconds after the supply voltage exceeds the undervoltage lockout threshold ($V_{IN} > V_{UVLO}$). It does not have a soft-start function, and its output ramps up as fast as the supply voltage slew rate and the linear regulator's output capacitance allow.

5.3.1.2 Power-Down (Linear Regulator)

The linear regulator is turned off as soon as the supply voltage falls below the undervoltage lockout threshold ($V_{IN} < V_{UVLO}$). V_{CC} is actively discharged during power-down.

5.3.1.3 Protection (Linear Regulator)

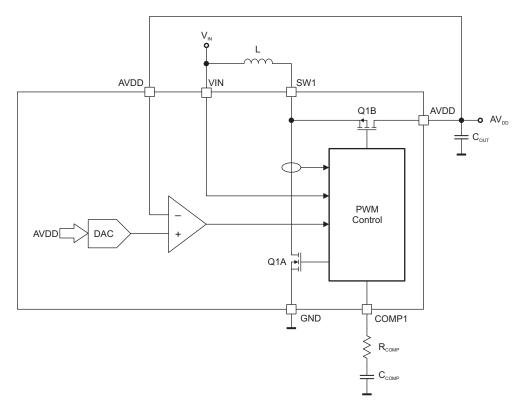
The linear regulator is protected against short-circuits and undervoltage conditions. An undervoltage condition is detected if the linear regulator's output falls below 70% of its programmed voltage for longer than 50 ms, in which case the IC is disabled. A short-circuit condition is detected if the linear regulator's output falls below 30% of its programmed voltage, in which case the IC is disabled immediately (short-circuit detection has no time delay associated with it). To recover normal operation following either an undervoltage condition or short-circuit condition, the cause of the error must be removed and a POR applied.

5.3.2 Boost Converter 1 (AV_{DD})

Boost converter 1 is synchronous and uses a virtual current mode topology that:

- achieves high efficiencies;
- allows the converter to work in continuous conduction mode under all operating conditions, simplifying compensation; and
- provides true input-output isolation when the boost converter is disabled.





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Figure 5-3. Boost Converter 1 Internal Block Diagram

Boost converter 1's switching frequency can be programmed to 400 kHz, 600 kHz, 800 kHz, or 1 MHz using the FSW1 register. Its output voltage can be programmed from 6.5 V to 9.6 V in 100 mV steps using the AVDD register.

Boost converter 1 uses an external compensation network connected to the COMP1 pin to stabilize its feedback loop. A simple series R-C network connected between the COMP1 pin and ground is sufficient to achieve good performance, that is, stable and with good transient response. Good starting values, which will work for most applications, are 25 k Ω and 3.9 nF.

In some applications (for example, those using electrolytic output capacitors), it may be necessary to include a second compensation capacitor between the COMP1 pin and ground. This has the effect of adding an additional pole in the feedback loop's frequency response, which cancels the zero introduced by the output capacitor's ESR.

The synchronous topology of boost converter 1 ensures that AV_{DD} is fully isolated from V_{IN} when the converter is disabled.

5.3.2.1 Power-Up (Boost Converter 1)

Boost converter 1 starts t_{DLY2} milliseconds after RST goes high. Delay time t_{DLY2} can be programmed from 0 ms to 75 ms using the DLY2 register.

To minimize inrush current during start-up, boost converter 1 ramps its output voltage in t_{SS2} milliseconds. Start-up time t_{SS2} can be programmed from 0.5 ms to 75 ms using the SS2 register. Longer soft-start times generate lower inrush currents.

5.3.2.2 Power-Down (Boost Converter 1)

Boost converter 1 is disabled when V_{IN}<V_{UVLO}. When disabled, boost converter 2 actively discharges AV_{DD} by turning on Q2.

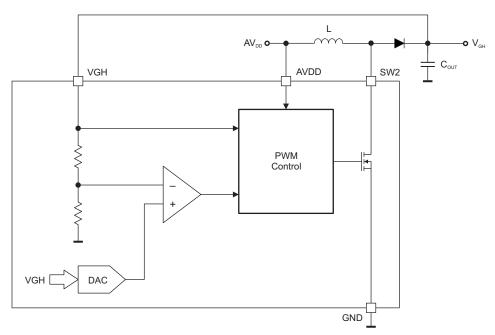
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5.3.2.3 Protection (Boost Converter 1)

Boost converter 1 is protected against short-circuits and undervoltage conditions. An undervoltage condition is detected if the boost converter's output falls below 70% of its programmed voltage for longer than 50 ms, in which case the IC is disabled. A short-circuit condition is detected if the boost converter's output falls below 30% of its programmed voltage, in which case the IC is disabled immediately (short-circuit detection has no time delay associated with it). To recover normal operation following either an undervoltage condition or short-circuit condition, the cause of the error must be removed and a POR applied.

5.3.3 Boost Converter 2 (V_{GH})

Boost converter 2 is non-synchronous and uses a constant off-time topology. The converter's switching frequency is not constant but adapts itself to V_{IN} and V_{GH} . Boost converter 2 uses peak current control and is designed to operate permanently in discontinuous conduction mode (DCM), thereby allowing the internal compensation circuit to achieve stable operation over a wide range of output voltages and currents. Boost converter 2's output voltage can be programmed from 18 V to 25.5 V using the VGH register.



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Figure 5-4. Boost Converter 2 Block Diagram

5.3.3.1 Power-Up (Boost Converter 2)

Boost converter 2 is enabled as soon as V_{GL} has finished ramping down. To minimize inrush current during start-up, boost converter 2 ramps V_{GH} linearly to its programmed value in t_{SS4} seconds. Soft-start time t_{SS4} can be programmed from 0.256 ms to 35 ms using the SS4 register. Because boost converter 2 is non-synchronous, its output is already equal to AV_{DD} (minus the voltage drop across its rectifier diode) before it starts switching, which means that the time during which V_{GH} is actually ramping during start-up is less than the actual programmed soft-start time (see Figure 5-5).

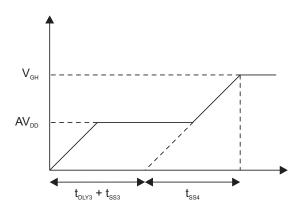


Figure 5-5. Boost Converter 2 Soft-Start

5.3.3.2 Power-Down (Boost Converter 2)

Boost converter 2 is disabled when $V_{IN} < V_{UVLO}$. The converter's output is not actively discharged when the converter is disabled.

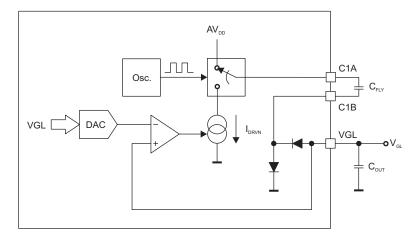
5.3.3.3 Protection (Boost Converter 2)

Boost converter 2 is protected against short-circuits and undervoltage conditions. An undervoltage condition is detected if the boost converter's output falls below 70% of its programmed voltage for longer than 50 ms, in which case the IC is disabled. A short-circuit condition is detected if the boost converter's output falls below 30% of its programmed voltage, in which case the IC is disabled immediately (short-circuit detection has no time delay associated with it). To recover normal operation following either an undervoltage condition or short-circuit condition, the cause of the error must be removed and a POR applied.

5.3.4 Negative Charge Pump (V_{GI})

The negative charge pump inverts AV_{DD} and regulates its output to the voltage set by the VGL register. V_{GL} can be programmed from -5 V to -8 V in 0.2 V steps using the VGL register, however, since the negative charge pump inverts AV_{DD} to generate its output, the most negative voltage that can be generated is approximately $-AV_{DD}+1$ V. Thus, if $AV_{DD}=8.0$ V, the usable range of V_{GL} is approximately -5 V to -7 V. If V_{GL} is programmed to a more negative voltage than this the charge pump may not be able to regulate its output. This will not damage the IC, but performance may be impaired.

The negative charge pump in the TPS65154 is fully integrated and requires only two external capacitors to operate (a flying capacitor connected between the C1A and C1B pins, and an output capacitor connected between the VGL pin and ground).



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Figure 5-6. Negative Charge Pump Block Diagram

5.3.4.1 Power-Up (Negative Charge Pump)

The negative charge pump starts t_{DLY3} milliseconds after boost converter 1 (AV_{DD}) starts ramping and ramps its output linearly from zero to its programmed output voltage in t_{SS3} ms. Delay time t_{DLY3} can be programmed from 0 ms to 35 ms using the DLY3 register. Soft-start time t_{SS3} can be programmed from 0 ms to 35 ms using the SS3 register.

5.3.4.2 Power-Down (Negative Charge Pump)

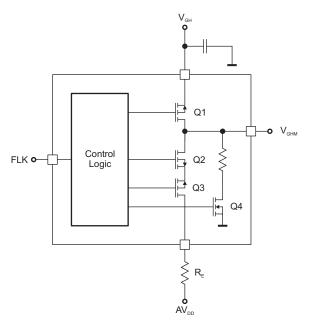
The negative charge pump is disabled when the supply voltage falls below the undervoltage lockout threshold ($V_{IN} < V_{UVLO}$). During power-down the charge pump's output is actively discharge to GND.

5.3.4.3 Protection (Negative Charge Pump)

The negative charge pump is protected against short-circuits and undervoltage conditions. An undervoltage condition is detected if the charge pump's output falls below 70% of its programmed voltage for longer than 50 ms, in which case the IC is disabled. A short-circuit condition is detected if the charge pump's output falls below 30% of its programmed voltage, in which case the IC is disabled immediately (short-circuit detection has no time delay associated with it). To recover normal operation following either an undervoltage condition or short-circuit condition, the cause of the error must be removed and a POR applied.

5.3.5 Gate Voltage Shaping

The gate voltage shaping function can be used to reduce image sticking in LCD panels by modulating the LCD panel's gate ON voltage (V_{GH}). Figure 5-7 shows a block diagram of the gate voltage shaping function and Figure 5-8 shows the typical waveforms during operation.



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Figure 5-7. Gate Voltage Shaping Block Diagram

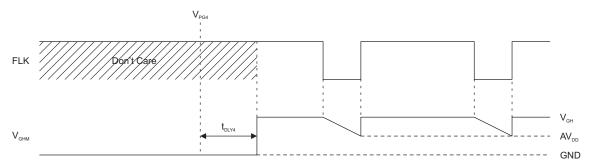


Figure 5-8. Gate Voltage Shaping Waveforms

Gate voltage shaping is controlled by the FLK input. When FLK is high, Q1 is on, Q2, Q3 and Q4 are off, and V_{GHM} is equal to V_{GHM} . On the falling edge of FLK, Q1 is turned off, Q2 and Q3 are turned on, and the LCD panel load connected to the VGHM pin discharges through the external resistor connected to the RE pin.

During power-up, Q1, Q2 and Q3 are held off and Q4 is turned on, pulling the VGHM pin pulled to GND, regardless of the state of the FLK signal, until t_{DLY4} milliseconds after boost converter 2 (V_{GH}) has finished ramping. The value of t_{DLY4} can be programmed from 0 ms to 35 ms using the DLY4 register.

During power-down Q1 is held permanently on and Q2, Q3 and Q4 permanently off, regardless of the state of the FLK signal.

5.3.6 Panel Discharge (XAO)

The TPS65154 provides an output signal via its $\overline{\text{XAO}}$ pin that can be used to drive the outputs of the display panel's gate driver IC high during power-down. The $\overline{\text{XAO}}$ pin is pulled low whenever $V_{\text{IN}} < V_{\text{DET}}$. The V_{DET} threshold voltage can be configured using the VDET register.

The \overline{XAO} output is an open-drain type and requires an external pull-up, typically in the range 10 k Ω to 100 k Ω .

5.3.7 Reset Generator (RST)

The \overline{RST} pin generates an active-low reset signal for the rest of the system. During power-up, the reset timer starts when V_{CC} has finished ramping. The reset pulse duration t_{RST} can be programmed from 0 ms to 15 ms using the RESET register. The \overline{RST} signal is latched when it goes high and will not be taken low again until the device is powered down (even if V_{CC} temporarily falls out of regulation). The active power-down threshold (V_{UVLO} or V_{DET}) can be selected using the RMODE bit in the CONFIG register.

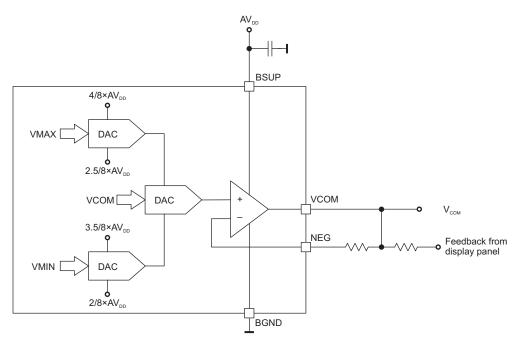
The \overline{RST} output is an open-drain type that requires an external pull-up resistor. Pull-up resistor values in the range 10 k Ω to 100 k Ω are recommended for most applications.

5.3.8 Programmable VCOM

The programmable VCOM uses three digital-to-analog converters (DACs) to generate a V_{COM} voltage that is subsequently buffered by a high-speed op-amp. The maximum value of V_{COM} is set by the 4-bit VMAX register, and can be programmed in the range $2.5/8\times AV_{DD}$ to $4/8\times AV_{DD}$. The minimum value of V_{COM} is set by the 4-bit VMIN register, and can be programmed in the range $2/8\times AV_{DD}$ to $3.5/8\times AV_{DD}$. Note, for proper operation, V_{MAX} must be greater than V_{MIN} . By programming the 7-bit VCOM parameter, users can adjust the V_{COM} voltage appearing at the OUT pin between V_{MIN} and V_{MAX} as follows:

$$V_{COM} = V_{MIN} + \frac{(V_{MAX} - V_{MIN}) \cdot VCOM}{127}$$
(1)

where VCOM is the value stored in the Wiper Register (see Figure 5-9).



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Figure 5-9. Programmable VCOM Block Diagram

The programmable VCOM function has three registers. The volatile Wiper Register (WR) contains the value currently output by the programmable VCOM DAC; this value is lost when power to the device is removed. The non-volatile Initial Value Register (IVR) contains the value loaded into the DAC every time the device is powered up. The Control Register (CR) determines whether data is written to or read from the WR, the IVR, or both. If the CR contains 00h, during write operations data is stored in the WR and the IVR, and during read operations data is read from the IVR. If the CR contains 80h, data is written to and read from the WR register only. 00h and 80h are the only valid values for the CR. Table 5-1 shows the programmable VCOM's register address map.



Table 5-1. Programmable VCOM Register Address Map

REGISTER ADDRESS	NON-VOLATILE	VOLATILE	
00h	Initial Value Register (IVR)	Wiper Register (WR)	
02h	Not Used	Control Register (CR)	

5.3.8.1 Operational Amplifier Performance

Like most op-amps, the V_{COM} op-amp in the TPS65154 is not designed to drive purely capacitive loads, so it is not recommended to connect a capacitor directly to its output in an attempt to increase performance; however, the op-amp is capable of delivering high peak currents that make such capacitors unnecessary in most applications.

High-speed op amps such as the one in the TPS65154 require care when using them. The most common problem is when parasitic capacitance at the inverting input creates a pole with the feedback resistor, reducing amplifier stability. Two things can be done to minimize the likelihood of this happening. Both of these work by shifting the pole (which can never be completely eliminated) to a frequency outside the op amp's bandwidth, where it has no effect.

- Reduce the value of the feedback resistor. In applications where no feedback from the panel is used, the feedback resistor can be made zero. In applications where a non-zero feedback resistor has to be used, a small capacitor (between 10 pF and 100 pF) across the feedback resistor will minimize ringing.
- Minimize the parasitic capacitance at the op amp's inverting input. This is achieved by using short PCB traces between the feedback resistor and the inverting input, and by removing ground planes and other copper areas above and below this PCB trace.

5.3.8.2 Power-Up (Programmable VCOM)

The programmable V_{COM} is enabled when $AV_{DD} > V_{UVLO2}$.

5.3.8.3 Power-Down (Programmable VCOM)

During power-down, the programmable VCOM continues to operate until $AV_{DD} < V_{UVLO2}$.

5.3.9 WLED Driver

5.3.9.1 WLED Boost Converter

The WLED boost converter boosts a 4.5~V to 24~V supply V_{BAT} to a higher voltage to supply the LED strings connected to the WLED driver. It uses a fixed-frequency, current-mode topology. The converter's output voltage is automatically adjusted to maintain the lowest feedback voltage (IFB1 to IFB6) between 450~mV and 750~mV, thus ensuring sufficient headroom for the output current sinks, but without dissipating excessive power in the IC. This approach automatically compensates for changes in the LED string voltage, for example, because of temperature effects. The WLED boost converter's switching frequency can be programmed to 400~kHz, 600~kHz, 800~kHz, and 1~MHz using the FSW3 register.

The WLED boost converter features a soft-start circuit to limit inrush current when the converter starts. The duration of the soft-start ramp depends on the value of the capacitor connected to the COMP3 pin. Note, that because the converter is a non-synchronous type, its output voltage before it starts switching is equal to V_{BAT} (minus the voltage drop across its rectifier).

5.3.9.2 Current Sinks

The brightness of the LED strings is determined by the *average* current flowing through each string, which is the product of the output duty cycle and the current sink's output current. The output current of all current sinks is the same and is set by the external resistor connected between the ISET pin and ground:

$$I_{MAX} = \frac{V_{SET}}{R_{SET}} \cdot K_{SET}$$
(2)

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where:

- V_{SET} is the voltage on the ISET pin
- R_{SET} is the resistance between the ISET pin and GND
- K_{SFT} is a constant

When the TPS65154 measures zero current flowing in one of the IFB pins it determines that the string is open and automatically disables that output. The WLED boost converter's output voltage is subsequently regulated according to the remaining operational strings. If an application uses fewer than six LED strings, it is recommended to connected the unused outputs to ground; this ensures the most rapid detection of the unused strings. Once open strings have been detected, they remain disabled until a POR occurs or EN is toggled.

5.3.9.3 Protection

The WLED boost converter and dimming circuits feature a variety of protection schemes to ensure reliable operation when subjected to various failure modes. These protection schemes are listed in Table 5-2.

DETECTION ERROR ACTION RECOVERY V_{OVP} exceeds programmed WLED boost converter output WLED boost converter output regulated to programmed threshold None required voltage too high (30 V, 33 V, 36 V or 39 V) threshold WLED boost converter switch Switch automatically re-enabled $I_{SW} > I_{LIM}$ Switch turned off current too high at start of next switching cycle Disable all output channels and Output channels re-enabled All LED strings open-circuit $I_{IFB} = 0$ mA and $V_{OUT} = V_{OVP}$ boost converter following power cycle Individual LED string(s) open-Disable affected output $I_{IFB} = 0$ mA and $V_{OUT} = V_{OVP}$ circuit channel(s) Affected output channel(s) re-Functional output channels enabled following power cycle Individual LED string(s) shorted- $I_{IFB} = 0$ mA for longer than 4 ms continue operating. circuited to ground

Table 5-2. WLED Driver Protection

5.3.9.4 Enable and Start-Up

The WLED driver is enabled and disabled by EN, however, this signal has no effect until the LCD bias functions have completed their start-up sequence. Following a POR, EN has no effect until $t_{\rm DLY4}$ is complete; after that the WLED driver can be enabled and disabled at any time using EN (providing nothing happens to cause the LCD bias functions to re-start) and applying a PWM signal. In applications that do not generate an EN signal, the EN pin can be tied to $V_{\rm IN}$, in which case the WLED driver will start automatically at the end of $t_{\rm DLY4}$. Note, that a permanently low PWM signal (0% duty cycle) will prevent boost converter 3 from starting-up.

When the WLED driver is enabled it first checks the status of IFB1 to IFB6 and shuts down any channels that it detects are disabled/unused. These channels will be subsequently ignored until a POR occurs or EN is toggled.

5.3.10 Undervoltage Lockout

An undervoltage lockout function disables the IC when the supply voltage is too low for proper operation.

5.4 Device Functional Modes

5.4.1 Dimming Modes

The TPS65154 support direct dimming and phase-shift dimming modes. The active dimming mode can be selected using the DMODE bit in the CONFIG register.



5.4.1.1 Direct Dimming

When direct dimming is selected, the output current sinks are controlled directly by the PWM signal. In this mode, they are turned on and off together, at the same frequency and duty cycle as the PWM signal (see Figure 5-10).

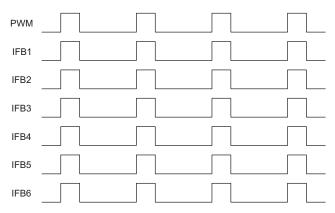


Figure 5-10. Direct Dimming

5.4.1.2 Phase-Shift Dimming

When phase-shift dimming mode is selected, the output dimming frequency does not depend on the frequency of the PWM signal but can be independently programmed from 15 kHz to 22 kHz using the FDIM register. In this mode, the duty cycle information contained in the PWM signal is extracted and reused to generate up to six outputs, at the output frequency set by the FDIM register, and phase-shifted with respect to each other by 360°/N, where N is the number of outputs in use (see Figure 5-11). Using phase-shifted outputs, the maximum load current step is reduced by the same factor N, resulting in reduced voltage ripple on the boost converter's output and consequently lower audible noise.

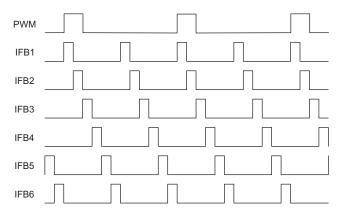


Figure 5-11. Phase-Shift Dimming

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5.4.2 Power Sequencing

Figure 5-12 shows the typical power-up/down characteristic of the TPS65154.

5.4.2.1 Power-Up

 V_{CC} starts ramping t_{DLY1} seconds after $V_{IN} > V_{UVLO}$.

 \overline{RST} is initially held low. t_{RST} seconds after V_{CC} has finished ramping \overline{RST} goes high.

 AV_{DD} starts ramping t_{DLY2} seconds after \overline{RST} has gone high.

 V_{GL} starts ramping t_{DLY3} seconds after AV_{DD} starts ramping.

V_{GH} starts ramping as soon as V_{GL} has finished ramping.

 V_{GHM} is initially held low (connected to RE). t_{DLY4} seconds after V_{GH} has finished ramping, gate voltage shaping is enabled and V_{GHM} follows the state of FLK.

 \overline{XAO} is initially held low. t_{DLY6} seconds after $V_{IN} > V_{DET}$ \overline{XAO} goes high.

The WLED driver is enabled by the logical AND of AV_{DD} (that is, AV_{DD} has finished ramping) and EN.

5.4.2.2 Power-Down

 V_{CC} , AV_{DD} , V_{GH} and V_{GL} are disabled when $V_{IN} < V_{UVLO}$.

 \overline{XAO} goes low when V_{IN} falls below the threshold selected for it (V_{UVLO} or V_{DET}).

 \overline{RST} goes low when V_{IN} falls below the threshold selected for it (V_{UVLO} or V_{DET}).

The WLED driver is turned off when EN = 0 or $V_{IN} < V_{UVLO}$.



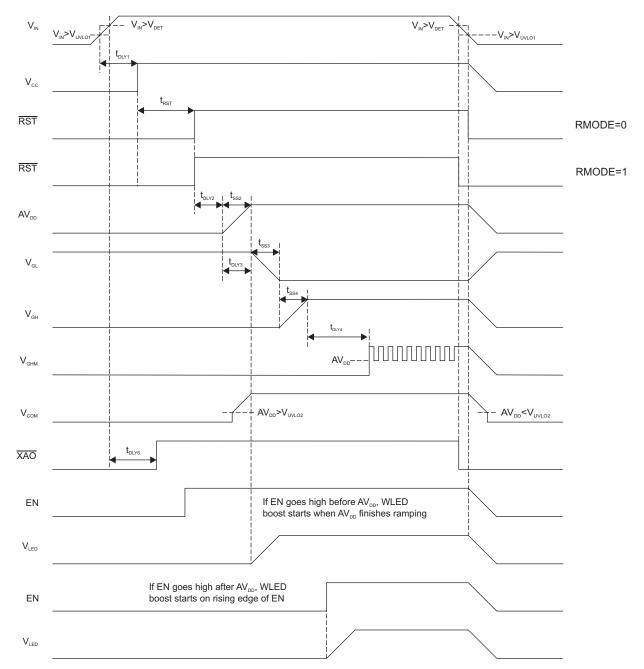


Figure 5-12. Power Up/Down Sequencing

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5.5 Programming

5.5.1 Configuration

The TPS65154 divides the configuration parameters into two categories:

- Configuration parameters
- VCOM

In typical applications, all configuration parameters except VCOM are programmed by the subcontractor during PCB assembly, and VCOM is programmed by the display manufacturer during display calibration.

5.5.1.1 General

Configuration parameters can be changed by writing the desired values to the appropriate RAM register(s). The RAM registers are volatile and their contents are lost when power is removed from the device. By writing to the Control Register, it is possible to store the active configuration in non-volatile EEPROM; during power-up, the contents of the EEPROM are copied into the RAM registers and used to configure the device.

5.5.1.1.1 PC Interface

The TPS65154 features an industry-standard I²C interface that supports both Standard and Fast modes of operation.

5.5.1.1.2 Slave Addresses

The configuration parameters are all accessed using slave address 74h and the VCOM is accessed using slave address 28h.

5.5.1.1.3 Write Protect

An active-high Write Protect pin (WP) prevents the configuration parameters from being changed by accident. This pin is internally pulled high and must be actively pulled low to access to the EEPROM or RAM registers. Note that the WP pin disables all I²C traffic to the TPS65154, and must also be pulled low during read operations. This is to ensure that noise present on the I²C lines does not erroneously overwrite the active configuration stored in RAM (which would not be protected by a simple EEPROM write-protect scheme). The write protect function can be enabled and disabled using the WPEN bit in the CONFIG register. Note that once the write protect function is enabled it is not possible to disable again it without pulling the WP pin low. For this reason, it is strongly recommended that applications include some way to pull the WP pin low (for example, a test pad), even if it is not normally used.



5.5.2 Programming Examples (Excluding VCOM)

5.5.2.1 Writing to a Single RAM Register

- 1. Bus master sends START condition
- 2. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 3. TPS65154 acknowledges
- 4. Bus master sends address of RAM register (00h)
- 5. TPS65154 acknowledges
- 6. Bus master sends data to be written
- 7. TPS65154 acknowledges
- 8. Bus master sends STOP condition



Figure 5-13. Writing to a Single RAM Register



5.5.2.2 Writing to Multiple RAM Registers

- 1. Bus master sends START condition
- 2. Bus master sends 7-bit slave address plus low R/W bit (E8h).
- 3. TPS65154 acknowledges
- 4. Bus master sends address of first RAM register to be written to (00h)
- 5. TPS65154 acknowledges
- 6. Bus master sends data to be written to first RAM register
- 7. TPS65154 acknowledges
- 8. Bus master sends data to be written to RAM register at next higher address (auto-increment)
- 9. TPS65154 acknowledges
- 10. Steps (8) and (9) repeated until data for final RAM register has been sent
- 11. TPS65154 acknowledges
- 12. Bus master sends STOP condition

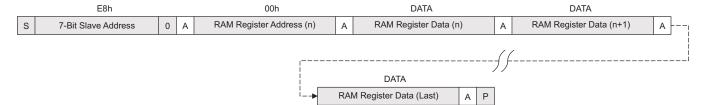


Figure 5-14. Writing to Multiple RAM Registers



5.5.2.3 Saving Contents of all RAM Registers to EEPROM

- 1. Bus master sends START condition
- 2. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 3. TPS65154 acknowledges
- 4. Bus master sends address of Control Register (FFh)
- 5. TPS65154 acknowledges
- 6. Bus master sends data to be written to the Control Register (80h)
- 7. TPS65154 acknowledges
- 8. Bus master sends STOP condition



Figure 5-15. Saving Contents of all RAM Registers to EEPROM



5.5.2.4 Reading from a Single RAM Register

- 1. Bus master sends START condition
- 2. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 3. TPS65154 acknowledges
- 4. Bus master sends address of Control Register (FFh)
- 5. TPS65154 acknowledges
- 6. Bus master sends data for Control Register (00h)
- 7. TPS65154 acknowledges
- 8. Bus master sends STOP condition
- 9. Bus master sends START condition
- 10. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 11. TPS65154 acknowledges
- 12. Bus master sends address of RAM register (00h)
- 13. TPS65154 acknowledges
- 14. Bus master sends REPEATED START condition
- 15. Bus master sends 7-bit slave address plus high R/W bit (E9h)
- 16. TPS65154 acknowledges
- 17. TPS65154 sends RAM register data
- 18. Bus master does not acknowledge
- 19. Bus master sends STOP condition

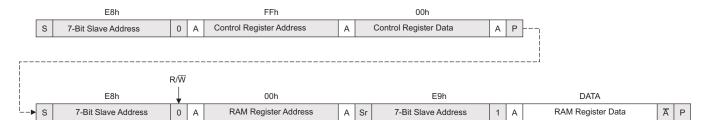


Figure 5-16. Reading from a Single RAM Register



5.5.2.5 Reading from a Single EEPROM Register

- 1. Bus master sends START condition
- 2. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 3. TPS65154 acknowledges
- 4. Bus master sends address of Control Register (FFh)
- 5. TPS65154 acknowledges
- 6. Bus master sends data for Control Register (01h)
- 7. TPS65154 acknowledges
- 8. Bus master sends STOP condition
- 9. Bus master sends START condition
- 10. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 11. TPS65154 acknowledges
- 12. Bus master sends address of EEPROM register (00h)
- 13. TPS65154 acknowledges
- 14. Bus master sends REPEATED START condition
- 15. Bus master sends 7-bit slave address plus high R/W bit (E9h)
- 16. TPS65154 acknowledges
- 17. TPS65154 sends EEPROM register data
- 18. Bus master does not acknowledge
- 19. Bus master sends STOP condition

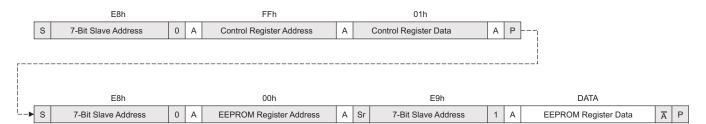


Figure 5-17. Reading from a Single EEPROM Register



5.5.2.6 Reading from Multiple RAM Registers

- 1. Bus master sends START condition
- 2. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 3. TPS65154 acknowledges
- 4. Bus master sends address of Control Register (FFh)
- 5. TPS65154 acknowledges
- 6. Bus master sends data for Control Register (00h)
- 7. TPS65154 acknowledges
- 8. Bus master sends STOP condition
- 9. Bus master sends START condition
- 10. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 11. TPS65154 acknowledges
- 12. Bus master sends address of first register to be read (00h)
- 13. TPS65154 acknowledges
- 14. Bus master sends REPEATED START condition
- 15. Bus master sends 7-bit slave address plus high R/W bit (E9h)
- 16. TPS65154 acknowledges
- 17. TPS65154 sends contents of first RAM register to be read
- 18. Bus master acknowledges
- 19. TPS65154 sends contents of second RAM register to be read
- 20. Bus master acknowledges
- 21. TPS65154 sends contents of third (last) RAM register to be read
- 22. Bus master does not acknowledge
- 23. Bus master sends STOP condition

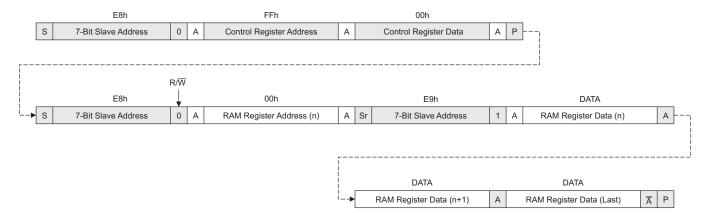


Figure 5-18. Reading from Multiple RAM Registers



5.5.2.7 Reading from Multiple EEPROM Registers

- 1. Bus master sends START condition
- 2. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 3. TPS65154 acknowledges
- 4. Bus master sends address of Control Register (FFh)
- 5. TPS65154 acknowledges
- 6. Bus master sends data for Control Register (01h)
- 7. TPS65154 acknowledges
- 8. Bus master sends STOP condition
- 9. Bus master sends START condition
- 10. Bus master sends 7-bit slave address plus low R/W bit (E8h)
- 11. TPS65154 acknowledges
- 12. Bus master sends address of first EEPROM register to be read (00h)
- 13. TPS65154 acknowledges
- 14. Bus master sends REPEATED START condition
- 15. Bus master sends 7-bit slave address plus high R/W bit (E9h)
- 16. TPS65154 acknowledges
- 17. TPS65154 sends contents of first EEPROM register to be read
- 18. Bus master acknowledges
- 19. TPS65154 sends contents of second EEPROM register to be read
- 20. Bus master acknowledges
- 21. TPS65154 sends contents of third (last) EEPROM register to be read
- 22. Bus master does not acknowledge
- 23. Bus master sends STOP condition

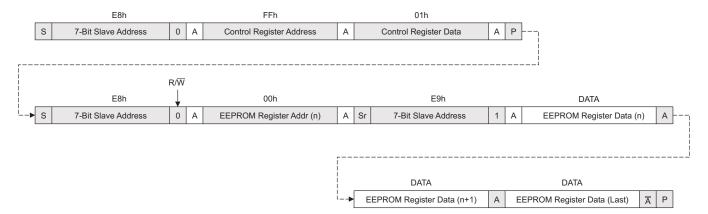


Figure 5-19. Reading from Multiple EEPROM Registers



5.5.3 Programming Examples - VCOM

5.5.3.1 Writing a VCOM Value of 77h to WR

- 1. The bus master sends a START condition.
- 2. The bus master sends 7-bit slave address plus low R/\overline{W} bit.
- 3. TPS65154 slave acknowledges.
- 4. The bus master sends the CR address of 02h.
- 5. The TPS65154 acknowledges.
- 6. The bus master sends the CR contents of 80h.
- 7. The TPS65154 slave acknowledges.
- 8. The bus master sends a STOP condition.
- 9. The bus master sends a START condition.
- 10. The bus master sends 7-bit slave address plus low R/\overline{W} bit.
- 11. TPS65154 slave acknowledges.
- 12. The bus master sends the WR address of 00h.
- 13. The TPS65154 acknowledges.
- 14. The bus master sends the WR contents of 77h (right-justified).
- 15. The TPS65154 slave acknowledges.
- 16. The bus master sends a STOP condition.

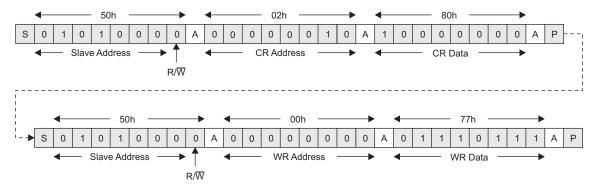


Figure 5-20. Writing a VCOM Value of 77h to WR



5.5.3.2 Writing a VCOM Value of 77h to IVR and WR

- 1. The bus master sends a START condition.
- 2. The bus master sends 7-bit slave address plus low R/W bit.
- 3. TPS65154 slave acknowledges.
- 4. The bus master sends the CR address of 02h.
- 5. The TPS65154 acknowledges.
- 6. The bus master sends the CR contents of 00h.
- 7. The TPS65154 slave acknowledges.
- 8. The bus master sends a STOP condition.
- 9. The bus master sends a START condition.
- 10. The bus master sends 7-bit slave address plus low R/\overline{W} bit.
- 11. TPS65154 slave acknowledges.
- 12. The bus master sends the WR address of 00h.
- 13. The TPS65154 acknowledges.
- 14. The bus master sends the WR contents of 77h (right-justified).
- 15. The TPS65154 slave acknowledges.
- 16. The bus master sends a STOP condition.

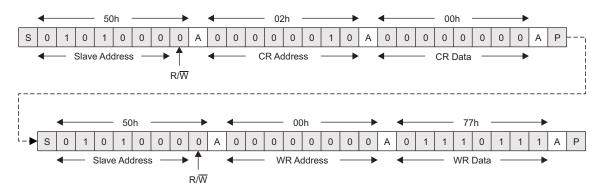


Figure 5-21. Writing a VCOM Value of 77h to IVR and WR



5.5.3.3 Reading a VCOM Value of 77h from WR

- 1. The bus master sends a START condition.
- 2. The bus master sends 7-bit slave address plus low R/\overline{W} bit.
- 3. TPS65154 slave acknowledges.
- 4. The bus master sends the CR address of 02h.
- 5. The TPS65154 acknowledges.
- 6. The bus master sends the CR contents of 80h.
- 7. The TPS65154 slave acknowledges.
- 8. The bus master sends a STOP condition.
- 9. The bus master sends a START condition.
- 10. The bus master sends 7-bit slave address plus low R/\overline{W} bit.
- 11. TPS65154 slave acknowledges.
- 12. The bus master sends the WR address of 00h.
- 13. The TPS65154 acknowledges.
- 14. The bus master sends a REPEATED START condition.
- 15. The bus master sends 7-bit slave address plus high R/W bit.
- 16. The TPS65154 sends the WR contents of 77h (right-justified).
- 17. The bus master does not acknowledge.
- 18. The bus master sends a STOP condition.

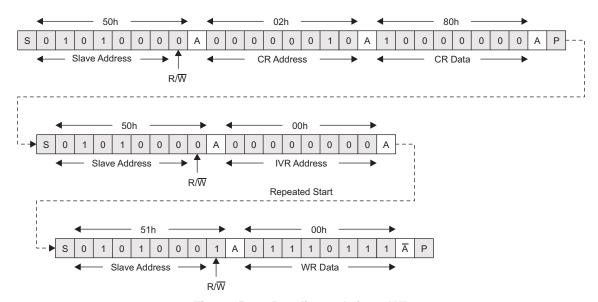


Figure 5-22. Reading 77h from WR



5.5.3.4 Reading a VCOM Value of 77h from IVR

- 1. The bus master sends a START condition.
- 2. The bus master sends 7-bit slave address plus low R/W bit.
- 3. TPS65154 slave acknowledges.
- 4. The bus master sends the CR address of 02h.
- 5. The TPS65154 acknowledges.
- 6. The bus master sends the CR contents of 00h.
- 7. The TPS65154 slave acknowledges.
- 8. The bus master sends a STOP condition.
- 9. The bus master sends a START condition.
- 10. The bus master sends 7-bit slave address plus low R/\overline{W} bit.
- 11. TPS65154 slave acknowledges.
- 12. The bus master sends the WR address of 00h.
- 13. The TPS65154 acknowledges.
- 14. The bus master sends a REPEATED START condition.
- 15. The bus master sends 7-bit slave address plus high R/\overline{W} bit.
- 16. The TPS65154 sends the WR contents of 77h (right-justified).
- 17. The bus master does not acknowledge.
- 18. The bus master sends a STOP condition.

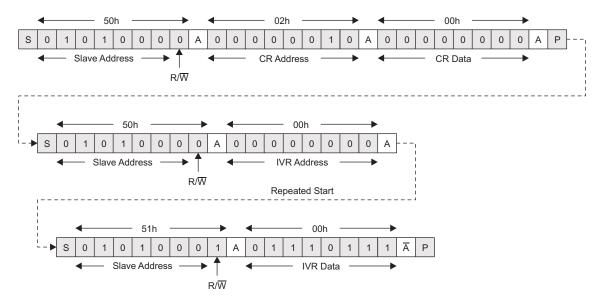


Figure 5-23. Reading 77h from IVR



5.6 Register Map

5.6.1 Configuration Registers (Excluding VCOM)

Table 5-3 shows the memory map of the configuration parameters.

Table 5-3. Configuration Memory Map

REGISTER ADDRESS	REGISTER NAME	FACTO	ORY DEFAULT	DESCRIPTION
00h	CONFIG	02h	KMODE = 0 WPEN = 0 DMODE = 1 RMODE = 0	Sets miscellaneous configuration bits
01h	VCC	03h	2.5 V	Sets the output voltage of the linear regulator (V _{CC})
02h	DLY1	02h	10 ms	Sets the start-up delay of the linear regulator (V _{CC})
03h	AVDD	0Fh	8.0 V	Sets the output voltage of boost converter 1 (AV _{DD})
04h	FSW1	01h	600 kHz	Sets the switching frequency of boost converter 1 (AV _{DD})
05h	SS2	04h	20 ms	Sets the soft-start time of boost converter 1 (AV _{DD})
06h	DLY2	02h	10 ms	Sets the start-up delay of boost converter 1 (AV _{DD})
07h	VGL	09h	-6.8 V	Sets the output voltage of the negative charge pump (V _{GL})
08h	SS3	01h	5 ms	Sets the soft-start time of the negative charge pump (V _{GL})
09h	DLY3	01h	5 ms	Sets the start-up delay of the negative charge pump (V _{GL})
0Ah	VGH	04h	20.0 V	Sets the output voltage of boost converter 2 (V _{GH})
0Bh	SS4	01h	5 ms	Sets the soft-start time of boost converter 2 (V _{GH})
0Ch	FSW3	01h	600 kHz	Sets the switching frequency of boost converter 3 (WLED)
0Dh	DLY4	02h	10 ms	Sets the start-up delay of the gate voltage shaping function (V _{GHM})
0Eh	OVP	03h	39 V	Sets the over-voltage protection threshold of boost converter 3 (WLED)
0Fh	FDIM	07h	22 kHz	Sets the output dimming frequency of the WLED driver in phase-shift dimming mode
10h	RESET	05h	5 ms	Sets the reset pulse duration
11h	VDET	00h	$V_{DET} = V_{UVLO}$	Sets the threshold of the RST and XAO signals
12h	DLY6	02h	30 ms	Sets the start-up delay of the $\overline{\text{XAO}}$ signal
13h	VMAX	07h	3.2 V	Sets the maximum V _{COM} voltage
14h	VMIN	07h	2.7 V	Sets the minimum V _{COM} voltage
15h	USER1	00h	00h	For customer use
FFh	CONTROL	00h		Controls whether read and write operations access RAM or EEPROM registers



5.6.1.1 CONFIG (00h)

The CONFIG register can be written to and read from.

Figure 5-24. CONFIG Register Bit Allocation

7	6	5	4	3	2	1	0
ADIS		Reserved		KMODE	WPEN	DMODE	RMODE
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-1	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-4. CONFIG Register Field Descriptions

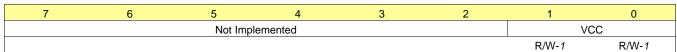
Bit	Field	Value	Description
	1 1010	Value	·
7	ADIS		This bit can be used to disable boost converter 1 (AV_{DD}), boost converter 2 (V_{GH}) and the negative charge pump (V_{GL}) during device programming. This bit is volatile and is never stored in EEPROM. It is always reset (that is, ADIS = 0) following power-up, that is, the affected converters are always enabled following power-up.
		0	Boost converter 1 (AV $_{DD}$), boost converter 2 (V $_{GH}$), and negative charge pump (V $_{GL}$) enabled.
		1	Boost converter 1 (AV $_{DD}$), boost converter 2 (V $_{GH}$), and negative charge pump (V $_{GL}$) disabled.
6-4	Reserved	N/A	These bits are reserved for future use and should be programmed to 0 to ensure proper operation.
3	KMODE		This bit can be used to enable and disable boost converter 1's active discharge function.
		0	Boost converter 1 (AV _{DD}) active discharge enabled.
		1	Boost converter 1 (AV _{DD}) active discharge disabled.
2	WPEN		This bit can be used to enable and disable the write protect function.
		0	Disabled. WP not used and I ² C interface always active.
		1	Enabled. I ² C interface only active when WP pulled low.
1	DMODE		This bit determines which dimming mode is used by the WLED driver.
		0	Direct dimming.
		1	Phase-shift dimming.
0	RMODE		This bit determines which threshold is used to assert RST during power-down.
		0	V _{UVLO} threshold used.
		1	V _{DET} threshold used.



5.6.1.2 VCC (01h)

The VCC register can be written to and read from.

Figure 5-25. VCC Register Bit Allocation



LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-5. VCC Register Field Descriptions

Bit	Field	Value	Description
7-2	Not implemented	N/A	These bits are not implemented. During write operations, data for these bits is ignored, and during read operations 0 is returned.
1-0	VCC		These bits determine the output voltage of the linear regulator (V _{CC}).
		0h	1.0 V
		1h	1.2 V
		2h	1.89 V
		3h	2.5 V



5.6.1.3 DLY1 (02h)

The DLY1 register can be written to and read from.

Figure 5-26. DLY1 Register Bit Allocation

7	6	5	4	3	2	1	0	
	Not Impl	emented		DLY1				
				R/W-0	R/W-0	R/W-1	R/W-0	

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-6. DLY1 Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during write operations 0 is returned.
3-0	DLY1		These bits determine how soon after V _{IN} >V _{UVLO} the linear regulator (V _{CC}) starts.
		0h	0 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms
		8h	40 ms
		9h	45 ms
		Ah	50 ms
		Bh	55 ms
		Ch	60 ms
		Dh	65 ms
		Eh	70 ms
		Fh	75 ms



5.6.1.4 AVDD (03h)

The AVDD register can be written to and read from.

Figure 5-27. AVDD Register Bit Allocation

7	6 5		4	3	2	1	0
Not Implemented					AVDD		
			R/W-0	R/W-1	R/W-1	R/W-1	R/W-1

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-7. AVDD Register Field Descriptions

Bit	Field	Value	Description
1	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
0	AVDD		These bits determine the output voltage of boost converter 1 (AV _{DD}).
		00h	6.5 V
		01h	6.6 V
		02h	6.7 V
		03h	6.8 V
		04h	6.9 V
		05h	7.0 V
		06h	7.1 V
		07h	7.2 V
		08h	7.3 V
		09h	7.4 V
		0Ah	7.5 V
		0Bh	7.6 V
		0Ch	7.7 V
		0Dh	7.8 V
		0Eh	7.9 V
		0Fh	8.0 V
		10h	8.1 V
		11h	8.2 V
		12h	8.3 V
		13h	8.4 V
		14h	8.5 V
		15h	8.6 V
		16h	8.7 V
		17h	8.8 V
		18h	8.9 V
		19h	9.0 V
		1Ah	9.1 V
		1Bh	9.2 V
		1Ch	9.3 V
		1Dh	9.4 V
		1Eh	9.5 V
		1Fh	9.6 V



5.6.1.5 FSW1 (04h)

The FSW1 register can be written to and read from.

Figure 5-28. FSW1 Register Bit Allocation

7	6	5	4	3	2	1	0	
	Not Implemented						FSW1	
	·					R/W-0	R/W-1	

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-8. FSW1 Register Field Descriptions

Bit	Field	Value	Description
7-2	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
1-0	FSW1		These bits determine the switching frequency of boost converter 1 (AV _{DD}).
		0h	400 kHz
		1h	600 kHz
		2h	800 kHz
		3h	1 MHz



5.6.1.6 SS2 (05h)

The SS2 register can be written to and read from.

Figure 5-29. SS2 Register Bit Allocation

7	6	5	4	3	2	1	0	
	Not Impl	emented		SS2				
				R/W-0	R/W-1	R/W-0	R/W-0	

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-9. SS2 Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	SS2		These bits determine the soft-start time of boost converter 1 (AV _{DD}).
		0h	0.5 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms
		8h	40 ms
		9h	45 ms
		Ah	50 ms
		Bh	55 ms
		Ch	60 ms
		Dh	65 ms
		Eh	70 ms
		Fh	75 ms

44



5.6.1.7 DLY2 (06h)

The DLY2 register can be written to and read from.

Figure 5-30. DLY2 Register Bit Allocation

7	6	5	4	3	2	1	0
	Not Implemented				DL	.Y2	
	<u>, </u>			R/W-0	R/W-0	R/W-1	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-10. DLY2 Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	DLY2		These bits determine how soon after $\overline{\text{RST}}$ goes high boost converter 1 (AV _{DD}) starts.
		0h	0 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms
		8h	40 ms
		9h	45 ms
		Ah	50 ms
		Bh	55 ms
		Ch	60 ms
		Dh	65 ms
		Eh	70 ms
		Fh	75 ms



5.6.1.8 VGL (07h)

The VGL register can be written to and read from.

Figure 5-31. VGL Register Bit Allocation

7	6	5	4	3	2	1	0
	Not Implemented				V	GL	
				R/W-1	R/W-0	R/W-0	R/W-1

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-11. VGL Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	VGL		These bits determine the output voltage of the negative charge pump (V _{GL}).
		0h	-5.0 V
		1h	-5.2 V
		2h	−5.4 V
		3h	-5.6 V
		4h	-5.8 V
		5h	-6.0 V
		6h	−6.2 V
		7h	−6.4 V
		8h	-6.6 V
		9h	-6.8 V
		Ah	-7.0 V
		Bh	−7.2 V
		Ch	−7.4 V
		Dh	−7.6 V
		Eh	−7.8 V
		Fh	-8.0 V



5.6.1.9 SS3 (08h)

The SS3 register can be written to and read from.

Figure 5-32. SS3 Register Bit Allocation

7	6	5	4	3	2	1	0
		Not Implemented		SS3			
				R/W-0	R/W-0	R/W-1	

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-12. SS3 Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	SS3		These bits determine the soft-start time of the negative charge pump (V _{GL}).
		0h	0.256 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms



5.6.1.10 DLY3 (09h)

The DLY3 register can be written to and read from.

Figure 5-33. DLY3 Register Bit Allocation

7	6	5	4	3	2	1	0
		Not Implemented		DLY3			
				R/W-0	R/W-0	R/W-1	

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-13. DLY3 Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	DLY3		These bits determine how soon after boost converter 1 (AV $_{DD}$) starts the negative charge pump (V $_{GL}$) starts.
		0h	0 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms



5.6.1.11 VGH (0Ah)

The VGH register can be written to and read from.

Figure 5-34. VGH Register Bit Allocation

7	6	5	4	3	2	1	0
	Not Implemented				V	ЭH	
	·			R/W-0	R/W-1	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-14. VGH Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	VGH		These bits determine the output voltage of boost converter 2 (V _{GH}).
		0h	18.0 V
		1h	18.5 V
		2h	19.0 V
		3h	19.5 V
		4h	20.0 V
		5h	20.5 V
		6h	21.0 V
		7h	21.5 V
		8h	22 0 V
		9h	22.5 V
		Ah	23.0 V
		Bh	23.5 V
		Ch	24.0 V
		Dh	24.5 V
		Eh	25.0 V
		Fh	25.5 V



5.6.1.12 SS4 (0Bh)

The SS4 register can be written to and read from.

Figure 5-35. SS4 Register Bit Allocation

7	6	5	4	3	2	1	0
		Not Implemented		SS4			
			R/W-0	R/W-0	R/W-1		

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-15. SS4 Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	SS4		These bits determine the soft-start time of boost converter 2 (V _{GH}).
		0h	0.256 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms



5.6.1.13 FSW3 (0Ch)

The FSW3 register can be written to and read from.

Figure 5-36. FSW3 Register Bit Allocation

7	6	5	4	3	2	1	0
		FSW3					
	·					R/W-0	R/W-1

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-16. FSW3 Register Field Descriptions

Bit	Field	Value	Description
7-2	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
1-0	FSW3		These bits determine the switching frequency of boost converter 3 (WLED).
		0h	400 kHz
		1h	600 kHz
		2h	800 kHz
		3h	1 MHz



5.6.1.14 DLY4 (0Dh)

The DLY4 register can be written to and read from.

Figure 5-37. DLY4 Register Bit Allocation

7	6	5	4	3	2	1	0
		Not Implemented		DLY4			
			R/W-0	R/W-1	R/W-0		

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-17. DLY4 Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	DLY4		These bits determine the start-up delay of the gate voltage shaping function.
		0h	0 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms

52



5.6.1.15 OVP (0Eh)

The OVP register can be written to and read from.

Figure 5-38. OVP Register Bit Allocation

7	6	5	4	3	2	1	0
		OVP					
	·					R/W-1	R/W-1

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-18. OVP Register Field Descriptions

Bit	Field	Value	Description
7-2	Not implemented	N/A	These bits are not implemented. During write operations, data for these bits is ignored, and during read operations 0 is returned.
1-0	OVP		These bits determine the overvoltage threshold of boost converter 3 (WLED).
		0h	30 V
		1h	33 V
		2h	36 V
		3h	39 V



5.6.1.16 FDIM (OFh)

The FDIM register can be written to and read from.

Figure 5-39. FDIM Register Bit Allocation

7	6	5	4	3	2	1	0
		Not Implemented	FDIM				
			R/W-1	R/W-1	R/W-1		

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-19. FDIM Register Field Descriptions

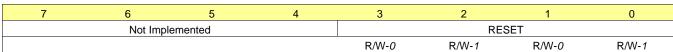
Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	FDIM		These bits determine the WLED driver's output dimming frequency in phase-shift dimming mode.
		0h	15 kHz
		1h	16 kHz
		2h	17 kHz
		3h	18 kHz
		4h	19 kHz
		5h	20 kHz
		6h	21 kHz
		7h	22 kHz



5.6.1.17 RESET (10h)

The RESET register can be written to and read from.

Figure 5-40. RESET Register Bit Allocation



LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-20. RESET Register Field Descriptions

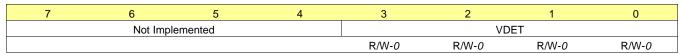
Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	RESET		These bits determine the duration of the reset pulse (RST).
		0h	0 ms
		1h	1 ms
		2h	2 ms
		3h	3 ms
		4h	4 ms
		5h	5 ms
		6h	6 ms
		7h	7 ms
		8h	8 ms
		9h	9 ms
		Ah	10 ms
		Bh	11 ms
		Ch	12 ms
		Dh	13 ms
		Eh	14 ms
		Fh	15 ms



5.6.1.18 VDET (11h)

The VDET register can be written to and read from.

Figure 5-41. VDET Register Bit Allocation



LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-21. VDET Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	VDET		These bits determine the threshold voltage of the $\overline{\text{XAO}}$ signal.
		0h	V _{UVLO}
		1h	2.0 V
		2h	2.1 V
		3h	2.2 V
		4h	2.3 V
		5h	2.4 V
		6h	2.5 V
		7h	2.6 V
		8h	2.7 V
		9h	2.8 V
		Ah	2.9 V
		Bh	3.0 V
		Ch	3.0 V
		Dh	3.0 V
		Eh	3.0 V
		Fh	3.0 V



5.6.1.19 DLY6 (12h)

The DLY6 register can be written to and read from.

Figure 5-42. DLY6 Register Bit Allocation

7	6	5	4	3	2	1	0
		Not Implemented	DLY6				
			R/W-0	R/W-1	R/W-0		

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-22. DLY6 Register Field Descriptions

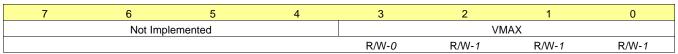
Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	DLY6		These bits determine the start-up delay time of the $\overline{\text{XAO}}$ signal.
		0h	0 ms
		1h	5 ms
		2h	10 ms
		3h	15 ms
		4h	20 ms
		5h	25 ms
		6h	30 ms
		7h	35 ms



5.6.1.20 VMAX (13h)

The VMAX register can be written to and read from.

Figure 5-43. VMAX Register Bit Allocation



LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-23. VMAX Register Field Descriptions

Bit	Field	Value	Description			
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.			
3-0	VMAX		These bits determine the maximum V _{COM} voltage.			
		0h	$2.5/8 \times AV_{DD}$			
		1h	$2.6/8 \times AV_{DD}$			
		2h	$2.7/8 \times AV_{DD}$			
		3h	$2.8/8 \times AV_{DD}$			
		4h	$2.9/8 \times AV_{DD}$			
		5h	$3.0/8 \times AV_{DD}$			
		6h	$3.1/8 \times AV_{DD}$			
		7h	$3.2/8 \times AV_{DD}$			
		8h	$3.3/8 \times AV_{DD}$			
		9h	$3.4/8 \times AV_{DD}$			
		Ah	$3.5/8 \times AV_{DD}$			
		Bh	$3.6/8 \times AV_{DD}$			
		Ch	$3.7/8 \times AV_{DD}$			
		Dh	$3.8/8 \times AV_{DD}$			
		Eh	$3.9/8 \times AV_{DD}$			
		Fh	$4.0/8 \times AV_{DD}$			



5.6.1.21 VMIN (14h)

The VMIN register can be written to and read from.

Figure 5-44. VMIN Register Bit Allocation

7	6	5	4	3	2	1	0	
	Not Implemented				VMIN			
				R/W-0	R/W-1	R/W-1	R/W-1	

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-24. VMIN Register Field Descriptions

Bit	Field	Value	Description
7-4	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
3-0	VMIN		These bits determine the minimum V _{COM} voltage.
		0h	$2.0/8 \times AV_{DD}$
		1h	$2.1/8 \times AV_{DD}$
		2h	$2.2/8 \times AV_{DD}$
		3h	$2.3/8 \times AV_{DD}$
		4h	$2.4/8 \times AV_{DD}$
		5h	$2.5/8 \times AV_{DD}$
		6h	$2.6/8 \times AV_{DD}$
		7h	$2.7/8 \times AV_{DD}$
		8h	$2.8/8 \times AV_{DD}$
		9h	$2.9/8 \times AV_{DD}$
		Ah	$3.0/8 \times AV_{DD}$
		Bh	$3.1/8 \times AV_{DD}$
		Ch	$3.2/8 \times AV_{DD}$
		Dh	$3.3/8 \times AV_{DD}$
		Eh	$3.4/8 \times AV_{DD}$
		Fh	$3.5/8 \times AV_{DD}$



5.6.1.22 USER (15h)

The USER register can be written to and read from.

Figure 5-45. USER Register Bit Allocation

7	6	5	4	3	2	1	0	
	USER							
R/W-0								

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-25. USER Register Field Descriptions

Bit	Field	Value	Description
7-0	USER	N/A	These bits are free for customer use. Their contents have no effect on device operation.



5.6.1.23 CONTROL (FFh)

Figure 5-46. CONTROL Register Bit Allocation

7	6	5	4	3	2	1	0
WED	Not Implemented						
R/W-0							R/W-0

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-26. CONTROL Register Field Descriptions

Bit	Field	Value	Description
7	WED		This bit determines whether write operations affect the contents of the volatile or non-volatile registers.
		0h	Not applicable (see below).
		1h	Data is copied from the RAM registers to the EEPROM registers. This bit is automatically reset upon completion of this task.
6-1	Not Implemented	N/A	These bits are not implemented. During write operations data for these bits is ignored, and during read operations 0 is returned.
0	RED		This bit determines whether read operations return the contents of the volatile or non-volatile registers.
		0h	Volatile register data is returned.
		1h	Non-volatile register data is returned.



5.6.2 VCOM Registers

5.6.2.1 VCOM DATA (Slave Address 28h, Register Address 00h)

The VCOM DATA register can be written to and read from.

Figure 5-47. VCOM DATA Register Bit Allocation

7	6	5	4	3	2	1	0
NI				VCOM			
R-0	R/W-1	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-27. VCOM DATA Register Bit Description

Bit	Field	Value	Description
7	Not implemented	N/A	This bit is reserved for future use and should be programmed to 0 for proper operation.
6-0	VCOM		Bits 6 through 0 set the value of the V _{COM} voltage.
		N/A	$V_{COM}=(VCOM/127) \times (V_{MAX}-V_{MIN}) + V_{MIN}$

5.6.2.2 VCOM CONTROL (Slave Address 28h, Register Address 02h)

The VCOM CONTROL register is write-only.

Figure 5-48. VCOM CONTROL Register Bit Allocation

7	6	5	4	3	2	1	0	
SEL		Not Implemented						
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	

LEGEND: R/W = Read/Write; R = Read only; -n = factory default

Table 5-28. VCOM CONTROL Register Bit Description

Bit	Field	Value	Description
7	SEL		The SEL bit determines whether read/write operations to the VCOM DATA register access the IVR, the WR, or both.
		0	Write operations store data in the IVR <i>and</i> WR. Read operations return the contents of the IVR.
		1	Write operations store data in the WR only. Read operations return the contents of the WR.
6-0	Not implemented	N/A	Bits 6 through 0 are reserved for future use. They should be programmed to 0 for proper operation.

Detailed Description



6 Application and Implementation

NOTE

Information in the following Applications section is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

6.1 Application Information

The TPS65154 devices is intended primarily for use in notebook PC and tablet applications. It needs these two supply voltages

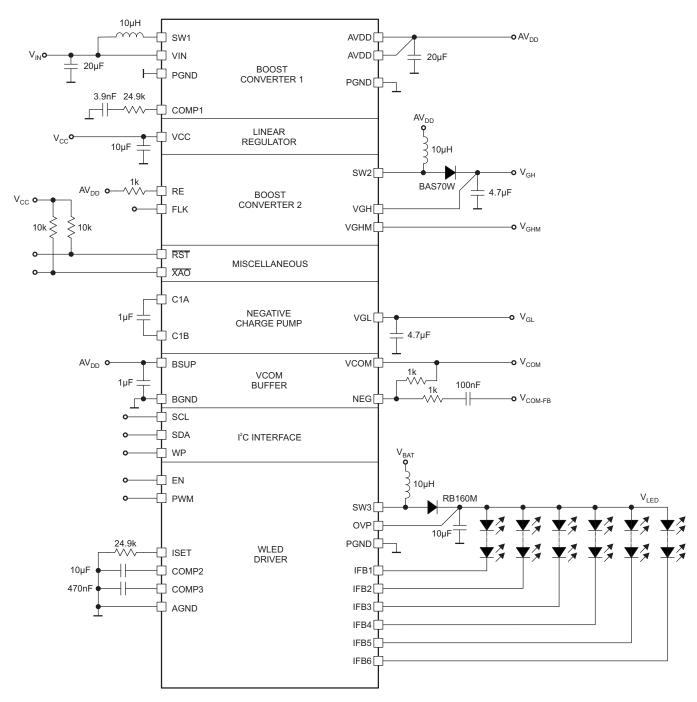
- A regulated 3.3-V or 5-V supply for the LCD bias functions
- A direct connection to the battery for the WLED driver functions

The device configuration parameters are set by I²C interface and stored in the on-chip nonvolatile memory.

6.2 Typical Application

Figure 6-1 shows the recommended application circuit for typical applications. The I²C interface is used to optimize the circuit's operating parameters for a specific application. If different component values are used, make sure that the values are within the recommended operating conditions (see *Recommended Operating Conditions*). If different component values are used, the compensation components may also need to be optimized for stability and best performance.





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Figure 6-1. Typical Application Circuit

6.2.1 Design Requirements

This design example uses the parameters listed in Table 6-1 as the input parameters.

Table 6-1. Input Parameters

PARAMETER	SYMBOL	VALUE
Input supply voltage – LCD bias functions	V _{IN}	3.3 V
Input supply voltage – WLED driver	V_{BAT}	9 V to 21 V



Table 6-1. Input Parameters (continued)

PARAMETER	SYMBOL	VALUE
Boost converter 1 output voltage	AV_DD	8 V
Inverting charge pump output voltage	V_{GL}	–6.8 V
Boost converter 2 output voltage	V_{GH}	20 V
Linear regulator output voltage	V _{CC}	2.5 V
WLED driver output current (per string)	I _{SET}	50 mA

6.2.2 Detailed Design Procedure

6.2.2.1 External Component Selection

Care should be applied to the choice of external components since they greatly affect overall performance. The TPS65154 was developed with the twin goals of high performance and small/low-profile solution size. Since these two goals are often in direct opposition to one another (for example, larger inductors tend to achieve higher efficiencies), some trade-off is always necessary.

Inductors must have adequate current capability so that they do not saturate under worst-case conditions. For high efficiency, they should also have low dc resistance (DCR).

Capacitors must have adequate effective capacitance under the applicable dc bias conditions they experience in the application. MLCC capacitors typically exhibit only a fraction of their nominal capacitance under real-world conditions and this must be taken into consideration when selecting them. This problem is especially acute in low profile capacitors, in which the dielectric field strength is higher than in taller components. In general, the capacitance values shown in circuit diagrams in this data sheet refer to the effective capacitance after dc bias effects have been taken into consideration. Reputable capacitor manufacturers provide capacitance versus dc bias curves that greatly simplify component selection.

The following tables list some components suitable for use with the TPS65154. The list is not exhaustive – other components may exist that are equally suitable (or better), however, these components have been proven to work well and were used extensively during the development of the TPS65154.

Table 6-2. Linear Regulator External Component Recommendations

REF.	DESCRIPTION	PART NUMBER	MANUFACTURER	MAX. THICKNESS
C _{OUT}	10 μF, 6.3 V, ±20%, X5R, 0603	GRM188R60J106ME84	Murata	0.95 mm

Table 6-3. Boost Converter 1 External Components

REF.	DESCRIPTION	PART NUMBER	MANUFACTURER	MAX. THICKNESS
L	10 μH, 1.5 A, 0.205 Ω	NRS6012T100MMGG	Taiyo Yuden	1.2 mm
C _{OUT}	10 μF, 16 V, ±10%, X5R, 1206	GRM319R61C106KE15D	Murata	0.85 ±0.1 mm

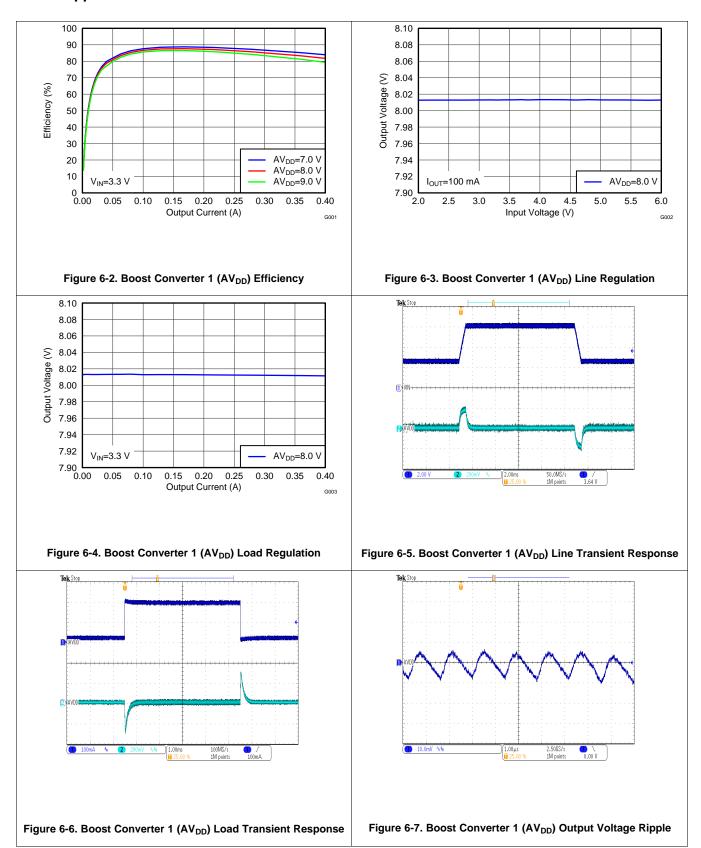
Table 6-4. Boost Converter 2 External Components

REF.	DESCRIPTION	PART NUMBER	MANUFACTURER	MAX. THICKNESS
L	10 μH, 0.6 A	NRH3010T100MN	Taiyo Yuden	1 mm
C _{OUT}	4.7 μF, 50 V, ±10%, X5R, 1206	GRM319R61H475KA12	Murata	0.95 mm

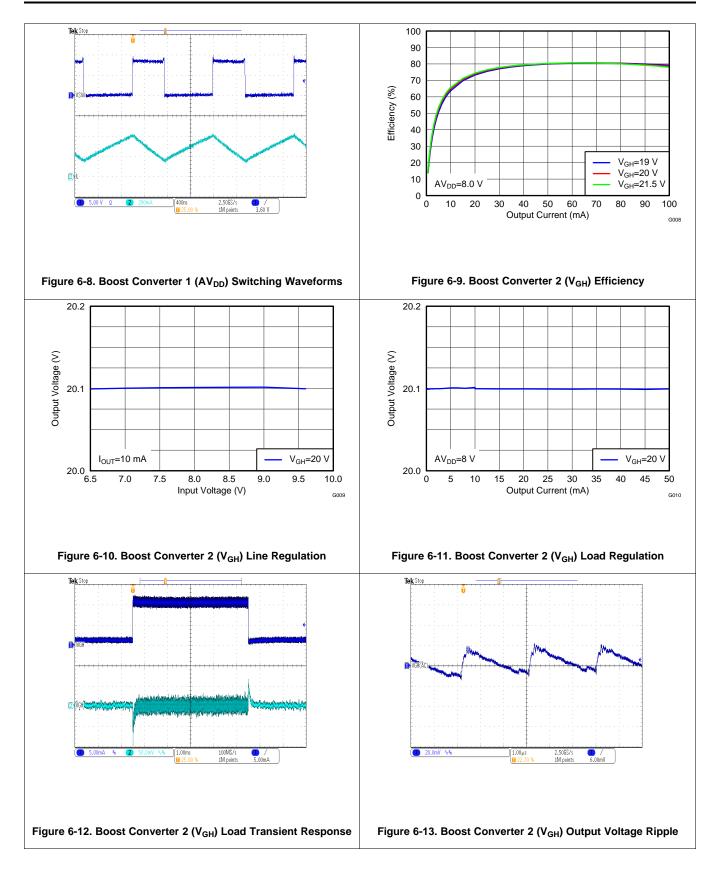
Table 6-5. Boost Converter 3 External Components

REF.	DESCRIPTION	PART NUMBER	MANUFACTURER	MAX. THICKNESS
L	10 μH, 1.5 A, 0.205 Ω	NRS6012T100MMGGJ	Taiyo Yuden	1.2 mm
C _{OUT}	4.7 μF, 50 V, ±10%, X5R, 1206	GRM319R61H475KA12	Murata	0.95 mm

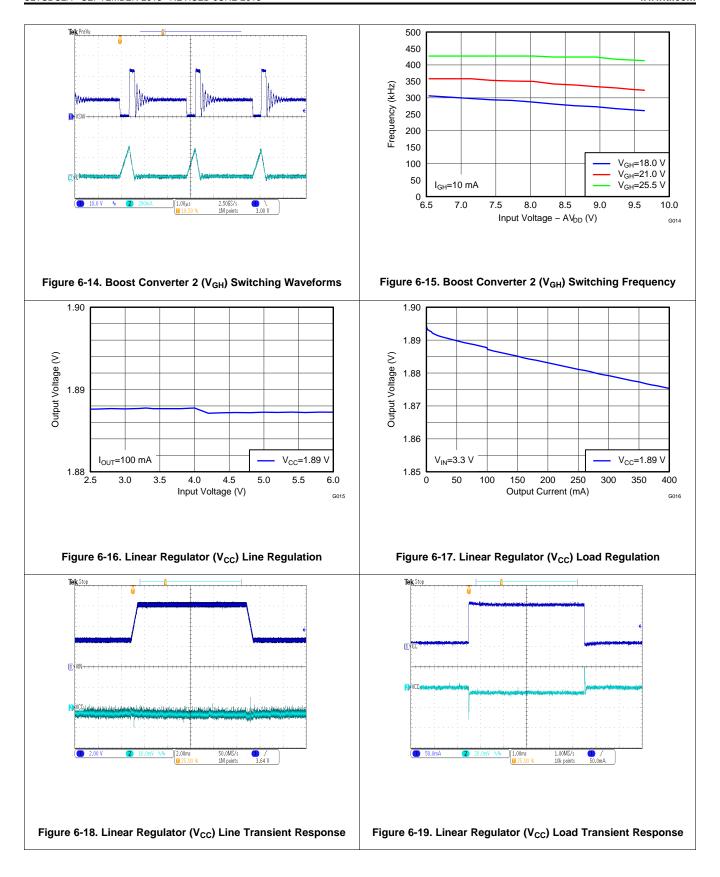
6.2.3 Application Curves



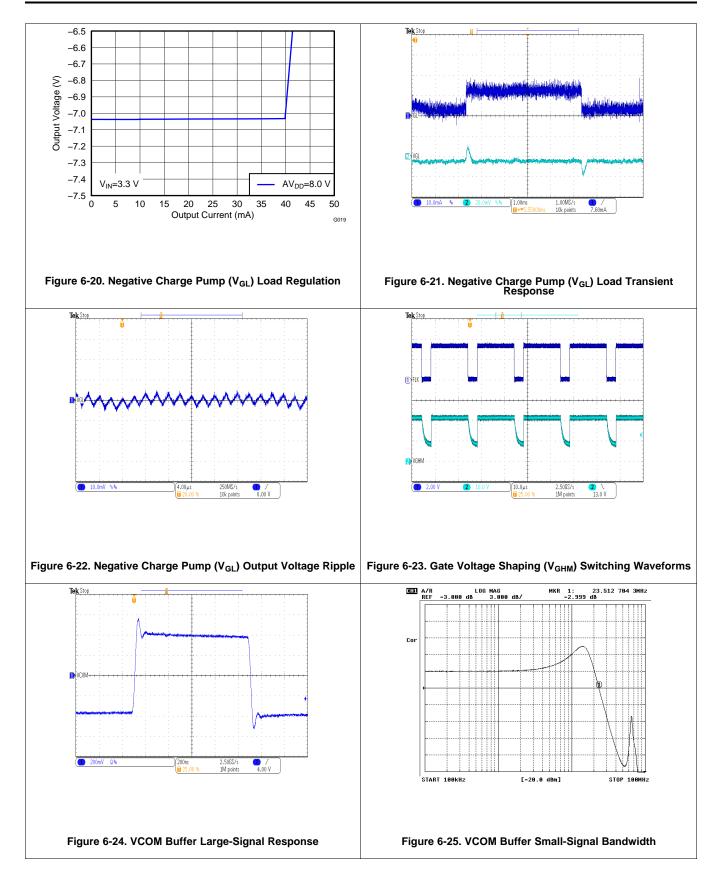




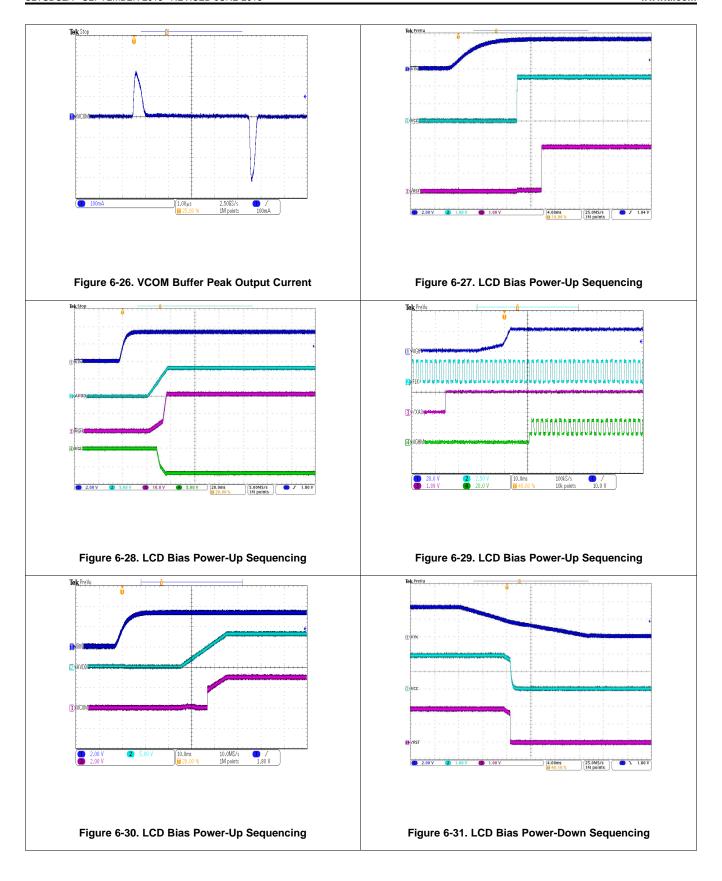




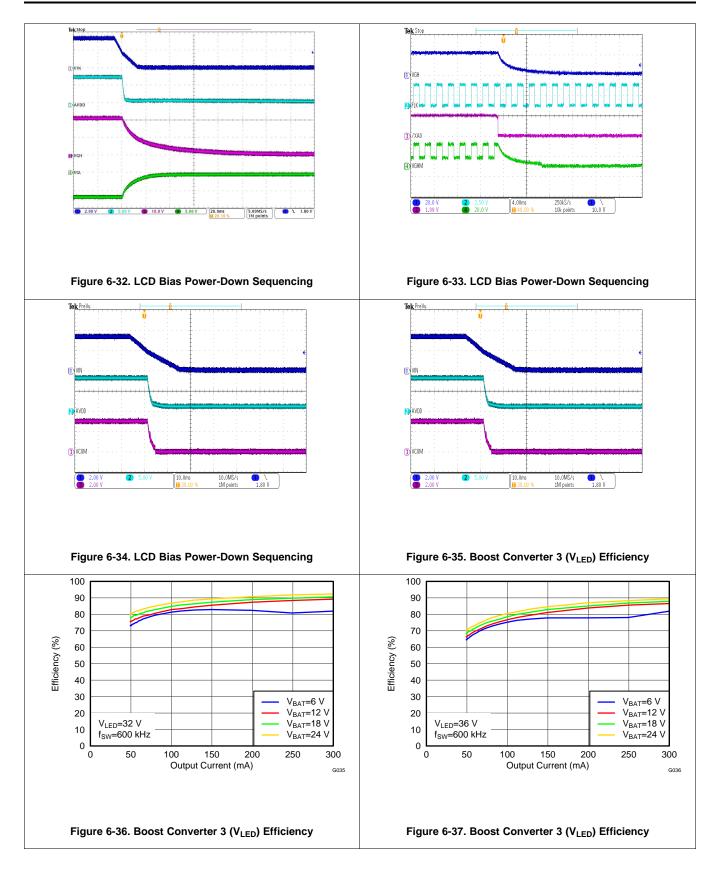




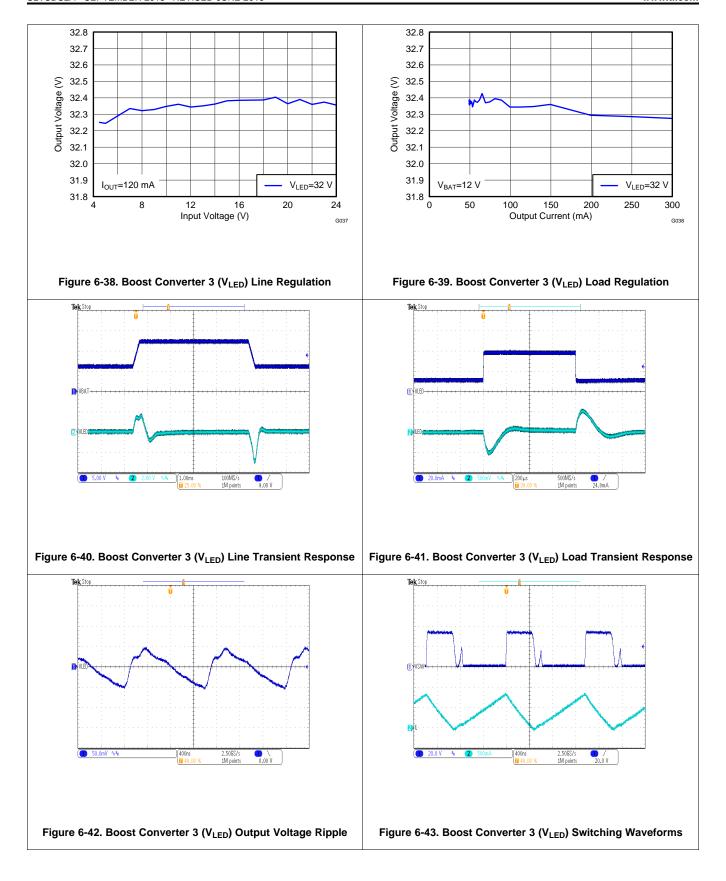




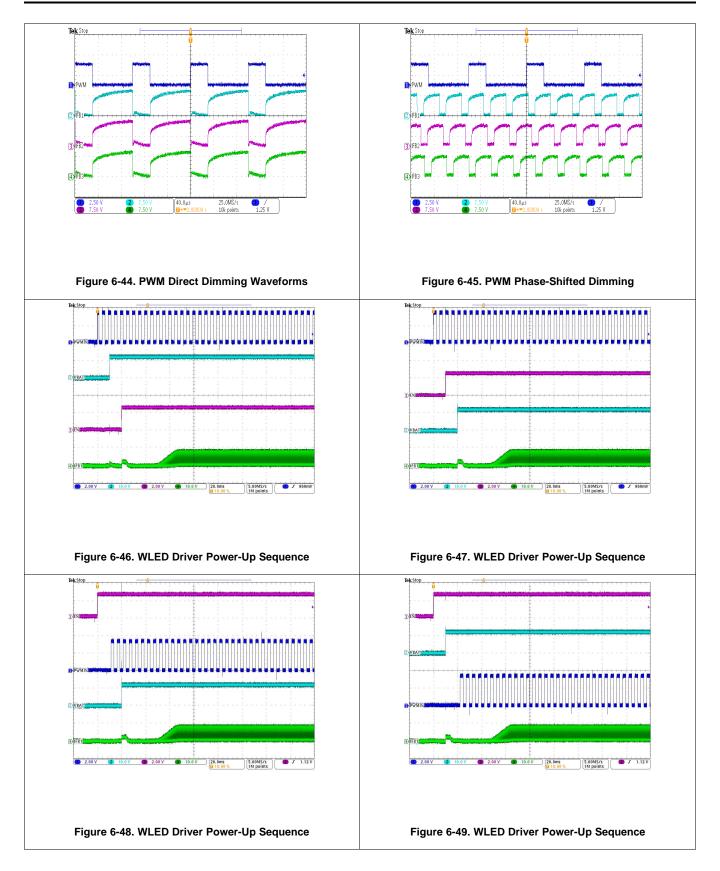




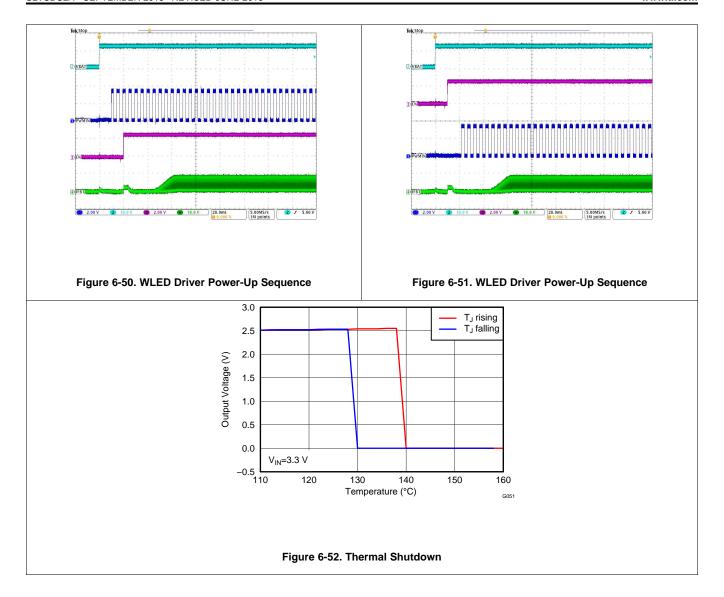












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7 Power Supply Recommendations

The TPS65154 device is designed to operate with two input supplies:

- One supply in the range 2 V to 5.5 V powers the LCD bias functions. Typically, this is a regulated 3.3-V or 5-V supply generated by a dc-dc converter somewhere else in the system. Note that this supply must be higher than 2.5 V if the user wants to program the EEPROM.
- One supply in the range 4.5 V to 24 V powers the WLED driver boost converter. Typically, this is an unregulated supply taken from the battery system in a notebook PC or tablet.

The input supplies must be stable and free of noise to achieve the full performance of the device. If the input supplies are located more than a few centimeters away from the TPS65154 device, additional bulk capacitance may be required. The input capacitance shown in Figure 6-1 is sufficient for typical applications.

8 Layout

8.1 Layout Guidelines

The PCB layout is an important step in a power supply design. An incorrect layout can cause converter instability, load regulation problems, noise, and EMI issues. The list of recommendations below highlights the most important points to consider when doing the layout for the TPS65154 device. However, all PCB layout is a trade-off between theory and practice, and some compromise is always necessary.

- If possible, use a 4-layer PCB. Route high di/dt signals on layer 1 and use the second layer to form a solid ground plane. If a 2-layer PCB is used, route high di/dt signals on layer 1 and add a copper pour connected to ground on the bottom layer.
- Place a decoupling capacitor close to the VIN pin. Use short, wide traces on layer 1 to connect to it.
- Place at least one of the boost converter 1 output capacitors close to the device. Use short, wide traces on layer 1 to connect it between pins 3 and 4, and pin 6.
- Place the boost converter 3 rectifier diode and output capacitor close to the device. Use short, wide traces on layer 1 to connect them to pins 9 and 10.
- Place the boost converter 2 rectifier diode and output capacitor close to the device. Use short, wide traces on layer 1 to connect them to pins 33 and 34.
- Place the flying capacitor connected to pins 19 and 20 and the output capacitor connected to pin 18 close to the device. Use short, wide traces on layer 1 to connect to them.
- Place the VCOM buffer decoupling capacitor connected between pin 2 and pin 47 close to the device.
 Use short, wide traces on layer 1 to connect to it.
- Route the signals to the compensation components connected to pin 7, pin 40 and pin 46 away from noisy signals.
- Use thermal vias to connect the thermal pad to a large, unbroken copper ground plane (typically, on layer 2).

8.2 Layout Example

Figure 8-1 shows the main features of the TPS65154 Evaluation Module PCB layout.



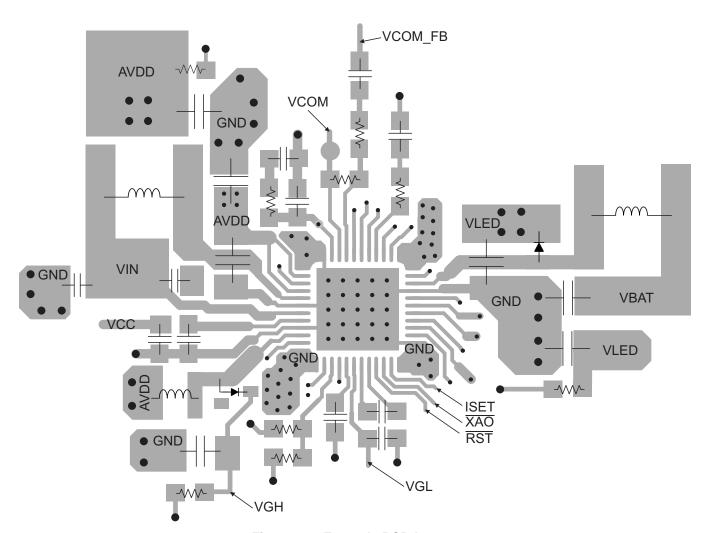


Figure 8-1. Example PCB Layout



9 Device and Documentation Support

9.1 Device Support

9.1.1 Third-Party Products Disclaimer

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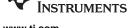
This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.6 Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

Submit Documentation Feedback Product Folder Links: TPS65154



Mechanical, Packaging, and Orderable Information

10.1 Packaging Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

www.ti.com 15-Oct-2025

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material	MSL rating/ Peak reflow	Op temp (°C)	Part marking (6)
TPS65154RSLR	Active	Production	VQFN (RSL) 48	2500 LARGE T&R	Yes	FULL NIPDAU	Level-3-260C-168 HR	-40 to 85	TPS 65154
TPS65154RSLR.A	Active	Production	VQFN (RSL) 48	2500 LARGE T&R	Yes	FULL NIPDAU	Level-3-260C-168 HR	-40 to 85	TPS 65154

⁽¹⁾ Status: For more details on status, see our product life cycle.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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⁽²⁾ Material type: When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ RoHS values: Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

⁽⁴⁾ Lead finish/Ball material: Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ MSL rating/Peak reflow: The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ Part marking: There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

PACKAGE MATERIALS INFORMATION

www.ti.com 23-May-2025

TAPE AND REEL INFORMATION





A0	Dimension designed to accommodate the component width
В0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	U	Package Drawing		SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS65154RSLR	VQFN	RSL	48	2500	330.0	16.4	6.3	6.3	1.1	12.0	16.0	Q2

PACKAGE MATERIALS INFORMATION

www.ti.com 23-May-2025



*All dimensions are nominal

	Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)	
ı	TPS65154RSLR	VQFN	RSL	48	2500	552.0	367.0	38.0	

PACKAGE MATERIALS INFORMATION

www.ti.com 23-May-2025

TUBE



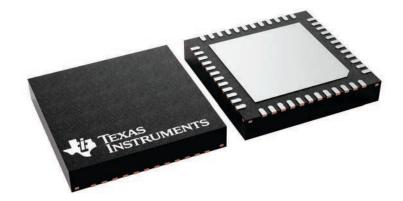
*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
TPS65154RSLR	RSL	VQFN	48	2500	381.5	7.92	2286	0
TPS65154RSLR.A	RSL	VQFN	48	2500	381.5	7.92	2286	0

6 x 6, 0.4 mm pitch

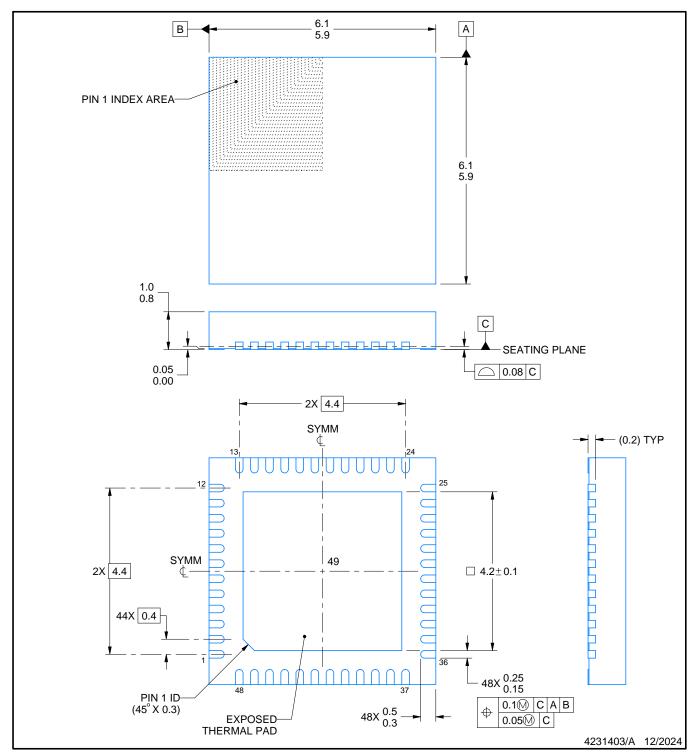
QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary. Refer to the product data sheet for package details.





PLASTIC QUAD FLATPACK - NO LEAD

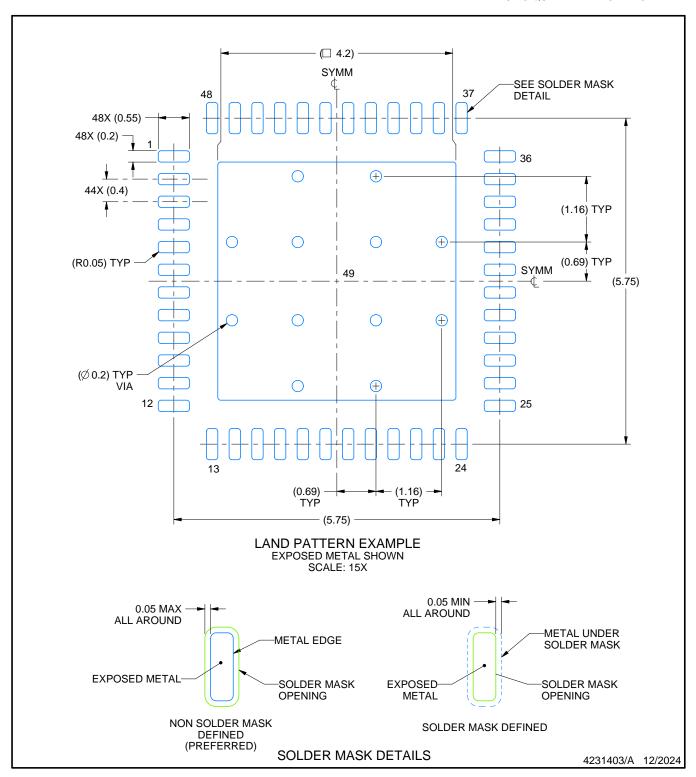


NOTES:

- 1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
 2. This drawing is subject to change without notice.
- 3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



PLASTIC QUAD FLATPACK - NO LEAD

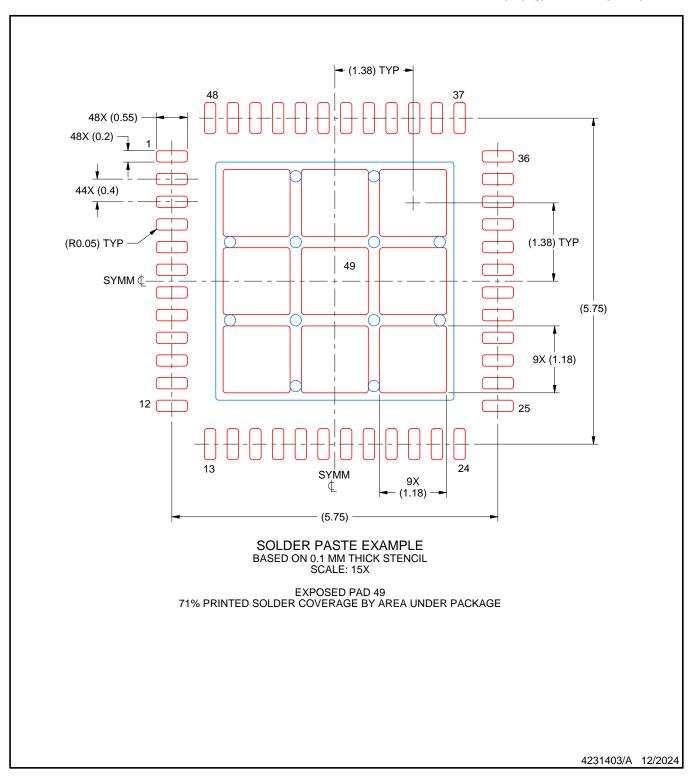


NOTES: (continued)

- 4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
- 5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



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