SGM41602

I²C Controlled, 2-Cell, 8A Switched Cap Parallel Battery Charger with Integrated Protection and Dual-Input Selector

GENERAL DESCRIPTION

The SGM41602 is an efficient 8A switched-capacitor battery charging device with I²C control that can operate either in charge-pump voltage divider mode or in bypass mode. It can charge 2-cell Li-Ion or Li-polymer battery in a wide 6.2V to 22V input voltage range (VBUS) from smart wall adapters or wireless charger. The switched-capacitor architecture is optimized for 50% duty cycle to cut the input current to one-half of the battery current and reduce the wiring drops, losses and temperature rise in the application.

A two-channel switched-capacitor topology is used to reduce the required input capacitors, improve efficiency and minimize the output ripple. It supports dual-input configuration through integrated MUX control and driver for external OVPFETs. It also allows single-input with no external OVPFET or single OVPFET. Moreover, it supports two devices in parallel for higher power systems.

The SGM41602 is available in a Green WLCSP-3.2×4.1-80B package.

APPLICATIONS

Smartphone, Tablet PC, Non-military Drone

Notebooks, Chromebook

FEATURES

- **Efficiency Optimized Switched-Capacitor Architecture**
  - **Up to 8A Output Current**
  - **6.2V to 22V Input Voltage Range**
  - **187.5kHz to 750kHz Switching Frequency Setting**
  - **Above 98.1% Voltage Divider Mode Efficiency (when V_{BAT} = 8.4V, I_{BAT} = 8A)**
- **Comprehensive Integrated Protection Feature**
  - **External Dual-Input OVP Control**
  - **Input Over-Voltage Protection (VBUS_OVP)**
  - **Input Over-Current Protection (IBUS_OCP)**
  - **Input Under-Current Protection (IBUS_UCP)**
  - **Input Reverse-Current Protection (IBUS_RCP)**
  - **Input Short-Circuit Protection (VBUS_SCP)**
  - **Output Over-Voltage Protection (VOUT_OVP)**
  - **Battery Over-Voltage Protection (VBAT_OVP)**
  - **IBAT Over-Current Protection (IBAT_OCP)**
  - **C_{FLY} Short-Circuit Protection (CFLY_SHORT)**
  - **Battery and Cable Connector Temperature Monitoring (TSBAT_FLT and TSBUS_FLT)**
  - **Die Over-Temperature Protection (TDIE_OTP)**
- **Up to 14A Charging Current with Synchronized Dual SGM41602 for Parallel Charging**
- **10-Channel 16-Bit (Effective) ADC Converter**
  - **VAC1, VAC2, VBUS, IBUS, VOUT, VBAT, IBAT, TSBUS, TSBAT, TDIE for Monitoring**

TYPICAL APPLICATION

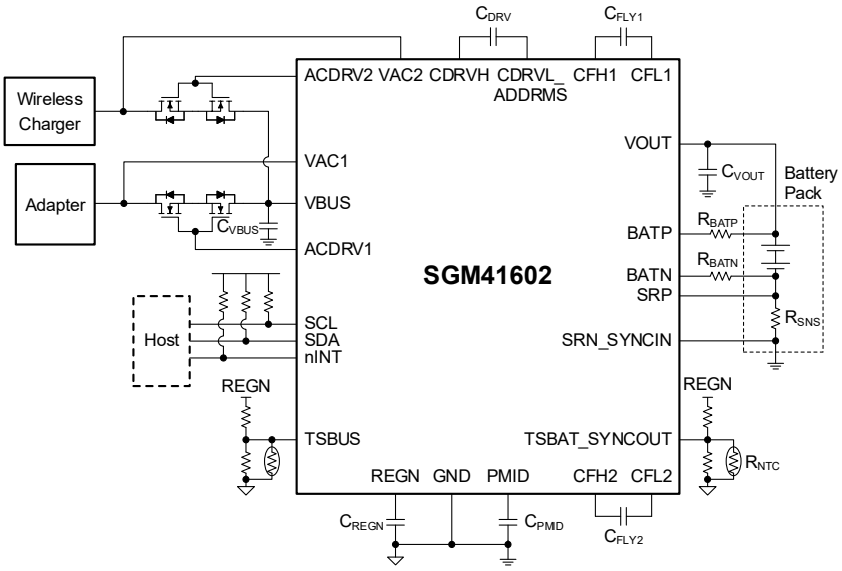


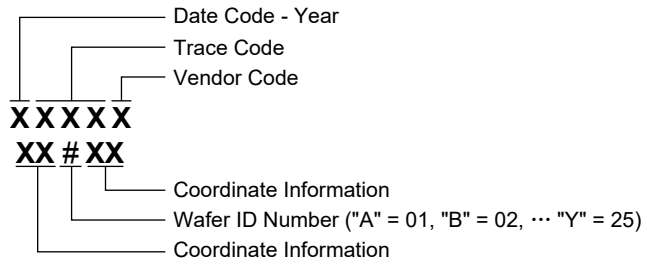
Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41602	WLCSP-3.2×4.1-80B	-40℃ to +85℃	SGM41602YG/TR	SGM 41602 XXXXX XX#XX	Tape and Reel, 5000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code. XX#XX = Coordinate Information and Wafer ID Number.



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

VAC1, VAC2 (Converter Not Switching) .. -2V (100ns) to 37V
VBUS (Converter Not Switching) ..... -2V (100ns) to 28V
PMID (Converter Not Switching) ..... -0.3V to 28V
ACDRV1, ACDRV2 ..... -0.3V to 30V
PMID to VBUS ..... -0.3V to 11V
PMID to CFH1/CFH2 ..... -0.3V to 11V
CFH1, CFH2 to VOUT ..... -0.3V to 11V
VOUT to CFL1/CFL2 ..... -0.3V to 11V
CFL1, CFL2 to GND ..... -0.3V to 11V
VOUT ..... -0.3V to 11V
BATP ..... -0.3V to 11V
nINT, SDA, SCL, CDRVL_ADDRMS, REGN, BATN, SRN_SYNCIN, TSBAT_SYNCOUT, TSBUS ..... -0.3V to 6V
CDRVH ..... -0.3V to 26V
SRP ..... -0.3V to 1.8V
Package Thermal Resistance
WLCSP-3.2×4.1-80B, θ_{JA} ..... 25.5℃/W
WLCSP-3.2×4.1-80B, θ_{JB} ..... 3.5℃/W
WLCSP-3.2×4.1-80B, θ_{JC} ..... 8.4℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility (1) (2)
HBM ..... ±1500V
CDM ..... ±1000V

NOTES:
1. For human body model (HBM), all pins comply with ANSI/ESDA/JEDEC JS-001 specifications.
2. For charged device model (CDM), all pins comply with ANSI/ESDA/JEDEC JS-002 specifications.

RECOMMENDED OPERATING CONDITIONS

VAC1, VAC2 ..... 3.4V to 22V
VBUS (Bypass Mode) ..... 6.2V to 11V
VBUS (Voltage Divider Mode) ..... 12.4V to 22V
VOUT, BATP ..... 6.2V to 10V
I_{VOUT} (Bypass Mode) ..... 0A to 7A
I_{VOUT} (Voltage Divider Mode) ..... 0A to 8A
(CFH1 - VOUT), CFL1 ..... 0V to 10V
(CFH2 - VOUT), CFL2 ..... 0V to 10V
(SRP-SRN) ..... 0V to 10V
Junction Temperature Range ..... -40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

ESD SENSITIVITY CAUTION

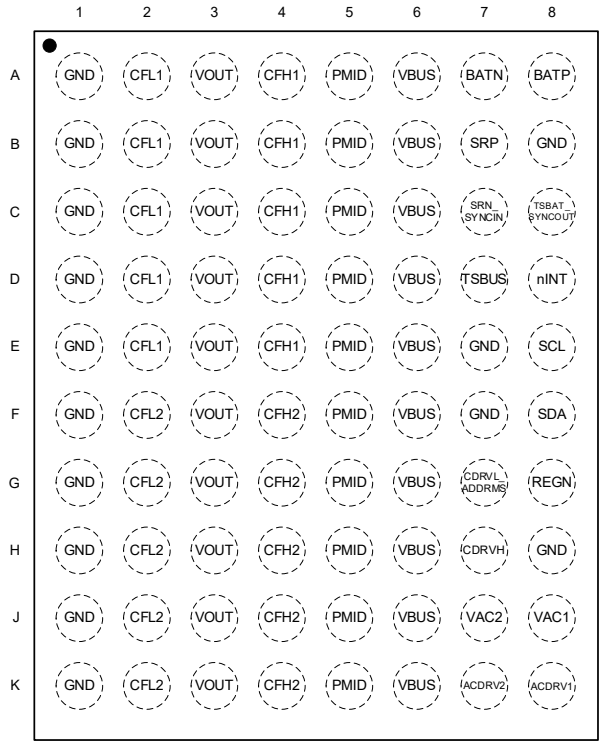
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATION

(TOP VIEW)



WLCSP-3.2×4.1-80B

PIN DESCRIPTION

PIN NUMBER	PIN NAME	TYPE (1)	DESCRIPTION
A1, B1, C1, D1, E1, F1, G1, H1, J1, K1, B8, E7, F7, H8	GND	P	Power Ground Pins.
A2, B2, C2, D2, E2	CFL1	P	Channel-1 Flying Capacitor Negative Pins. Connect 3~5 22μF parallel capacitors between CFH1 and CFL1 as close as possible to the device.
A3, B3, C3, D3, E3, F3, G3, H3, J3, K3	VOUT	P	Device Output Pins. Connect it to the battery pack positive terminal. A 22μF capacitor between VOUT and GND pins is recommended.
A4, B4, C4, D4, E4	CFH1	P	Channel-1 Flying Capacitor Positive Pins. Connect 3~5 22μF parallel capacitors between CFH1 and CFL1 as close as possible to the device.
A5, B5, C5, D5, E5, F5, G5, H5, J5, K5	PMID	P	Power Stage Supply Input Pins. Bypass them with at least a 10μF ceramic capacitor to GND.
A6, B6, C6, D6, E6, F6, G6, H6, J6, K6	VBUS	P	Device Power Input Pins. Use a 1μF or larger ceramic capacitor between VBUS and GND pins close to the device.
A7	BATN	AI	Battery Voltage Sensing Negative Input. Connect a 100Ω resistor between BATN and negative terminal of the battery pack.
A8	BATP	AI	Battery Voltage Sensing Positive Input. Connect a 100Ω resistor between BATP and positive terminal of the battery pack.
B7	SRP	AI	Battery Current Sensing Positive Input. Place a 2mΩ or 5mΩ (R_{SNS}) shunt resistor between SRP and SRN_SYNCIN pin. Short SRP and SRN_SYNCIN together to GND if not used.

PIN DESCRIPTION (continued)

PIN NUMBER	PIN NAME	TYPE(1)	DESCRIPTION
C7	SRN_SYNCIN	AI	Battery Current Sensing Negative Input and SYNCIN for Secondary Configuration. Place a 2mΩ or 5mΩ (R_{SNS}) shunt resistor between SRP and SRN_SYNCIN pin. Short SRP and SRN_SYNCIN together to GND if not used. If configured as a secondary IC for parallel charging, this pin functions as SYNCIN, and connect it to TSBAT_SYNCOUT of the primary IC, as well as connect a 1kΩ pull-up resistor from this pin to REGN.
C8	TSBAT_SYNCOUT	AIO	Battery Temperature Sense Input and SYNCOUT for Primary Configuration. Connect it to the battery NTC thermistor and the external resistor divider that is pulled up to REGN. See the TSBAT section for choosing the resister divider values. If configured as a primary IC for parallel charging, this pin functions as SYNCOUT, and is connected to SRN_SYNCIN of the secondary IC.
D7	TSBUS	AI	BUS Temperature Sense Input. Connect it to the cable connector NTC thermistor and the external resistor divider that is pulled up to REGN. See the TSBUS section for choosing the resister divider values.
D8	nINT	DO	Open-Drain Interrupt Output Pin. Use a 10kΩ pull-up to the logic high rail. It is normally high but generates a low 256μs pulse when a charge status or fault occurs to inform the host.
E8	SCL	DI	I²C Interface Clock Input Line.
F2, G2, H2, J2, K2	CFL2	P	Channel-2 Flying Capacitor Negative Pins. Connect 3~5 22μF parallel capacitors between CFH2 and CFL2 as close as possible to the device.
F4, G4, H4, J4, K4	CFH2	P	Channel-2 Flying Capacitor Positive Pins. Connect 3~5 22μF parallel capacitors between CFH2 and CFL2 as close as possible to the device.
F8	SDA	DIO	I²C Interface Data Line.
G7	CDRVL_ADDRMS	AIO	Charge Pump for Gate Drive. Connect a 0.22μF MLCC capacitor between CDRVH and CDRVL_ADDRMS. During POR, this pin is also used to assign the I²C address of the device and the mode of the device as standalone, primary, or secondary.
G8	REGN	AO	Internal 5V LDO Output. Connect a 4.7μF MLCC capacitor between this pin and GND. When in primary/secondary mode, connect through 1kΩ resistor to the TSBAT_SYNCOUT and SRN_SYNCIN pins. Do not use REGN for any other function.
H7	CDRVH	AIO	Charge Pump for Gate Drive. Connect a 0.22μF MLCC capacitor between CDRVH and CDRVL_ADDRMS.
J7	VAC2	AI	VAC2 Voltage Sense Input Pin. Connect it to VBUS if ACFET2 and RBFET2 are not used.
J8	VAC1	AI	VAC1 Voltage Sense Input Pin. Connect it to VBUS if ACFET1 and RBFET1 are not used.
K7	ACDRV2	P	External Dual N-MOSFET Gate Control Pin. Connect it to the gate of the external back-to-back N-MOSFET in the port2 charging path, or connect it to ground if the back-to-back N-MOSFET is not used.
K8	ACDRV1	P	External Dual N-MOSFET Gate Control Pin. Connect it to the gate of the external back-to-back N-MOSFET in the port1 charging path, or connect it to ground if the back-to-back N-MOSFET is not used.

NOTE:
1. P = Power, AI = Analog Input, AO = Analog Output, AIO = Analog Input/Output, DI = Digital Input, DIO = Digital Input/Output.

ELECTRICAL CHARACTERISTICS

(T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Currents						
Battery Only Quiescent Current	I_{Q_BAT}	ADC disabled, charge disabled, VBUS, VAC1, VAC2 not present, V_{BAT} = 8V		20	27	μA
		ADC enabled (slowest mode). charge disabled, VBUS, VAC1, VAC2 not present, V_{BAT} = 8V		900	1100	μA
VAC Quiescent Current	I_{Q_VAC}	ADC disabled, charge disabled, ACDRV disabled, V_{VAC1} or V_{VAC2} = 16V		500	580	μA
		ADC disabled, charge disabled, ACDRV enabled, V_{VAC1} or V_{VAC2} = 16V		650	950	μA
VAC UVLO Rising Threshold	$V_{AC\_UVLO\_R}$	V_{VAC1} or V_{VAC2} rising, for active I²C	3.15	3.35	3.55	V
VAC UVLO Falling Threshold	$V_{AC\_UVLO\_F}$	V_{VAC1} or V_{VAC2} falling	2.95	3.15	3.35	V
VAC UVLO Hysteresis	$V_{AC\_UVLO\_HYS}$			200		mV
VBUS UVLO Rising Threshold	$V_{BUS\_UVLO\_R}$	V_{VBUS} rising	3.1	3.3	3.5	V
VBUS UVLO Falling Threshold	$V_{BUS\_UVLO\_F}$	V_{VBUS} falling	2.6	2.8	3	V
VBUS UVLO Hysteresis	$V_{BUS\_UVLO\_HYS}$			500		mV
VBUS Present Rising Threshold	$V_{BUS\_PRESENT\_R}$	V_{VBUS} rising to allow user set CHG_EN = 1	3.1	3.3	3.5	V
VBUS Present Falling Threshold	$V_{BUS\_PRESENT\_F}$	V_{VBUS} falling	2.9	3.1	3.3	V
VBUS Present Hysteresis	$V_{BUS\_PRESENT\_HYS}$			200		mV
VOUT UVLO Rising Threshold	$V_{OUT\_UVLO\_R}$	VOUT pin, V_{VOUT} rising, for active I²C	2.4	2.55	2.7	V
VOUT UVLO Falling Threshold	$V_{OUT\_UVLO\_F}$	VOUT pin, V_{VOUT} falling	2.2	2.35	2.5	V
VOUT UVLO Hysteresis	$V_{OUT\_UVLO\_HYS}$			200		mV
VOUT Present Rising Threshold	$V_{OUT\_PRESENT\_R}$	VOUT pin, V_{VOUT} rising to allow user set CHG_EN = 1	5.75	6	6.25	V
VOUT Present Falling Threshold	$V_{OUT\_PRESENT\_F}$	VOUT pin, V_{VOUT} falling	5.55	5.8	6.05	V
VOUT Present Hysteresis	$V_{OUT\_PRESENT\_HYS}$			200		mV
External OVP Control						
VAC Present Rising Threshold	$V_{AC\_PRESENT\_R}$	V_{VAC1} or V_{VAC2} rising to turn on ACFET- RBFET	3.15	3.35	3.55	V
VAC Present Falling Threshold	$V_{AC\_PRESENT\_F}$	V_{VAC1} or V_{VAC2} falling	2.95	3.15	3.35	V
VAC Present Hysteresis	$V_{AC\_PRESENT\_HYS}$			200		mV
VAC Present Rising Threshold Deglitch Time	$t_{VAC\_IN\_DEG}$	Deglitch between V_{VAC} rising above $V_{AC\_PRESENT\_R}$ and starting external OVPFET turn-on		6		ms
VAC OVP Rising Threshold Range	$V_{AC\_OVP\_R}$	V_{VAC1} or V_{VAC2} rising	6.5		24	V
VAC OVP Threshold Accuracy	$V_{AC\_OVPR\_ACC}$	V_{AC1_OVP} or V_{AC2_OVP} = 6.5V	6.3	6.5	6.7	V
		V_{AC1_OVP} or V_{AC2_OVP} = 12V	11.6	12	12.2	V
		V_{AC1_OVP} or V_{AC2_OVP} = 22V	21.2	22	22.2	V
VAC OVP Rising Deglitch Time	$t_{VAC\_OVPR\_DEG}$	Deglitch between V_{VAC1} or V_{VAC2} rising above $V_{AC\_OVP\_R}$ and triggering the protection action		100		ns
VAC OVP Resume Time	$t_{VAC\_OVP\_RSM}$			64		μs
VAC Pull-Down Resistance	R_{PDN_VAC}	V_{VAC1} or V_{VAC2} = 10V		150		Ω
VBUS Pull-Down Resistance	R_{PDN_VBUS}			6.5		kΩ
REGN LDO						
REGN LDO Output Voltage	V_{REGN}	V_{VBUS} = 16V, I_{REGN} = 20mA		5		V
REGN LDO Current Limit	I_{REGN}	V_{VBUS} = 16V, V_{REGN} = 4.5V	35			mA
Switched Cap Chargers						
VBUS to VOUT Resistance	$R_{DROPOUT}$	Bypass mode		13		mΩ
R_{DSON} of Reverse Blocking FET	R_{DS_QRB}	V_{VBUS} = 16V		2.5		mΩ
R_{DSON} of Q_{CH1}	R_{DS_QCH1}	V_{PMID} = 16V		12		mΩ

ELECTRICAL CHARACTERISTICS (continued)

(T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
R_{DSON} of Q_{DH1}	R_{DS_QDH1}	V_{CFLY} = 8V			5		mΩ
R_{DSON} of Q_{CL1}	R_{DS_QCL1}	V_{VOUT} = 8V			5		mΩ
R_{DSON} of Q_{DL1}	R_{DS_QDL1}	V_{CFLY} = 8V			9		mΩ
R_{DSON} of Q_{CH2}	R_{DS_QCH2}	V_{PMID} = 16V			12		mΩ
R_{DSON} of Q_{DH2}	R_{DS_QDH2}	V_{CFLY} = 8V			5		mΩ
R_{DSON} of Q_{CL2}	R_{DS_QCL2}	V_{VOUT} = 8V			5		mΩ
R_{DSON} of Q_{DL2}	R_{DS_QDL2}	V_{CFLY} = 8V			9		mΩ
Protection							
nINT Low Pulse Duration when a Protection Occurs	t_{INT}				256		μs
VBUS OVP Rising Threshold Range	$V_{BUS\_OVP\_R}$	Voltage divider mode	I²C programmable, 100mV per step, 17.8V by default	14		22	V
		Bypass mode	I²C programmable, 50mV per step, 8.9V by default	7		12.75	
VBUS OVP Accuracy	$V_{BUS\_OVPR\_ACC}$	$V_{BUS\_OVP\_R}$ = 8.9V		8.8	8.9	9.05	V
		$V_{BUS\_OVP\_R}$ = 17.8V		17.7	17.8	17.9	
VBUS OVP Rising Deglitch Time	$t_{VBUS\_OVPR\_DEG}$	Deglitch between V_{VBUS} rising above $V_{BUS\_OVP\_R}$ and triggering protection action			1		μs
VBUS OVP Alarm Rising Threshold Range	$V_{BUSOVP\_ALM\_R}$	Voltage divider mode	I²C programmable, 100mV per step, 17.4V by default	14		26.7	V
		Bypass mode	I²C programmable, 50mV per step, 8.7V by default	7		13.35	
VBUS OVP Alarm Hysteresis	$V_{BUSOVP\_ALM\_HYS}$	$V_{BUSOVP\_ALM\_R}$ = 8.7V			70		mV
VBUS OVP Alarm Accuracy	$V_{BUSOVP\_ALM\_ACC}$	$V_{BUSOVP\_ALM\_R}$ = 8.7V		8.6	8.7	8.9	V
		$V_{BUSOVP\_ALM\_R}$ = 17.4V		17.2	17.4	17.6	V
IBUS OCP Threshold Range	I_{BUS_OCP}	Voltage divider mode	I²C programmable, 262.5mA per step, 4.4625A by default	1.05		6.0375	A
		Bypass mode		1.05		8.925	A
IBUS OCP Threshold Accuracy	$I_{BUS\_OCP\_ACC}$	I_{BUS_OCP} = 2.1A, initial accuracy		2	2.1	2.2	A
IBUS OCP Deglitch Time	$t_{IBUS\_OCP\_DEG}$	Deglitch between I_{BUS} rising above I_{BUS_OCP} and trigger protection action			64		μs
IBUS UCP Threshold	I_{BUS_UCP}	Initial accuracy		200	250	300	mA
IBUS UCP Deglitch time	$t_{IBUS\_UCP\_DEG}$	Deglitch between I_{BUS} falling below I_{BUS_UCP} and trigger protection action. I²C programmable, 0.01ms by default.		0.01		150	ms
IBUS Reverse OCP Threshold	I_{BUS_RCP}	Initial accuracy		500	950	1350	mA
VOUT OVP Rising Threshold Range	$V_{OUT\_OVP\_R}$	I²C programmable, 0.2V per step, 10V by default		9.4		10	V
VOUT OVP Threshold Accuracy	$V_{OUT\_OVP\_ACC}$	$V_{OUT\_OVP\_R}$ = 10V		9.7	10	10.15	V
VOUT OVP Rising Deglitch Time	$t_{VOUT\_OVP\_DEG}$	Deglitch between V_{VOUT} rising above $V_{OUT\_OVP\_R}$ and triggering protection action			4		μs
VBAT OVP Rising Threshold Range	$V_{BAT\_OVP\_R}$	I²C programmable, 20mV per step, 8.8V by default		7		9.54	V
VBAT OVP Threshold Accuracy	$V_{BAT\_OVP\_ACC}$	$V_{BAT\_OVP\_R}$ = 8.8V		8.75	8.8	8.86	V
VBAT OVP Alarm Rising Threshold Range	$V_{BATOVP\_ALM\_R}$	I²C programmable, 20mV per step, 8.4V by default		7		9.54	V
VBAT OVP Alarm Hysteresis	$V_{BATOVP\_ALM\_HYS}$				50		mV
VBAT OVP Alarm Accuracy	$V_{BATOVP\_ALM\_ACC}$	$V_{BATOVP\_ALM\_R}$ = 8.8V		8.74	8.8	8.87	V
IBAT OCP Threshold Range	I_{BAT_OCP}	I²C programmable, 125mA per step, 10.125A by default		0		15.875	A
IBAT OCP Threshold Accuracy	$I_{BAT\_OCP\_ACC}$	I_{BAT_OCP} = 6A, R_{SNS} = 2mΩ, initial accuracy		5.82	6	6.18	A
		I_{BAT_OCP} = 8A, R_{SNS} = 2mΩ, initial accuracy		7.85	8	8.15	

ELECTRICAL CHARACTERISTICS (continued)

(T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
IBAT OCP Deglitch Time	$t_{IBAT\_OCP\_DEG}$	Deglitch between I_{BAT} rising above I_{BAT_OCP} and triggering protection action			512		μs
IBAT OCP Alarm Rising Threshold Range	$I_{BATOCP\_ALM\_R}$	I²C programmable, 125mA per step, 10A by default		0		15.875	A
IBAT OCP Alarm Threshold Accuracy	$I_{BATOCP\_ALM\_ACC}$	$I_{BATOCP\_ALM\_R}$ = 6A, R_{SNS} = 2mΩ, initial accuracy		5.8	6	6.18	A
		$I_{BATOCP\_ALM\_R}$ = 8A, R_{SNS} = 2mΩ, initial accuracy		7.75	8	8.25	
VBUS_HI Rising Threshold (V_{VBUS}/V_{VOUT})	$V_{BUS\_HI\_RISE}$	Voltage divider mode	V_{VOUT} = 8V		2.3		×V_{VOUT}
		Bypass mode			1.2		
VBUS_HI Falling Threshold (V_{VBUS}/V_{VOUT})	$V_{BUS\_HI\_FALL}$	Voltage divider mode	V_{VOUT} = 8V		2.25		
		Bypass mode			1.15		
TSBUS Percentage Fault Threshold Range	$TS_{BUS\_FLT\_F}$	I²C programmable, 0.19531% per step, 4.10151% by default		0		49.8041	%
TSBUS Percentage Fault Accuracy	TS_{BUSFLT_ACC}	$TS_{BUS\_FLT\_F}$ = 40.04%		39.3	40.04	41	%
TSBAT Percentage Fault Threshold Range	$TS_{BAT\_FLT\_F}$	I²C programmable, 0.19531% per step, 4.10151% by default		0		49.8041	%
TSBAT Percentage Fault Accuracy	TS_{BATFLT_ACC}	$TS_{BAT\_FLT\_F}$ = 40.04%		39.3	40.04	41	%
TDIE OTP Rising Threshold Range	$T_{DIE\_OTP\_R}$	I²C programmable, 20℃ per step, 140℃ by default		80		140	℃
TDIE OTP Threshold Accuracy	$T_{DIE\_OTP\_ACC}$			-6		6	℃
TDIE OTP Threshold Hysteresis	$T_{DIE\_OTP\_HYS}$				30		℃
TDIE OTP Alarm Rising Threshold Range	$T_{DIEOTP\_ALM\_R}$	I²C programmable, 0.5℃ per step, 125℃ by default		25		150	℃
TDIE OTP Alarm Threshold Accuracy	$T_{DIEOTP\_ALM\_ACC}$			-6		6	℃
TDIE OTP Alarm Threshold Hysteresis	$T_{DIEOTP\_ALM\_HYS}$				30		℃
ADC Specification							
ADC Conversion Time for Each Channel	t_{ADC_CONV}	ADC_SAMPLE[1:0] = 00			8		ms
		ADC_SAMPLE[1:0] = 01			4		
		ADC_SAMPLE[1:0] = 10			2		
		ADC_SAMPLE[1:0] = 11			1		
ADC Resolution	ADC_{RES}	ADC_SAMPLE[1:0] = 00		14	15		bit
		ADC_SAMPLE[1:0] = 01		13	14		
		ADC_SAMPLE[1:0] = 10		12	13		
		ADC_SAMPLE[1:0] = 11		11	12		
ADC IBUS Current Readable in REG0x25 and REG0x26	I_{BUS_ADC}	Effective Range		0		9	A
		LSB			1		mA
IBUS_ADC Accuracy (f_{SW} = 300kHz, 375kHz)	$I_{BUS\_ADC\_ACC}$	I_{BUS} = 3A, ADC_SAMPLE[1:0] = 00, initial accuracy		2.85	3	3.1	A
		I_{BUS} = 4A, ADC_SAMPLE[1:0] = 00, initial accuracy		3.8	4	4.2	A
ADC VBUS Voltage Readable in REG0x27 and REG0x28	V_{BUS_ADC}	Effective Range		3		24	V
		LSB			1		mV
VBUS_ADC Accuracy	$V_{BUS\_ADC\_ACC}$	V_{VBUS} = 8V, ADC_SAMPLE[1:0] = 00, initial accuracy		7.88	8	8.12	V
		V_{VBUS} = 16V, ADC_SAMPLE[1:0] = 00, initial accuracy		15.85	16	16.25	V
ADC VAC1 Voltage Readable in REG0x29 and REG0x2A	V_{AC1_ADC}	Effective Range		3		24	V
		LSB			1		mV
VAC1_ADC Accuracy	$V_{AC1\_ADC\_ACC}$	V_{VAC1} = 8V, ADC_SAMPLE[1:0] = 00, initial accuracy		7.88	8	8.12	V
		V_{VAC1} = 16V, ADC_SAMPLE[1:0] = 00, initial accuracy		15.85	16	16.25	V

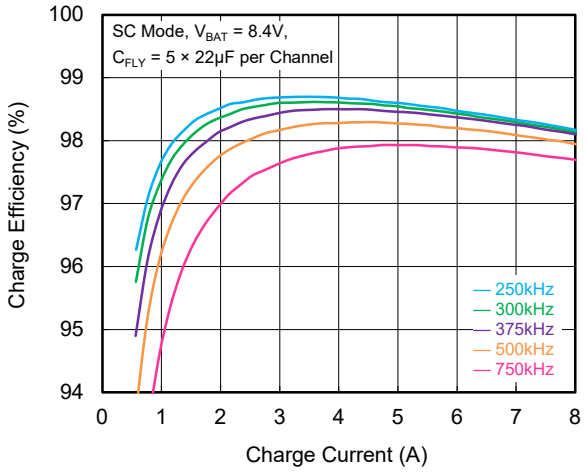
ELECTRICAL CHARACTERISTICS (continued)

(T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

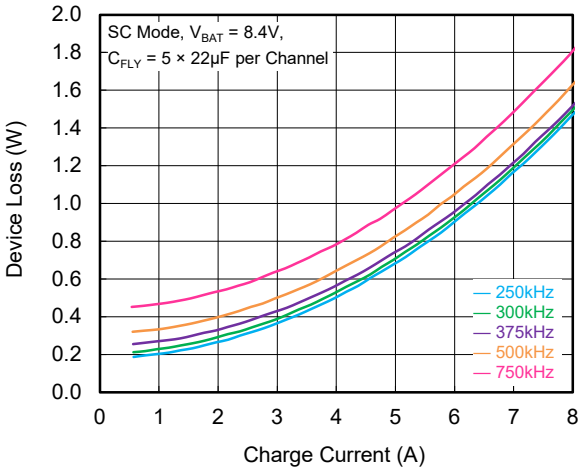
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
ADC VAC2 Voltage Readable in REG0x2B and REG0x2C	V_{AC2_ADC}	Effective Range	3		24	V
		LSB		1		mV
VAC2_ADC Accuracy	$V_{AC2\_ADC\_ACC}$	V_{VAC2} = 8V, ADC_SAMPLE[1:0] = 00, initial accuracy	7.88	8	8.12	V
		V_{VAC2} = 16V, ADC_SAMPLE[1:0] = 00, initial accuracy	15.85	16	16.25	V
ADC VOUT Voltage Readable in REG0x2D and REG0x2E	V_{OUT_ADC}	Effective Range	3		12	V
		LSB		1		mV
VOUT_ADC Accuracy	$V_{OUT\_ADC\_ACC}$	V_{OUT} = 8V, ADC_SAMPLE[1:0] = 00, initial accuracy	7.85	8	8.08	V
		V_{OUT} = 8.8V, ADC_SAMPLE[1:0] = 00, initial accuracy	8.65	8.8	8.88	V
ADC VBAT Voltage Readable in REG0x2F and REG0x30	V_{BAT_ADC}	Effective Range	3		12	V
		LSB		1		mV
VBAT_ADC Accuracy	$V_{BAT\_ADC\_ACC}$	V_{BAT} = 8V, ADC_SAMPLE[1:0] = 00, initial accuracy	7.95	8	8.04	V
		V_{BAT} = 8.8V, ADC_SAMPLE[1:0] = 00, initial accuracy	8.75	8.8	8.84	V
ADC IBAT Current Readable in REG0x31 and REG0x32	I_{BAT_ADC}	Effective Range	0		16	A
		LSB		1		mA
IBAT_ADC Accuracy	$I_{BAT\_ADC\_ACC}$	I_{BAT} = 6A, R_{SNS} = 2mΩ, ADC_SAMPLE[1:0] = 00, initial accuracy	5.9	6	6.15	A
		I_{BAT} = 8A, R_{SNS} = 2mΩ, ADC_SAMPLE[1:0] = 00, initial accuracy	7.85	8	8.15	A
ADC TSBUS Pin Percentage Readable in REG0x33 and REG0x34	TS_{BUS_ADC}	Effective Range	0		50	%
		LSB		0.09766		%
TSBUS_ADC Accuracy	$TS_{BUS\_ADC\_ACC}$	Initial accuracy	38.5	40.04	40.95	%
ADC TSBAT Pin Percentage Readable in REG0x35 and REG0x36	TS_{BAT_ADC}	Effective Range	0		50	%
		LSB		0.09766		%
TSBAT_ADC Accuracy	$TS_{BAT\_ADC\_ACC}$	Initial accuracy	38.5	40.04	40.95	%
ADC DIE Temperature Readable in REG0x37 and REG0x38	T_{DIE_ADC}	Effective Range	-40		150	℃
		LSB		0.5		℃
I²C Interface (SCL and SDA Pins)						
High Level Input Voltage	V_{IH_I2C}	SCL and SDA pins	0.9			V
Low Level Input Voltage	V_{IL_I2C}	SCL and SDA pins			0.4	V
Low Level Output Voltage	V_{OL_SDA}	Sink 5mA, SDA pin			0.4	V
High-Level Leakage Current	I_{LKG_I2C}	Connected to 3.3V			1	μA
SCL Clock Frequency	f_{CLK}				1000	kHz
Logic Output Pin (nINT, TSBAT_SYNCOUT)						
Low Level Output Voltage, nINT Pin	V_{OL_INT}	Sink 5mA			0.4	V
High-Level Leakage Current, nINT Pin	I_{LKG_nINT}	Connected to 3.3V			1	μA
Low Level Output Voltage, TSBAT_SYNCOUT Pin	$V_{OL\_TSBAT\_SYNCOUT}$	Sink 5mA			0.4	V
High-Level Leakage Current, TSBAT_SYNCOUT Pin	$I_{LKG\_TSBAT\_SYNCOUT}$	Connected to 3.3V			1	μA
Logic Input Pin (SRN_SYNCIN)						
High Level Input Voltage, SRN_SYNCIN Pin	$V_{IH\_SRN\_SYNCIN}$		0.9			V
Low Level Input Voltage, SRN_SYNCIN Pin	$V_{IL\_SRN\_SYNCIN}$				0.4	V
High-Level Leakage Current, SRN_SYNCIN Pin	$I_{LKG\_SRN\_SYNCIN}$	Connected to 3.3V			1	μA

TYPICAL PERFORMANCE CHARACTERISTICS

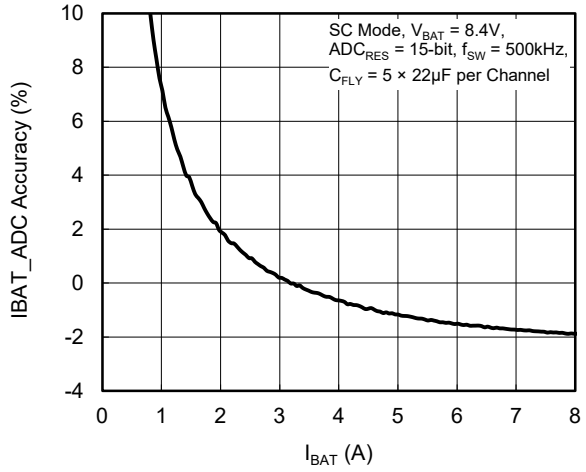
Charge Efficiency vs. Charge Current



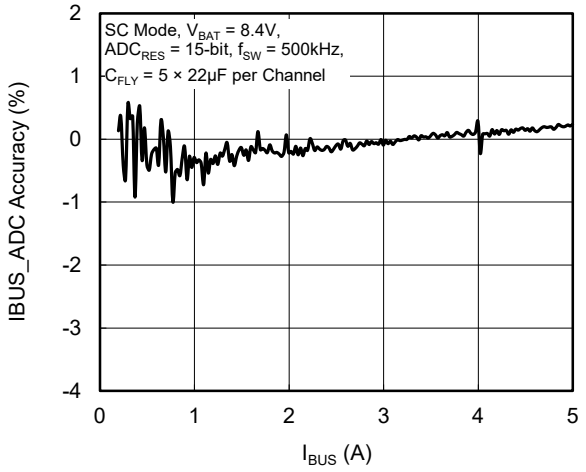
Device Loss vs. Charge Current



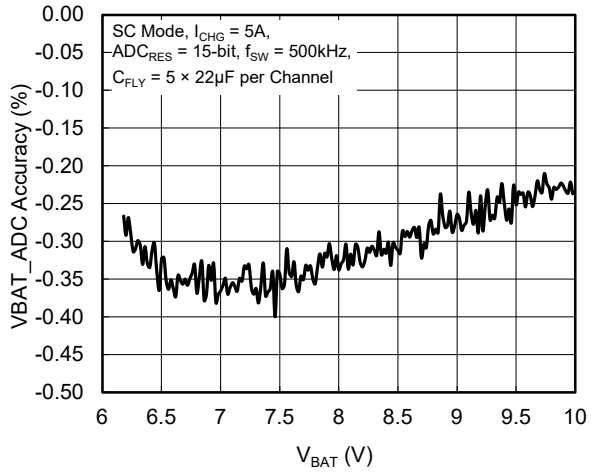
IBAT_ADC Accuracy vs. BAT Current



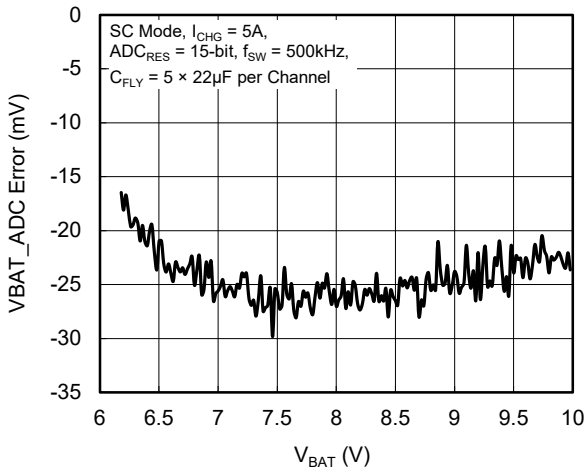
IBUS_ADC Accuracy vs. BUS Current



VBAT_ADC Accuracy vs. BAT Voltage

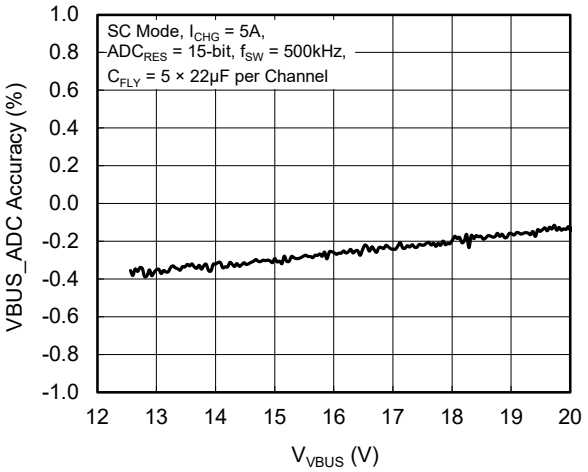


VBAT_ADC Error vs. BAT Voltage

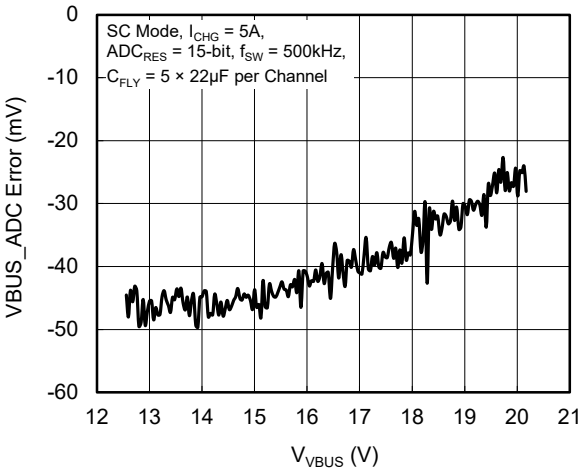


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

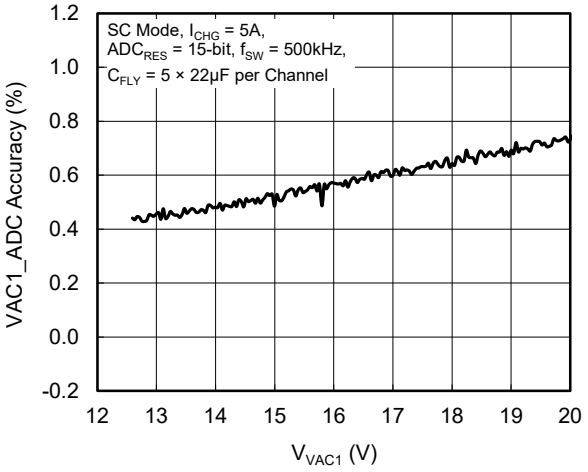
VBUS_ADC Accuracy vs. BUS Voltage



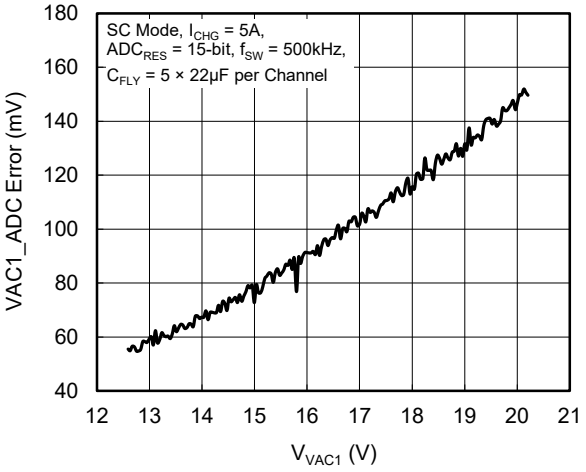
VBUS_ADC Error vs. BUS Voltage



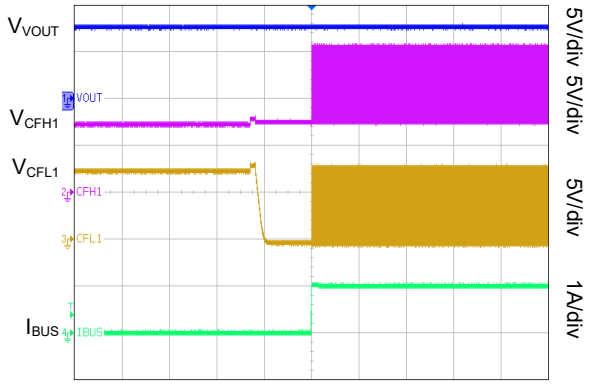
VAC1_ADC Accuracy vs. VAC1 Voltage



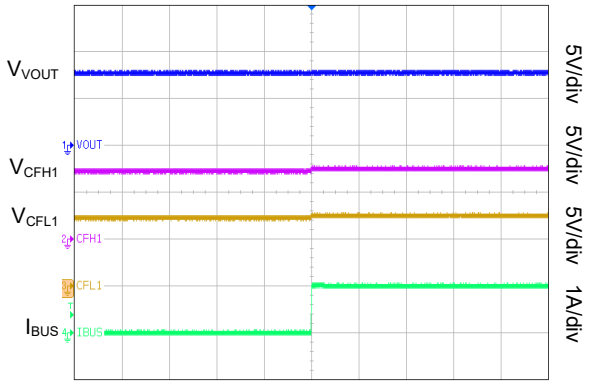
VAC1_ADC Error vs. VAC1 Voltage



Switched Cap Mode Power-Up

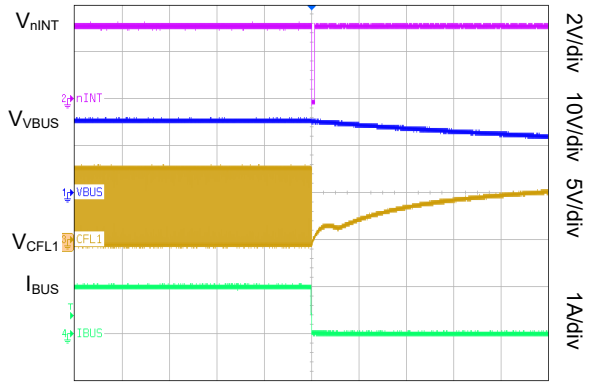


Bypass Mode Power-Up



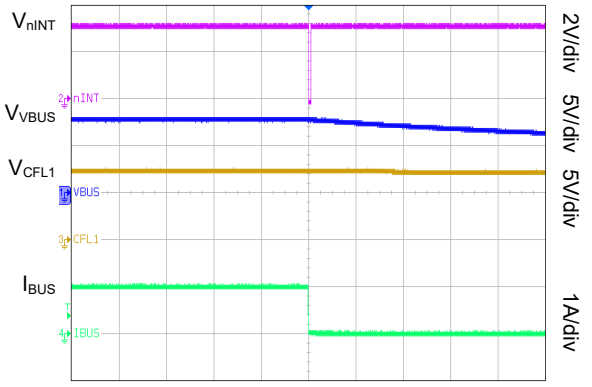
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Adapter Unplug in Switched Cap Mode



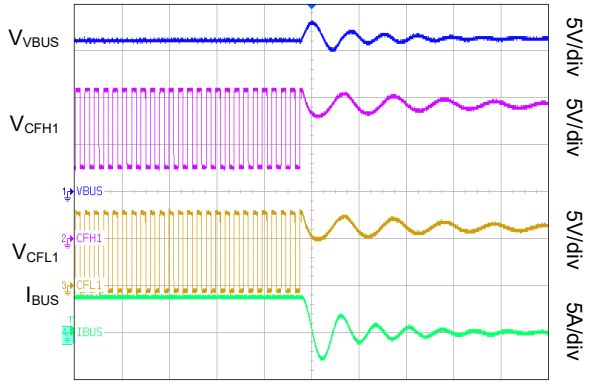
Time (5ms/div)

Adapter Unplug in Bypass Mode



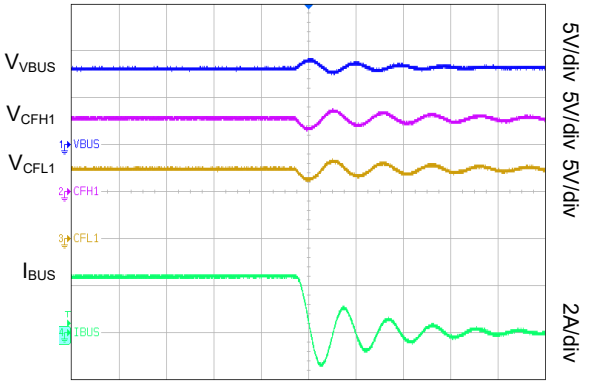
Time (5ms/div)

VBUS_OVP in Switched Cap Mode



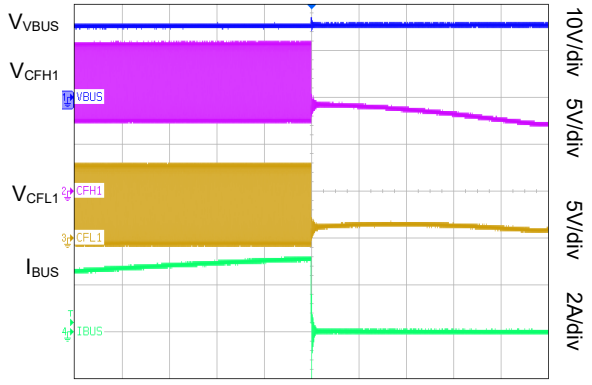
Time (10μs/div)

VBUS_OVP in Bypass Mode



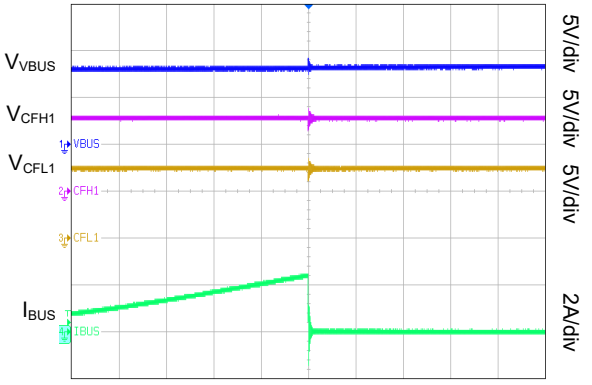
Time (10μs/div)

IBUS_OCP in Switched Cap Mode



Time (500μs/div)

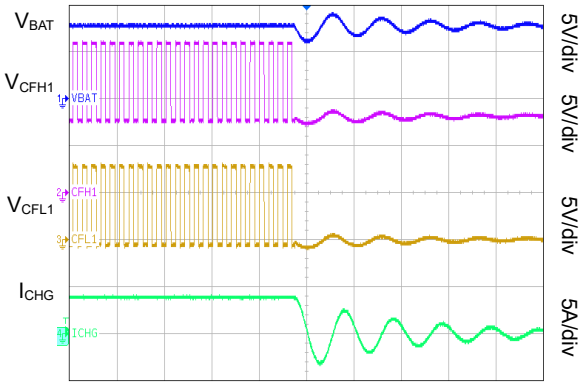
IBUS_OCP in Bypass Mode



Time (500μs/div)

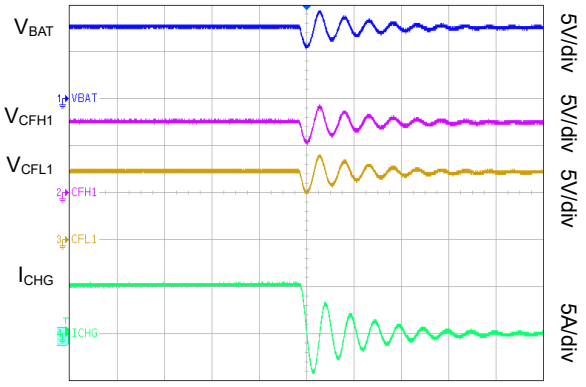
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

VBAT_OVP in Switched Cap Mode



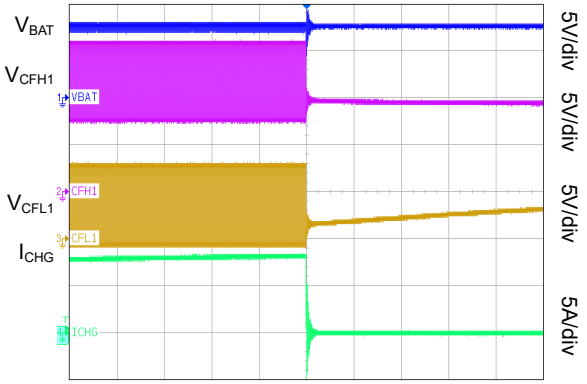
Time (10μs/div)

VBAT_OVP in Bypass Mode



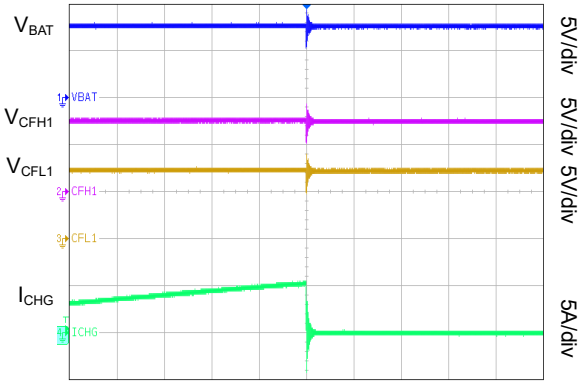
Time (20μs/div)

IBAT_OCP in Switched Cap Mode



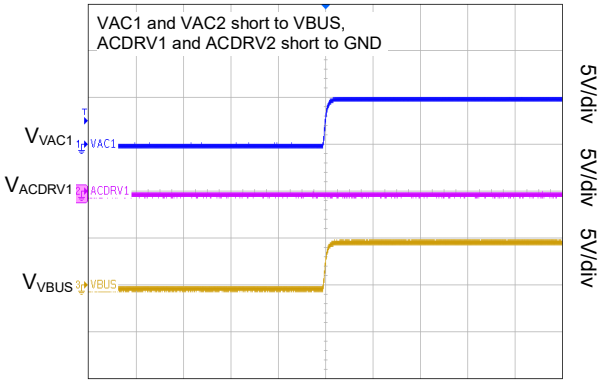
Time (500μs/div)

IBAT_OCP in Bypass Mode



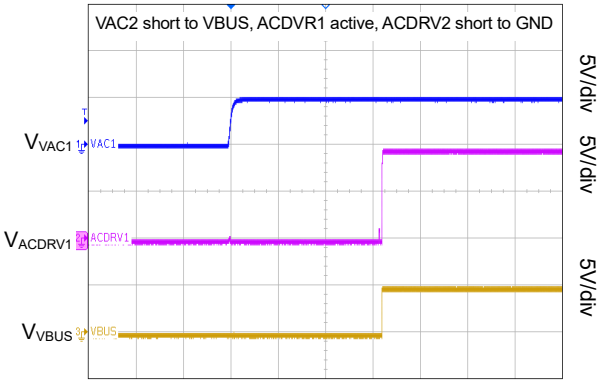
Time (500μs/div)

Power-Up without ACFET



Time (100ms/div)

Power-Up from VAC1



Time (100ms/div)

FUNCTIONAL BLOCK DIAGRAM

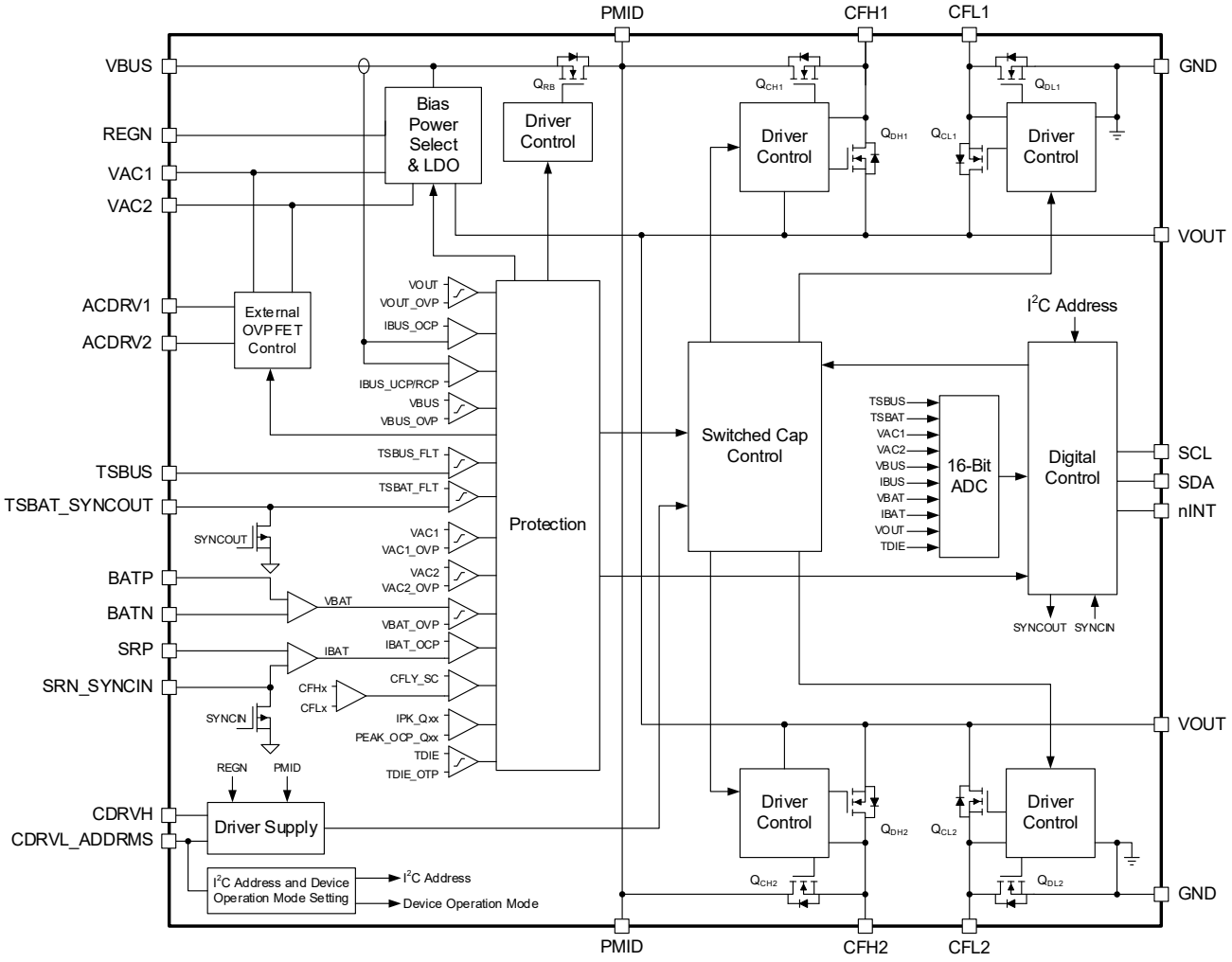


Figure 2. Functional Block Diagram

DETAILED DESCRIPTION

The SGM41602 is an efficient 8A switched-capacitor battery charging device with I²C control that can operate either in charge-pump voltage divider mode or in bypass mode. It can charge 2-cell Li-Ion or Li-polymer battery in a wide 6.2V to 22V input voltage range (VBUS) from smart wall adapters or wireless charger. The switched-capacitor architecture is optimized for 50% duty cycle to cut the input current to one-half of the battery current and reduce the wiring drops, losses and temperature rise in the application.

A two-channel switched-capacitor topology is used to reduce the required input capacitors, improve efficiency and minimize the output ripple. It supports dual input configuration through integrated MUX control and driver for external OVPFETs. It also allows single input with no external OVPFET or single OVPFET. Moreover, it supports two devices in parallel for higher power systems.

A high speed 16-bit ADC converter is also included to provide bus voltage, bus current, battery voltage, battery current, battery and cable connector temperature, and die temperature information for the charge management host via I²C serial interface.

Charge-Pump Voltage Divider Mode

The charge-pump voltage divider mode operates with a fixed 50% duty cycle. Taking one of the two channels in the switched-capacitor as example, the basic principle of operation is shown in Figure 3. In period 1, Q1 and Q3 are tuned on and V_{PMID} charges the C_{FLY} and the battery (in series) such that:

$$V_{CFLY} = V_{PMID} - V_{BAT} \quad (1)$$

In period 2, Q2 and Q4 are turned on and C_{FLY} appears in parallel with the battery:

$$V_{CFLY} = V_{BAT} \quad (2)$$

Ignoring the small fluctuation of the capacitor and battery voltages in period 1 and 2 in steady state operation, Equation 1 and 2 can be combined to calculate capacitor voltage:

$$V_{CFLY} = V_{BAT} = V_{PMID}/2 \quad (3)$$

Ignoring small energy loss in each switching period, the input and output cycle-average powers are equal. Therefore,

$$V_{PMID} \times I_{BUS} = V_{BAT} \times I_{BAT} \quad (4)$$

or

$$I_{BUS} = I_{BAT}/2 \quad (5)$$

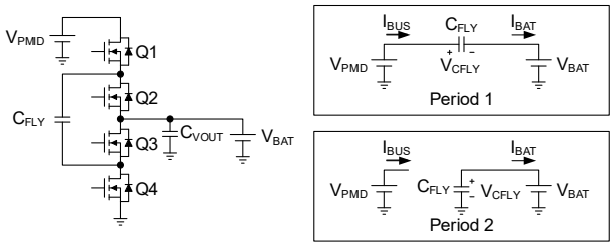


Figure 3. Voltage Divider Charger Operating Principle

Assuming no charge leakage path and considering R_{EFF} as the effective input to output resistance (due to the switch on-resistances and C_{FLY} losses), the divider can be modeled as shown in Figure 4. Using this model, the output voltage is half of the input voltage under no load conditions as explained before. The SGM41602 has two channels of such architecture operating at f_{SW} frequency with 180° phase difference. Each channel provides $I_{VOUT}/2$ at the VOUT node, so:

$$V_{VOUT} = ½V_{PMID} - ½R_{EFF} \times I_{VOUT} \quad (6)$$

At low switching frequencies the capacitor charge sharing losses are dominant and $R_{EFF} \approx 1/(4f_{SW}C_{FLY})$. As frequency increases, R_{EFF} finally approaches $(R_{DS\_QCH} + R_{DS\_QDH} + R_{DS\_QCL} + R_{DS\_QDL})/2$.

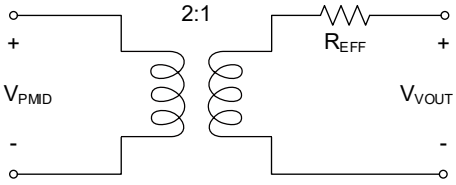


Figure 4. Model of Voltage Divider

The two-channel interleaved operation ensures a smooth input current and simplifies the noise filtering. The VOUT ripple can be estimated by first order approximation of C_{FLY} voltage drop due to the discharge in the half period, plus the discharge drop during the short dead time.

Selecting high quality C_{FLY} capacitors and proper switching frequency are the key factors for a well performing capacitor voltage divider. Switching frequency selection is a trade-off between efficiency and capacitor size. Lower frequency increases efficiency by reducing switching losses but requires larger capacitance to maintain low output ripple and low output impedance (R_{EFF}). An optimum switching frequency can be found for any selected C_{FLY} capacitor to minimize losses.

DETAILED DESCRIPTION (continued)

Bypass Mode

The SGM41602 is designed to operate in bypass mode when V_{VBUS} is close to the V_{VOUT}. When such valid voltage is present on VBUS, the device can enable bypass mode by setting EN_BYPASS = 1 and all switches between VBUS and VOUT are fully turned on while the other switches are kept off. When V_{VBUS} is near V_{VOUT}, the bypass mode offers the best efficiency and the device is capable of sourcing up to 7A. The bypass mode switched-capacitor charger is showed in Figure 5.

The output voltage is close to the V_{VBUS} minus a voltage drop caused by the on-resistances of the RBFET plus the two high-side switches of the two channels in parallel:

$$R_{EFF}\ (\text{Bypass mode}) \approx R_{DS\_QRB} + (R_{DS\_QCH1} + R_{DS\_QDH1}) \parallel (R_{DS\_QCH2} + R_{DS\_QDH2}) \quad (7)$$

where R_{DS_QXX} is the on-resistance of the switch Q_{XX}.

Charging System

The SGM41602 is a slave charger device and needs a host. The host must set up all protection functions and disable the main charger before enabling the SGM41602. The host must monitor the nINT interrupts especially during high current charging. It must also communicate with the wall adapter to control the charge current.

Figure 6 shows the block diagram of a charge system using the SGM41602 along with other devices. In this system, the PD controller is used to communicate with adapter by PD protocol. When the smart wall adapter is inserted, the AP unit controls the switching charger (SGM41575) that powers the load system and the switched capacitor charger (SGM41602) that provides high current charging. The communication between those devices is through I²C interface.

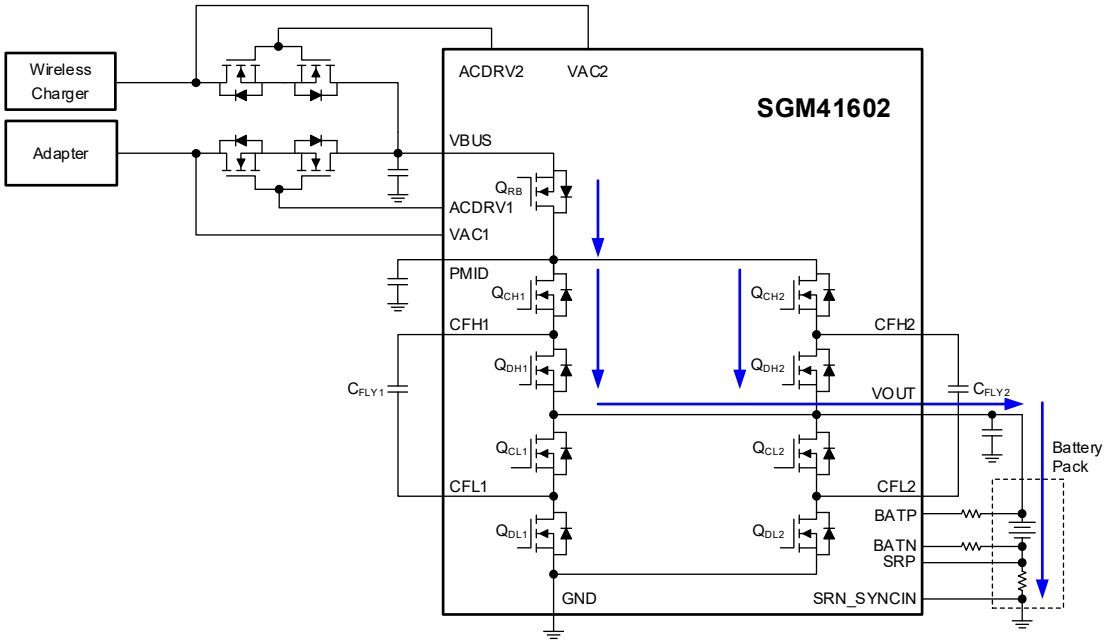


Figure 5. SGM41602 Bypass Mode

DETAILED DESCRIPTION (continued)

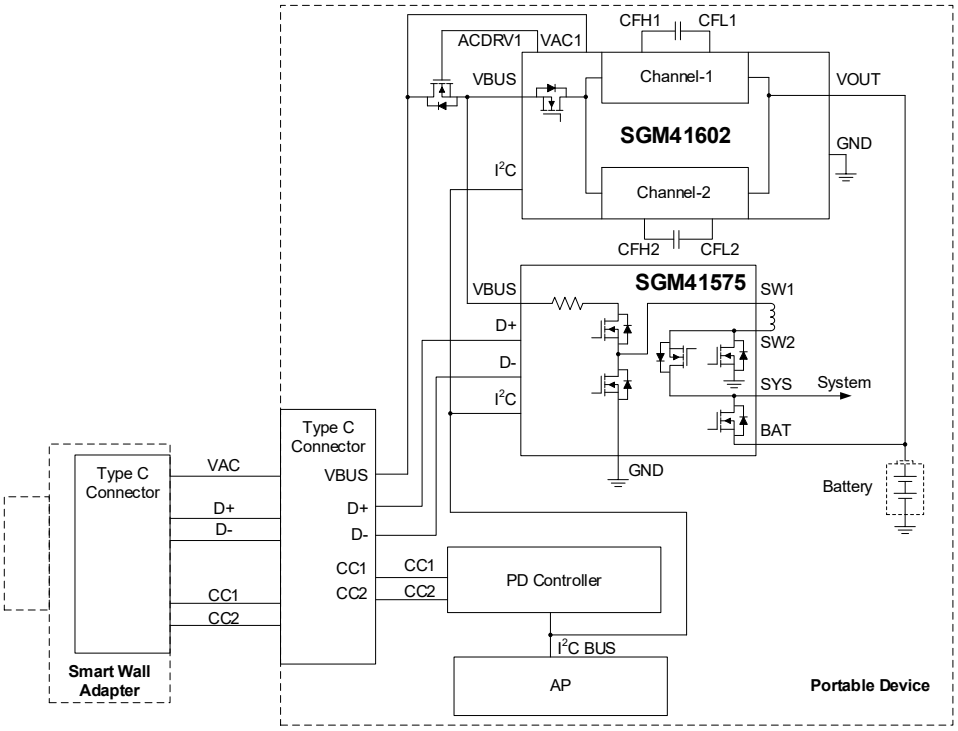


Figure 6. SGM41602 Charging System Diagram

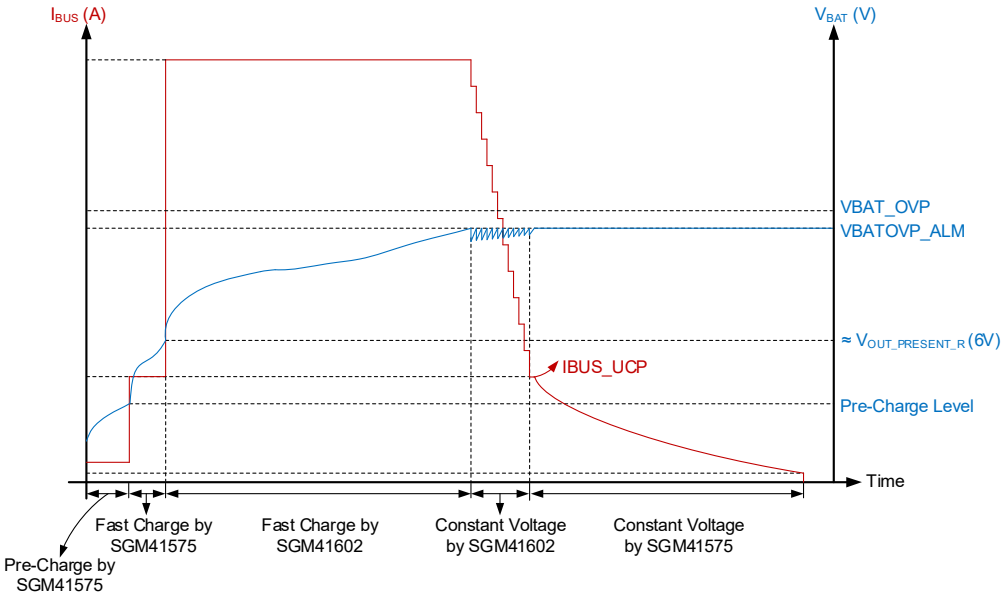


Figure 7. SGM41602 System Charging Profile

DETAILED DESCRIPTION (continued)

A typical charge profile for a high-capacity battery using switching charger and switched capacitor charger together is shown in Figure 7. During the trickle charge and pre-charge, the charging is controlled by the switching charger. Once the battery voltage reaches $V_{OUT\_PRESENT\_R}$ (6V, TYP), the adapter can negotiate for a higher bus voltage and enable the SGM41602 for charging (bypass or voltage divider mode). Once the battery voltage approaches the V_{BATOVP_ALM} point, the SGM41602 will notify the AP to reduce the IBUS current, and the AP will negotiate with adapter for a lower bus voltage to effectively taper the current until a point where the I_{BUS} current ramps down below I_{BUS_UCP}.

Startup Sequence

The SGM41602 is powered from the greater of VAC1, VAC2, VBUS or VOUT (VAC1 and VAC2 are used as sense inputs for adapter voltages as well). When V_{VOUT} rises above $V_{OUT\_UVLO\_R}$, or V_{VAC1}, V_{VAC2} or V_{VBUS} rises above their respective UVLO rising threshold, the I²C interface is ready for communication and all the registers are reset to default values.

The device does not start charging after powered up, because by default the charger is disabled but the ADC can be enabled and the AP can read the system parameters before enabling charge. The charge can be enabled only if $V_{VBUS} > V_{BUS\_PRESENT\_R}$ and $V_{VOUT} > V_{OUT\_PRESENT\_R}$.

Device Power up from Battery without Input Source

To reduce the quiescent current and maximize the battery run time when it is the only available source, the REGN LDO and most of the sensing circuits are turned off, except VAC1_PRESENT, VAC2_PRESENT, VBUS_PRESENT and VOUT_PRESENT functions.

Device Power up from Input Source

When an input source is plugged-in and the conditions of $V_{VBUS} > V_{BUS\_PRESENT\_R}$ and $V_{VOUT} > V_{OUT\_PRESENT\_R}$ are valid, the AP must initialize all protections to the desired thresholds before enabling charge. The protection thresholds that need to be set are VAC1_OVP, VAC2_OVP, VBUS_OVP, IBUS_OCP, IBUS_UCP, IBUS_RCP, VOUT_OVP, VBAT_OVP, IBAT_OCP, TSBUS_FLT, TSBAT_FLT and TDIE_OTP. If one of the protection trigger conditions is met, the charger stops switching. It will also be turned off the corresponding external OVPFETs when VAC1_OVP or VAC2_OVP or VBUS_SCP event occurs.

After setting protections, the VBUS voltage is checked to be between VBUS_LO and VBUS_HI to allow forward charge mode operation. When the AP configures bypass or voltage divider mode by setting EN_BYPASS = 0 or 1 and then set CHG_EN = 1, charging is enabled and current flows into the battery, and CONV_ACTIVE_STAT bit is set to 1 to indicate charging is active. Then raising the VBUS voltage will increase the battery charge current. When the converter is on, any command to change the charge mode is ignored. To do so, the charging must be disabled first, and then the charge mode can be changed by I²C serial interface.

Device HIZ State

The HIZ mode is activated when the AP sets EN_HIZ bit from 0 to 1. When the SGM41602 enters HIZ mode, the charging stops, ADC conversion discontinues, ACDRV and REGN LDO are turned off regardless of the presence of the adaptor or absence of any fault conditions. To exit HIZ mode, the AP should set EN_HIZ to 0, or the device POR occurs.

REGN Management

REGN provides the power required for the analog section. When V_{VOUT} is higher than $V_{OUT\_PRESENT\_R}$ and V_{VBUS} rise above $V_{BUS\_PRESENT\_R}$, REGN is powered up and ramps up to 5V. A 4.7μF or lager capacitor is required on the REGN pin.

When the faults, including VBUS_OVP, VBAT_OVP, VOUT_OVP, IBUS_OCP, IBAT_OCP, IBUS_UCP, IBUS_RCP, VBUS_SCP, VAC1_OVP, VAC2_OVP, TSBUS_FLT, TSBAT_FLT and TDIE_OTP, are triggered, the converter switching stops and CHG_EN bit is reset to 0, but the REGN LDO remains powered up. Refer to the device protection section for more details.

Dual Input Power Path Management

The SGM41602 features two ACDRV pins to drive two sets of back-to-back N-channel MOSFET, which select and manage the input power from two different input sources (such as wired and wireless input sources). Each set of back-to-back N-channel FETs consists of an input N-channel MOSFET (ACFET) and a reverse-blocking N-channel MOSFET (RBFET). During POR procedure, the internal bias circuit detects whether the ACDRV pin is short to GND to sense whether the ACFET-RBFET are connected, and then updates the ACRB1_CONFIG_STAT and ACRB2_CONFIG_STAT bits to indicate the connection status of ACFET-RBFET. If the external back-to-back N-channel FETs is not populated in the schematic, then tie corresponding VAC pin to VBUS and short ACDRV to GND. The device supports 4 input configurations: single input without any external FET, single input with only one ACFET, dual input with one set of ACFET-RBFET, and dual input with two sets of ACFET-RBFET. Detailed descriptions of the power-up sequences for different applications are provided below.

DETAILED DESCRIPTION (continued)

ACDRV Turn-on Condition

For most of the 4 configurations, the ACDRV controls the input power path for both SGM41602 and main charger. When one or both input power sources are plugged in (not in OTG mode), the ACDRV can be turned on when all of the following conditions are met:

1. The corresponding ACFET-RBFET is populated: VAC is connected to the input power and ACDRV is not short to GND.
2. V_{VAC} exceeds $V_{AC\_PRESENT\_R}$ and not higher than V_{AC_OVP} thresholds.
3. DIS_ACDRV_BOTH is not set to 1.
4. Not in HIZ mode: EN_HIZ is not set to 1.
5. V_{VBUS} is below $V_{BUS\_PRESENT\_F}$ threshold.

Single Input without ACFET-RBFET

In this configuration, the SGM41602 is not responsible for controlling the external OVPFET. VAC1 and VAC2 are both connected to VBUS directly, while ACDRV1 and ACDRV2 are both short to GND. The following table summarizes the related pin connections and the control function of relevant registers, as well as the status bits.

Table 1. Single Input without External OVPFET

Input Configuration	Single Input
External FET Connection	No external FET
Input Sense Pin Connection	VAC1 and VAC2 tied to VBUS
ACDRV Pin Connection	ACDRV1 and ACDRV2 short to GND
ACDRV1_STAT	0
ACDRV2_STAT	0
DIS_ACDRV_BOTH	1
ACRB1_CONFIG_STAT	0 = ACFET1-RBFET1 is not placed
ACRB2_CONFIG_STAT	0 = ACFET2-RBFET2 is not placed
EN_HIZ	No impact on ACDRV

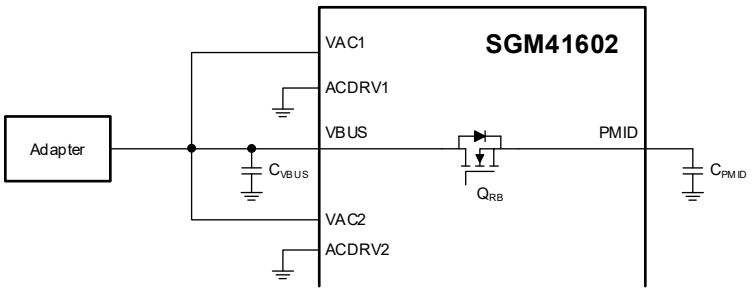


Figure 8. Single Input without ACFET-RBFET

DETAILED DESCRIPTION (continued)

Single Input with ACFET1

In this configuration, only one input N-channel MOSFET for VAC1 (ACFET1) is placed. RBFET1 and ACFET2-RBFET2 are not used. VAC1 and ACDRV1 are connected to the drain and the gate of ACFET1, respectively. VAC2 is tied to VBUS, and ACDRV2 is short to GND. This structure supports single input from VAC1. The following table summarizes the related pin connections and the control function of relevant registers, as well as the status bits.

Dual Input with ACFET1-RBFET1

In this configuration, only one set of back-to-back N-MOSFET for VAC1 is placed. VAC1 is connected to the drain of ACFET1. ACDRV1 is connected to the common gate of ACFET1-RBFET1. VAC2 is tied to VBUS and ACDRV2 is short to GND. This structure is able to support single input from VAC1. The following table summarizes the related pins connection and the control function of relevant registers, as well as the status bits.

Table 2. Single Input with Single OVPFET

Input Configuration	Single Input
External FET Connection	Only ACFET1, no RBFET1 and ACFET2-RBFET2
Input Sense Pin Connection	VAC1 tied to the input source, VAC2 short to VBUS
ACDRV Pin Connection	ACDRV1 tied to the gate of ACFET1, ACDRV2 short to GND
ACDRV1_STAT	1 = ACDRV1 is ON 0 = ACDRV1 is OFF
ACDRV2_STAT	0
DIS_ACDRV_BOTH	1 = Force ACDRV1 OFF 0 = ACDRV1 can be turned on when the activation conditions of ACDRV are valid
ACRB1_CONFIG_STAT	1 = ACFET1 is placed
ACRB2_CONFIG_STAT	0 = ACFET2-RBFET2 is not placed
EN_HIZ	1 = Enter HIZ mode, force ACDRV1 OFF 0 = Exit HIZ mode, ACDRV1 can be turned on when the activation conditions of ACDRV are valid

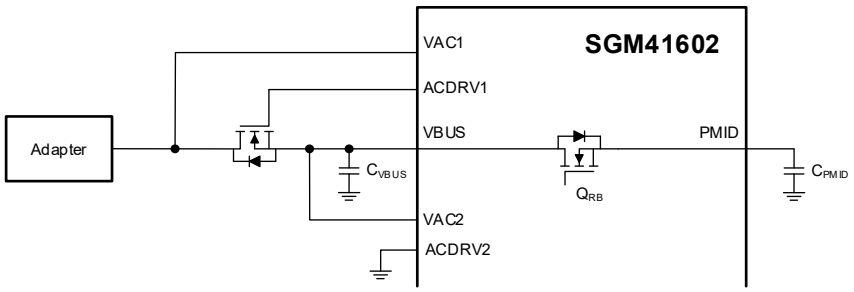


Figure 9. Single Input with ACFET1

Table 3. Dual Input with ACFET1-RBFET1

Input Configuration	Dual Input
External FET Connection	ACFET1-RBFET1, no ACFET2-RBFET2
Input Sense Pin Connection	VAC1 tied to the input source, VAC2 short to VBUS
ACDRV Pin Connection	ACDRV1 tied to the common gate of ACFET1-RBFET1, ACDRV2 short to GND
ACDRV1_STAT	1 = ACDRV1 ON 0 = ACDRV1 OFF
ACDRV2_STAT	0
DIS_ACDRV_BOTH	1 = Force ACDRV1 OFF 0 = ACDRV1 can be turned on when the activation conditions of ACDRV are valid
ACRB1_CONFIG_STAT	1 = ACFET1-RBFET1 is placed
ACRB2_CONFIG_STAT	0 = ACFET2-RBFET2 is not placed
EN_HIZ	1 = Enter HIZ mode, force ACDRV1 OFF 0 = Exit HIZ mode, ACDRV1 can be turned on when the activation conditions of ACDRV are valid

DETAILED DESCRIPTION (continued)

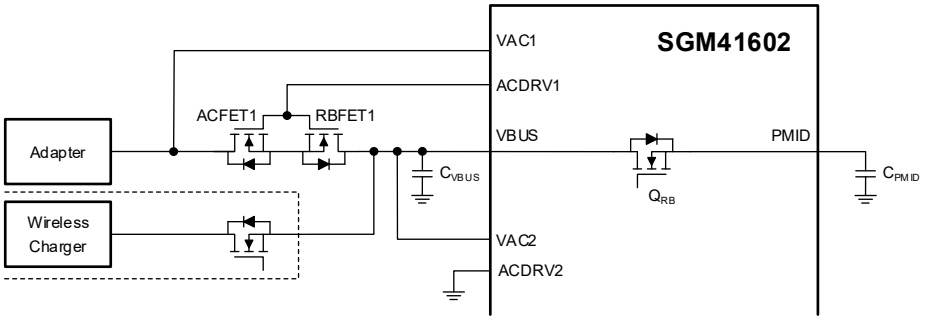


Figure 10. Dual Input with ACFET1-RBFET1

Input Source Swap with ACFET1-RBFET1

To switch the input source from VAC1 to wireless input, the AP should turn off ACDRV1 by setting DIS_ACDRV_BOTH = 1 to avoid that the two input sources are shorted together. In this configuration, writing ACDRV1_STAT = 0 will be ignored by SGM41602. After the ACFET1-RBFET1 is turned off and V_{VBUS} drops below $V_{BUS\_PRESENT\_F}$, the AP can enable the wireless input.

To switch the input source from wireless input to VAC1, the AP should remove or disable the wireless input first, and then set DIS_ACDRV_BOTH = 0 to turn on ACDRV1 after V_{VBUS} drops below $V_{BUS\_PRESENT\_F}$.

Dual Input with ACFET1-RBFET1 and ACFET2-RBFET2

In this configuration, both sets of back-to-back N-MOSFET for VAC1 and VAC2 are placed and SGM41602 supports dual input source from VAC1 and VAC2. The following table summarizes the related pin connections and the control function of relevant registers, as well as the status bits.

Table 4. Dual Input with Both ACFET1-RBFET1 and ACFET2-RBFET2

Input Configuration	Dual Input
External FET Connection	ACFET1-RBFET1, ACFET2-RBFET2
Input Sense Pin Connection	VAC1 tied to input source 1, VAC2 tied to input source 2
ACDRV Pin Connection	ACDRV1 tied to the common gate of ACFET1-RBFET1 ACDRV2 tied to the common gate of ACFET2-RBFET2
ACDRV1_STAT	1 = ACDRV1 ON 0 = ACDRV1 OFF In dual input configuration, the AP can use this bit to swap the input source if both input sources are valid
ACDRV2_STAT	1 = ACDRV2 ON 0 = ACDRV2 OFF In dual input configuration, the AP can use this bit to swap the input source if both input sources are valid
DIS_ACDRV_BOTH	1 = Force both ACDRV to turn off, both ACDRV1_STAT and ACDRV2_STAT become 0 0 = ACDRV1 or ACDRV2 can be turned on when the activation conditions of ACDRV are valid. If VAC1 and VAC2 become valid at the same time, ACDRV1 will be turned on with a higher priority, and ACDRV2 will be forcibly turned off
ACRB1_CONFIG_STAT	1 = ACFET1-RBFET1 is placed
ACRB2_CONFIG_STAT	1 = ACFET2-RBFET2 is placed
EN_HIZ	1 = Enter HIZ mode, force both ACDRV1 and ACDRV2 to turn off 0 = Exit HIZ mode, ACDRV1 or ACDRV2 can be turned on when the activation conditions of ACDRV are valid If VAC1 and VAC2 become valid at the same time, ACDRV1 will be turned on with a higher priority, and ACDRV2 will be forcibly turned off

DETAILED DESCRIPTION (continued)

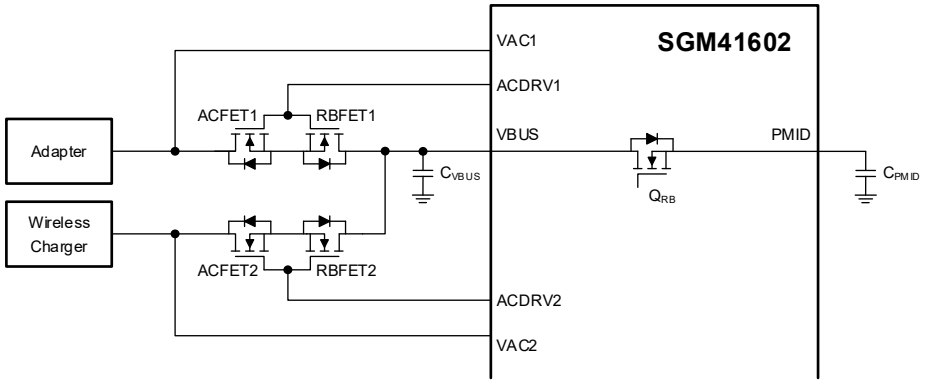


Figure 11. Dual Input with ACFET-RBFET1 and ACFET-RBFET2

Input Source Swap with ACFET-RBFET1 and ACFET-RBFET2

Three examples are provided below to illustrate the process of swapping the input source from VAC1 to VAC2 (the procedure for swapping from VAC2 to VAC1 is similar).

VAC2 is plugged in after VAC1 is removed

1. When VAC1 is removed and V_{VAC1} drops below $V_{AC\_PRESENT\_F}$, ACDRV1 will be turned off automatically, and V_{VBUS} will slowly drop below $V_{BUS\_PRESENT\_F}$. The AP can write 1 to the VBUS pull-down resistor enable bit (VBUS_PDN_EN) as needed to expedite the discharge for VBUS.
2. After VAC1 is removed, VAC2 is plugged in, and then the device will turn on ACDRV2 until V_{VBUS} drops below $V_{BUS\_PRESENT\_F}$. In this situation, the swapping procedure from VAC1 to VAC2 is controlled by SGM41602 and does not require intervention from the AP.

Both VAC1 and VAC2 are valid, the AP controls the swap from VAC1 to VAC2

1. Both VAC1 and VAC2 are valid, ACDRV1 has been turned on, and ACDRV2 is off.
2. The AP can set REG0x0F[1:0] (ACDRV1_STAT, ACDRV2_STAT) from 10b to 01b, the ACDRV1 will be turn off and then ACDRV2 will be turned on until V_{VBUS} drops below $V_{BUS\_PRESENT\_F}$.

In this situation, the on/off state of the two sets of back-to-back N-MOSFET is controlled by the AP. Note that writing REG0x0F[1:0] = 00 (to set ACDRV1_STAT = 0 and ACDRV2_STAT = 0 simultaneously) will be ignored. The AP can write DIS_ACDRV_BOTH = 1 to turn off both two sets of back-to-back N-MOSFET.

If VAC1 becomes invalid when ACDRV1 is on, the device will automatically swap to VAC2

1. Both VAC1 and VAC2 are valid, ACDRV1 has been turned on, and ACDRV2 is off.
2. When VAC1 becomes invalid (V_{VAC1} drops below $V_{AC\_PRESENT\_F}$ or rises above $V_{AC\_OVP\_R}$), the device will turn off ACDRV1, and then turn on ACDRV2 until V_{VBUS} drops below $V_{BUS\_PRESENT\_F}$.

In this situation, the on/off state of the two sets of back-to-back N-MOSFET is controlled by SGM41602.

OTG Mode Operation

If the switching charger works in OTG mode and the two sets of back-to-back N-MOSFET is controlled by SGM41602, they must be turned on/off manually, depending on which port is desired for OTG output. The corresponding external OVPFETs will be turned off when VAC1_OVP, VAC2_OVP, or VBUS_OVP fault occurs.

To enter OTG mode, the AP needs to follow the steps outlined below:

1. The AP writes EN_OTG = 1.
2. SGM41602 sets DIS_ACDRV_BOTH = 1 automatically.
3. The AP writes DIS_ACDRV_BOTH = 0 to allow to enable ACDRV, and then writes ACDRV1_STAT = 1 or ACDRV2_STAT = 1 or both, depending on which port is desired for OTG output.
4. The AP enables OTG mode for switching charger.
5. If VAC1_OVP or VAC2_OVP or VBUS_OVP fault occurs, SGM41602 will turn off the corresponding external OVPFETs but will not reset EN_OTG. After the fault is cleared, the AP needs to write ACDRV1_STAT = 1 or ACDRV2_STAT = 1 or both to enable OTG output again. It is recommended to set V_{AC1_OVP} and V_{AC2_OVP} to the same threshold in OTG mode.
6. To disable OTG output, the AP needs to set ACDRV1_STAT = 0 or ACDRV2_STAT = 0 or DIS_ACDRV_BOTH = 1, and can write 1 to the VAC1/VAC2/VBUS pull-down resistor enable bits (VAC1_PDN_EN/VAC2_PDN_EN/VBUS_PDN_EN) as needed to discharge the residual energy.

DETAILED DESCRIPTION (continued)

To exit OTG mode, the AP needs to follow the steps outlined below:

1. The AP disables OTG mode for switching charger.
2. The AP writes 1 to the VAC1/VAC2/VBUS pull-down resistor enable bits (VAC1_PDN_EN/VAC2_PDN_EN/VBUS_PDN_EN) as needed to discharge the residual energy.
3. After VBUS and VAC is discharged, the AP writes ACDRV1_STAT = 0 or ACDRV2_STAT = 0 or DIS_ACDRV_BOTH = 1 to turn off ACDRV.
4. The AP writes EN_OTG = 0 to exit OTG mode.

ADC

The SGM41602 integrates a fast 10-channel, 16-bit ADC converter to monitor input/output currents and voltages, as well as the temperature of the device, battery, and cable connector. The ADC is controlled by the ADC_CTRL0 and ADC_CTRL1 registers. Setting the ADC_EN bit to 1 enables the ADC. This bit can be used to turn off the ADC and save power when it is not needed. The ADC_RATE bit allows choosing continuous conversion or 1-shot conversion mode. The ADC_AVG bit is utilized to enable or disable ADC averaging (disabled default), and the ADC_AVG_INIT bit can be used to choose the average initial value (use an existing register value or a new value). The ADC operates independent of the faults, unless the AP sets the ADC_EN bit to 0.

The ADC can operate if V_{VAC} > 3.4V or V_{VBUS} > 3.4V or V_{VOUT} > 2.8V condition is valid. Otherwise the ADC conversion is postponed until one of them is satisfied. The ADC readings are valid only for DC values and not for transients.

By default, all ADC channels are converted in continuous conversion mode except the channels disabled by the ADC_CTRL0 and ADC_CTRL1 registers. If the 1-shot conversion mode is selected, the ADC_DONE_FLAG bit is set to 1 when all channels are converted, then the ADC_EN bit is reset to 0. In the continuous conversion mode, the ADC_DONE_FLAG bit is set to 0.

CDRVH and CDRVL_ADDRMS Functions

A 0.22μF MLCC capacitor is required between the CDRVH and CDRVL_ADDRMS pins to provide driver supply. In addition, the CDRVL_ADDRMS pin is used to set the default I²C address and operation mode of the device during the POR procedure. Refer to Table 5 to choose the appropriate resistor from CDRVL_ADDRMS pin to GND for desired configuration. It is recommended to utilize a surface mount resistor with a tolerance of either ±1% or ±2%. After POR procedure, the AP can read the operation mode of the device from MS[1:0] bits in CHARGER_CONTROL5 register.

Table 5. Selection for I²C Address and Operation Mode

Resister Value to GND on CDRVL_ADDRMS (kΩ)	I²C Address	Configuration
>75 or 4.7	0x65	Standalone
6.2	0x67	Standalone
8.2	0x66	Secondary for Parallel Charging
10.5	0x66	Primary for Parallel Charging
14	0x66	Standalone
18	0x67	Secondary for Parallel Charging
27	0x65	Primary for Parallel Charging

DETAILED DESCRIPTION (continued)

Parallel Operation

To achieve higher charging current, it is feasible to use two devices in parallel, with one configured in primary mode and the other in secondary mode. Using two devices in parallel can also enable each device to operate at a lower charging current, resulting the higher efficiency compared with single device at the same total charging current. During POR procedure, the CDRVL_ADDRMS pin is used to determine the operation mode of the device. Refer to Table 5 for selecting appropriate resistor from CDRVL_ADDRMS pin to GND.

The parallel charging configuration for dual charger is shown in Figure 12. When set as the primary, the TSBAT_SYNCOUT pin functions as the synchronization signal output pin, while the SRN_SYNCIN pin operates as SRN. When set as the secondary, the SRN_SYNCIN pin functions as the synchronization signal input pin, and the TSBAT_SYNCOUT pin operates as TSBAT. The TSBAT_SYNCOUT pin of the primary should be tied to the SRN_SYNCIN pin of the secondary, and should be pulled up to REGN of the primary through a 1kΩ resistor. The external OVPFETs are controlled by the primary, and the ACDRV pins of the secondary should short to GND.

The parallel charging configuration can operate in both bypass mode and voltage divider mode. The distribution of current between the primary and secondary is influenced by the loop impedance, and the chargers do not automatically balance it. To achieve current balance, it is essential to design the board layout with maximum symmetry.

nINT Pin, STAT, Flag and Mask Bits

The nINT pin is an open-drain output and must be pulled up to a logic high rail. It is pulled low with a duration of t_{INT} to notify the AP when it is triggered by an event. See the register map for all event flag and control bits.

When an event occurs, a nINT signal is sent to the AP, and the corresponding status and flag bits are set to 1. The flag bit can be read to clear but the status bit remains as 1 if the event is still present. The nINT signal is not sent again if an event is still present after the flag bit is read cleared, unless another kind of event occurs. If an event mask bit is set, that event will not send nINT signal, but the flag bit is still updated independent of the mask bit.

Table 6 lists all the enable condition and corresponding actions for different fault events.

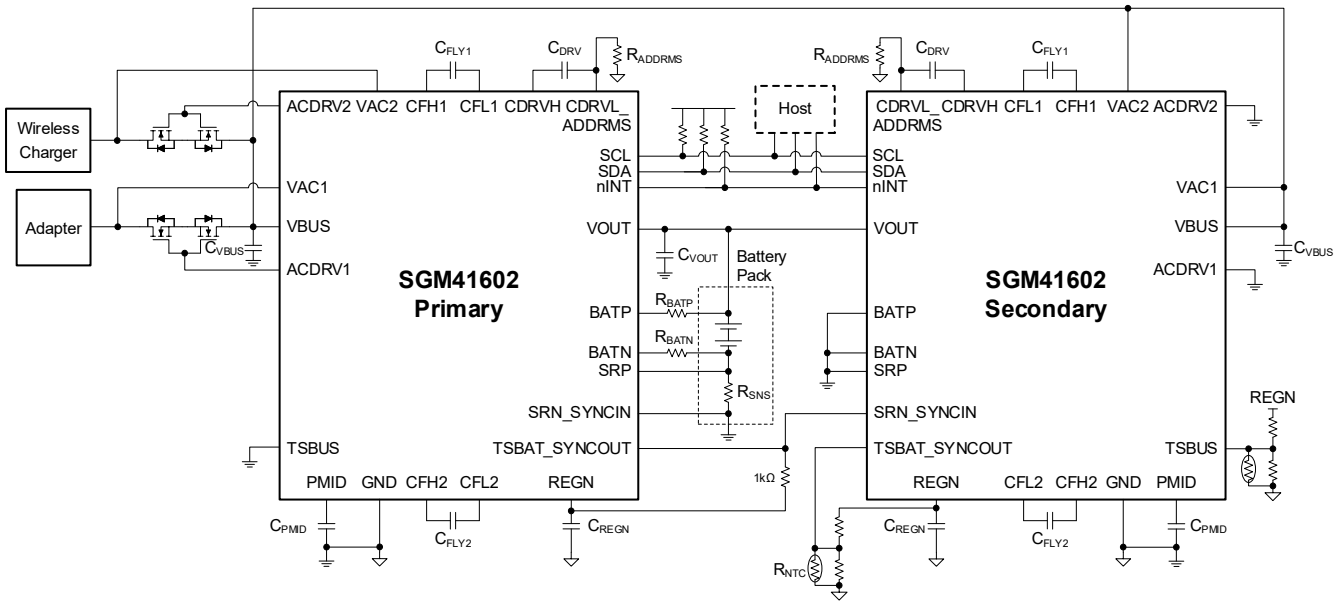


Figure 12. Parallel Operation of SGM41602

DETAILED DESCRIPTION (continued)

Table 6. Fault Event Activation List

Fault Event	Conditions	Protection Action
VAC_OVP	V_{VACx} > $V_{AC\_OVP\_R}$ during VACx_PRESENT interval (x = 1 or 2)	Reset CHG_EN bit to 0 and turn off Q_{RB}, turn off ACDRVx in 100ns and reset ACDRVx_STAT = 0
VBUS_OVP	V_{VBUS} > $V_{BUS\_OVP\_R}$ during VBUS_PRESENT interval	Reset CHG_EN bit to 0 and turn off Q_{RB} OTG mode: if ACDRVx_STAT = 1, turn off ACDRVx and reset ACDRVx_STAT = 0 (x = 1 or 2)
VBUSOVP_ALM	V_{VBUS} > $V_{BUSOVP\_ALM\_R}$ during VBUS_PRESENT interval	None
VBUS_SCP	V_{VBUS} < 3V during VBUS_PRESENT interval	Turn off ACDRVx in 100ns, reset CHG_EN bit to 0, turn off Q_{RB}, and restart PRESENT detection after 760ms
VBUS_LO	V_{VBUS} < V_{BUS_LO} during charging initiation V_{BUS_LO} = 0.85 × V_{VOUT} in bypass mode and 1.7 × V_{VOUT} in voltage divider mode	Reset CHG_EN bit to 0 and turn off Q_{RB}
VBUS_HI	V_{VBUS} > V_{BUS_HI} during charging initiation V_{BUS_HI} = 1.2 × V_{VOUT} in bypass mode and 2.3 × V_{VOUT} in voltage divider mode	Bypass mode: reset CHG_EN bit to 0 and turn off QRB Voltage divider mode: charging initiation suspended
IBUS_OCP	I_{BUS} > I_{BUS_OCP} with $t_{IBUS\_OCP\_DEG}$ deglitch	Reset CHG_EN bit to 0 and turn off Q_{RB}
IBUS_UCP	I_{BUS} < I_{BUS_UCP} with $t_{IBUS\_UCP\_DEG}$ deglitch after soft-start timer expired	Reset CHG_EN bit to 0 and turn off Q_{RB}
IBUS_RCP	I_{BUS} < I_{BUS_RCP} with 2μs deglitch	Reset CHG_EN bit to 0 and turn off Q_{RB}
VOUT_OVP	V_{VOUT} > $V_{OUT\_OVP\_R}$ with $t_{VOUT\_OVP\_DEG}$ deglitch during VOUT_PRESENT interval	Reset CHG_EN bit to 0 and turn off Q_{RB}
VBAT_OVP	V_{BAT} > $V_{BAT\_OVP\_R}$ during VOUT_PRESENT interval V_{BAT} = (V_{BATP} - V_{BATN})	Reset CHG_EN bit to 0 and turn off Q_{RB}
VBATOVP_ALM	V_{BAT} > $V_{BATOVP\_ALM\_R}$ during VBAT_INSERT interval V_{BAT} = (V_{BATP} - V_{BATN})	None
IBAT_OCP	I_{BAT} > I_{BAT_OCP} with $t_{IBAT\_OCP\_DEG}$ deglitch	Reset CHG_EN bit to 0 and turn off Q_{RB}
IBATOCP_ALM	I_{BAT} > $I_{BATOCP\_ALM\_R}$	None
TSBUS_FLT	TS_{BUS} < $TS_{BUS\_FLT\_F}$ during REGN power up interval TS_{BUS} = V_{TSBUS}/V_{REGN} × 100%	Reset CHG_EN bit to 0 and turn off Q_{RB}
TSBAT_FLT	TS_{BAT} < $TS_{BAT\_FLT\_F}$ during REGN power up interval TS_{BAT} = V_{TSBAT}/V_{REGN} × 100%	Reset CHG_EN bit to 0 and turn off Q_{RB}
TSBUS_TSBAT_ALM	TS_{BUS} < $TS_{BUS\_FLT\_F}$ + 5% or TS_{BAT} < $TS_{BAT\_FLT\_F}$ + 5% during REGN power up interval	None
TDIE_OTP	T_{DIE} > $T_{DIE\_OTP\_R}$	Reset CHG_EN bit to 0 and turn off Q_{RB}
TDIEOTP_ALM	T_{DIE} > $T_{DIEOTP\_ALM\_R}$	None
PEAK_OCP_Qxx	I_{QXX} > I_{CONV_OCP}	Reset CHG_EN bit to 0 and turn off Q_{RB}
CFLY_SHORT	V_{CFLYx} < V_{CFLY_SC}	Reset CHG_EN bit to 0 and turn off Q_{RB}
WD_TIMEOUT	When watchdog timer expires	First reset CHG_EN and turn off Q_{RB}, then reset EN_BYPASS and ADC_EN bit to 0

Input Over-Voltage Protection (VAC1_OVP, VAC2_OVP)

The SGM41602 monitors the adapter voltage on the VAC1/VAC2 pin to use the ACDRV1/ACDRV2 output to control the external OVPFETs respectively. Taking VAC1_OVP as an example, the VAC1 over-voltage protection circuit is enabled if V_{VAC1} rises above $V_{AC\_PRESENT\_R}$. If V_{VAC1} is above $V_{AC\_PRESENT\_R}$ for at least $t_{VAC\_IN\_DEG}$ time and DIS_ACDRV_BOTH = 0, the ACDRV1 will output drive signal to turn on the ACFET1-RBFET1. If the V_{AC1} reaches the $V_{AC\_OVP\_R}$ threshold, the gate voltage starts to drop and eventually the ACFET1-RBFET1 is fully turned off. Figure 13 shows the VAC_OVP and ACDRV operation timings. The $V_{AC\_OVP\_R}$ threshold can be set by I²C serial interface. The adapter voltage must never exceed the absolute maximum rating of the VAC1/VAC2 pin and the external OVPFETs.

DETAILED DESCRIPTION (continued)

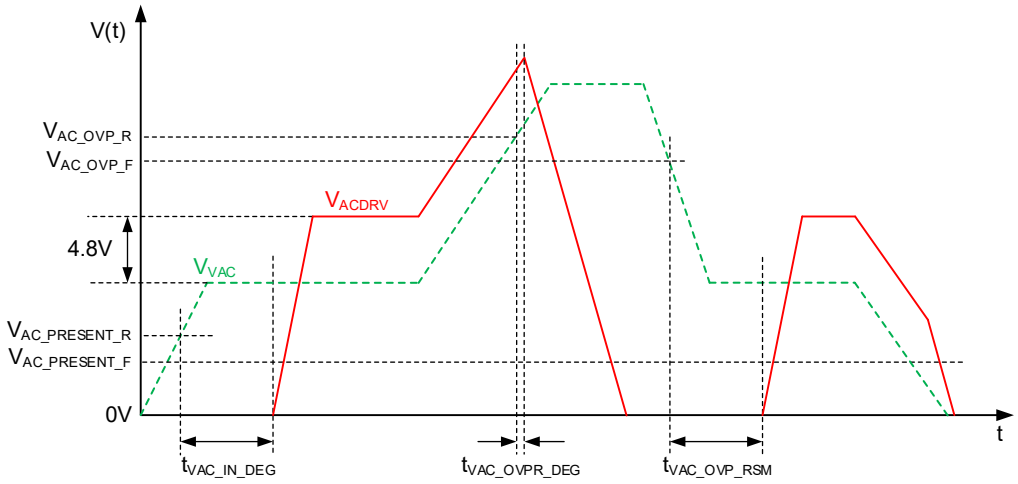


Figure 13. ACDRV Operation Timing

Input Short-Circuit Protection (VBUS_SCP)

The VBUS_SCP function monitors the VBUS pin for short-circuit. This function is enabled if the external OVPFETs are turned on or if V_{VBUS} rises above $V_{BUS\_PRESENT\_R}$. If the V_{VBUS} falls below 3V, the OVPFETs are turned off, and charging is stopped. CHG_EN bit is reset to 0 (disable). Also, VBUS_SCP_STAT and VBUS_SCP_FLAG bits are set to 1, and an INT pulse is asserted. The device will wait for 760ms before automatically re-enabling and initiating startup sequence.

VBUS Charge Voltage Range (VBUS_LO & VBUS_HI)

The VBUS_LO and VBUS_HI functions are included to avoid problems due to wrong VBUS setting for forward charging. In bypass mode, if V_{VBUS} is beyond the range between V_{BUS_LO} and V_{BUS_HI}, CHG_EN will be reset to 0 and Q_{RB} will be turned off. In voltage divider charging mode, if $V_{VBUS} < V_{BUS\_LO}$, CHG_EN will be reset to 0 and Q_{RB} will be turned off, but if $V_{VBUS} > V_{BUS\_HI}$, the device remains in charge initiation operation. Once V_{VBUS} is within the charge range, charging will start and VBUS_LO and VBUS_HI functions will be disabled.

Input, Output and Battery Over-Voltage Protection (VBUS_OVP, VOUT_OVP and VBAT_OVP)

The VBUS_OVP, VOUT_OVP and VBAT_OVP functions detect input and output voltage conditions. If either input or output voltage is higher than the protection threshold, the device stops charging and resets CHG_EN bit to 0 (disable). The VBUS_OVP function monitors VBUS pin voltage. The VOUT_OVP function monitors VOUT pin voltage. The VBAT_OVP uses BATP and BATN remote sense pins to monitor differential voltage between the battery terminals. To minimize the risk of battery terminal short in the manufacturing process, two 100Ω resistors are needed to connect in series to the BATP and BATN pins respectively. The VBUS_OVP, VOUT_OVP and VBAT_OVP thresholds can be set by I²C serial interface.

Input and Battery Over-Current Protection (IBUS_OCP and IBAT_OCP)

The IBUS_OCP function monitors the input current via Q_{RB}. If CHG_EN bit are set to enable charge, the Q_{RB} is turned on and the IBUS_OCP function starts detecting the input current. If the I_{BUS} reaches I_{BUS_OCP} threshold, the device stops charging and resets CHG_EN bit to 0 (disable). The battery current is monitored by the voltage across an external series shunt resistor. This differential voltage is measured between SRP and SRN_SYNCIN pins. If I_{BAT_OCP} threshold is reached, the device stops charging and resets CHG_EN bit to 0 (disable). The IBUS_OCP and IBAT_OCP thresholds can be set by I²C serial interface.

Input Under-Current Protection (IBUS_UCP)

The IBUS_UCP function detects the input current via Q_{RB} during forward charging. After charging is started and soft-start time expired, if I_{BUS} is below I_{BUS_UCP} with $t_{IBUS\_UCP\_DEG}$ deglitch time, the charging will be stopped and CHG_EN bit is reset to 0 (disable). The $t_{IBUS\_UCP\_DEG}$ timer can be set by I²C serial interface.

DETAILED DESCRIPTION (continued)

CFLY Diagnosis (CFLY_SHORT)

The CFLY diagnosis function identifies the health of flying capacitors before and during voltage divider switching (charging). The device initialization process is started after CHG_EN bit is set to 1. When V_{VBUS} and V_{BAT} are in the charge range, the flying capacitors in both channels are pre-charged. A CFLY short-circuit is detected if they cannot be charged, and the voltage between V_{CFHx} and V_{CFLx} remains below (V_{VOUT} - 1.2V). If so, the initialization process is stopped and CHG_EN bit is reset to 0 (disable). Even if CFLY capacitors pass the short-circuit test in the initialization process, the CFLY diagnosis function remains active and whenever a V_{CFLY} voltage falls below (V_{VOUT} - 1.2V), the operation is stopped and CHG_EN bit is reset to 0 (disable). The CFLY_SHORT_FLAG bit is set to 1 and an INT pulse is generated as well. During a CFLY short-circuit event, other protection events such as IBUS_OCP, VBAT_OVP or PEAK_OCP may occur.

Converter Peak Over-Current Protection (PEAK_OCP)

The PEAK_OCP function monitors the converter switch operating currents. If the Q_{CLx} or Q_{DLx} current reaches switch OCP threshold (I_{CONV_OCP}) during charging, the charging is stopped and CHG_EN bit is reset to 0.

TDIE Over-Temperature Protection (TDIE_OTP)

The TDIE_OTP function prevents operation in over-temperature condition. The die temperature is monitored and if the $T_{DIE\_OTP\_R}$ threshold is reached, the charging is stopped and CHG_EN bit is reset to 0 (disable). The startup sequence cannot be initiated again until the die temperature falls down with a 30℃ hysteresis. The TDIE_OTP threshold can be set by I²C serial interface.

Battery and Cable Connector Temperature Monitoring (TSBAT_FLT and TSBUS_FLT)

The SGM41602 monitors battery and cable connector temperature through the TSBAT_SYNCOUT and TSBUS pins, which are connected to the external resistor divider that is pulled up to REGN. A negative coefficient thermistor (NTC) is needed in parallel with the low-side resistor. When the voltage on the TSBUS or TSBAT_SYNCOUT pin drops below the specific threshold, it indicates a "hot" temperature condition. In response, the device will stop charging and reset CHG_EN to 0. The startup sequence cannot be initiated again until the battery or cable connector temperature fall down, which resulting a voltage rising on TSBAT_SYNCOUT or TSBUS pin. The TSBUS_FLT and TSBAT_FLT thresholds can be set by I²C serial interface.

Taking TSBAT_SYNCOUT pin as example, the external bias resistors network is shown as Figure 14. The selection of R_{T1} and R_{T2} resistors depends on the NTC utilized. For a 10kΩ NTC, R_{T1} and R_{T2} should be 10kΩ resistors. If a 100kΩ NTC is selected, choose 100kΩ resistors as R_{T1} and R_{T2}.

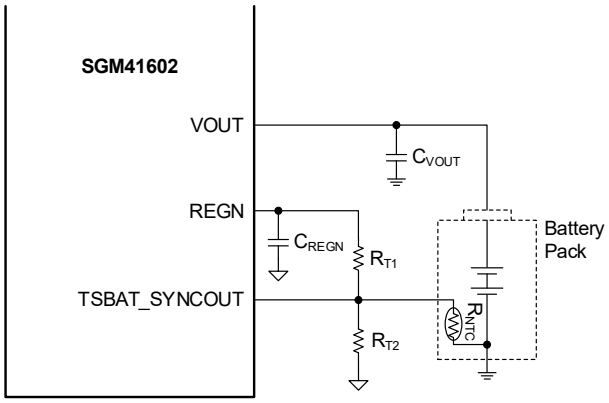


Figure 14. TSBAT_SYNCOUT Thermistor and Bias Network

The voltage percentage of the TSBUS and TSBAT_SYNCOUT pin (V_{TS}/V_{REGN} × 100%) may vary from 0% to 50%, and the voltage on the TSBUS and TSBAT_SYNCOUT pin is determined by the following equation:

$$V_{TSBUS} \text{ or } V_{TSBAT} \text{ (V)} = \frac{\frac{1}{(\frac{1}{R_{NTC}}+\frac{1}{R_{T1}})}}{R_{T2}+(\frac{1}{R_{NTC}}+\frac{1}{R_{T1}})} \times V_{REGN} \quad (8)$$

The voltage percentage of the TSBUS and TSBAT_SYNCOUT pin is determined by the following equation.

$$\text{TSBUS or TSBAT (\%)} = \frac{\frac{1}{(\frac{1}{R_{NTC}}+\frac{1}{R_{T1}})}}{R_{T2}+(\frac{1}{R_{NTC}}+\frac{1}{R_{T1}})} \quad (9)$$

In addition, a TSBUS_TSBAT_ALM warning interrupt will be send to notify the AP if the voltage percentage of TSBUS or TSBAT falls with 5% of the TSBUS or TSBAT setting.

REGISTER MAPS

All registers are 8-bit and individual bits are named from D[0] (LSB) to D[7] (MSB).

I²C Register Address Map

FUNCTION	STAT	FLAG	MASK	THRESHOLD SETTING	ENABLE	DEGLITCH
REG_RST	--	--	--	--	0x0F[7]	--
EN_HIZ	--	--	--	--	0x0F[6]	--
EN_OTG	--	--	--	--	0x0F[5]	--
CHG_EN	--	--	--	--	0x0F[4]	--
EN_BYPASS	--	--	--	--	0x0F[3]	--
ACDRV1	0x0F[1] & 0x15[1]	0x1A[1]	0x1F[1]	--	0x0F[2] & 0x0F[1]	--
ACDRV2	0x0F[0] & 0x15[0]	0x1A[0]	0x1F[0]	--	0x0F[2] & 0x0F[0]	--
FSW_SET	--	--	--	0x10[7:5]	--	--
FREQ_SHIFT	--	--	--	0x12[4:3]	0x12[4:3]	--
WATCHDOG	0x16[0]	0x1B[0]	0x20[0]	0x10[4:3]	0x10[2]	--
SS_TIMEOUT	0x16[6]	0x1B[6]	0x20[6]	0x11[6:4]		--
VOUT_OVP	0x13[5]	0x18[5]	0x1D[5]	0x12[6:5]	0x12[7]	--
VOUT_PRESENT	0x15[5]	0x1A[5]	0x1F[5]	--	--	--
VBAT_OVP	0x13[7]	0x18[7]	0x1D[7]	0x00[6:0]	0x00[7]	--
VBATOVP_ALM	0x13[6]	0x18[6]	0x1D[6]	0x01[6:0]	0x01[7]	--
IBAT_OCP	0x13[4]	0x18[4]	0x1D[4]	0x02[6:0]	0x02[7]	--
IBATOCP_ALM	0x13[3]	0x18[3]	0x1D[3]	0x03[6:0]	0x03[7]	--
VBUS_OVP	0x13[1]	0x18[1]	0x1D[1]	0x06[6:0]	--	--
VBUSOVP_ALM	0x13[0]	0x18[0]	0x1D[0]	0x07[6:0]	0x07[7]	--
VBUS_PDN	--	--	--	--	0x06[7]	--
VBUS_PRESENT	0x15[2]	0x1A[2]	0x1F[2]	--	--	--
IBUS_OCP	0x14[7]	0x19[7]	0x1E[7]	0x08[4:0]		--
IBUS_UCP	0x14[5]	0x19[5]	0x1E[5]	--	0x05[7]	0x11[3:2]
IBUS_RCP	0x14[4]	0x19[4]	0x1E[4]	--	0x05[5]	--
VBUS_SCP	0x14[3]	0x19[3]	0x1E[3]	--	--	--
VBUS_HI	0x17[4]	0x1C[4]	0x21[4]	--	0x05[2]	--
VBUS_LO	0x14[0]	0x19[0]	0x1E[0]	--	--	--
TDIE_OTP	0x16[2]	0x1B[2]	0x20[2]	0x0A[6:5]	0x0A[7]	--
TDIEOTP_ALM	0x16[1]	0x1B[1]	0x20[1]	0x0B[7:0]	0x0A[4]	--
TSBUS_FLT	0x16[4]	0x1B[4]	0x20[4]	0x0C[7:0]	0x0A[3]	--
TSBAT_FLT	0x16[3]	0x1B[3]	0x20[3]	0x0D[7:0]	0x0A[2]	--
TSBUS_TSBAT_ALM	0x16[5]	0x1B[5]	0x20[5]	--	--	--
VAC1_OVP	0x15[7]	0x1A[7]	0x1F[7]	0x0E[7:5]	--	--
VAC1_PDN	--	--	--	--	0x0E[1]	--
VAC1_PRESENT	0x15[4]	0x1A[4]	0x1F[4]	--	--	--
VAC2_OVP	0x15[6]	0x1A[6]	0x1F[6]	0x0E[4:2]	--	--
VAC2_PDN	--	--	--	--	0x0E[0]	--
VAC2_PRESENT	0x15[3]	0x1A[3]	0x1F[3]	--	--	--
CFLY_SHORT	0x14[2]	0x19[2]	0x1E[2]	--	--	--
REGN_GOOD	0x17[7]	0x1C[7]	0x21[7]	--	--	--
CONV_ACTIVE	0x17[6]	0x1C[6]	0x21[6]	--	--	--
ADC	0x16[7]	0x1B[7]	0x20[7]	0x23[6]	0x23[7]	--

REGISTER MAPS (continued)

Bit Types:
R: Read only
R/W: Read/Write
RC: Read clears the bit
R/WC: Read/Write. Writing a '1' clears the bit. Writing a '0' has no effect.

REG0x00: BAT_OVP Register [reset = 0x5A]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VBAT_OVP_DIS	0	R/W	VBAT OVP Protection Disable Bit 0 = Enabled (Default) 1 = Disabled	REG_RST
D[6:0]	VBAT_OVP[6:0]	101 1010	R/W	VBAT OVP Protection Rising Threshold Setting Bits $V_{BAT\_OVP\_R}$ = 7V + VBAT_OVP[6:0] × 20mV Offset: 7V Range: 7V (000 0000) – 9.54V (111 1111) Default: 8.8V (101 1010)	REG_RST

REG0x01: VBATOVP_ALM Register [reset = 0x46]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VBATOVP_ALM_DIS	0	R/W	VBAT OVP Alarm Disable Bit 0 = Enabled (Default) 1 = Disabled	REG_RST
D[6:0]	VBATOVP_ALM[6:0]	100 0110	R/W	VBAT OVP Alarm Rising Threshold Setting Bits $V_{BATOVP\_ALM\_R}$ = 7V + VBAT_OVP[6:0] × 20mV Offset: 7V Range: 7V (000 0000) – 9.54V (111 1111) Default: 8.4V (100 0110) The VBAT OVP alarm rising threshold should be set lower than $V_{BAT\_OVP\_R}$ to ensure proper operation.	REG_RST

REG0x02: IBAT_OCP Register [reset = 0x51]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	IBAT_OCP_DIS	0	R/W	IBAT OCP Protection Disable Bit 0 = Enabled (Default) 1 = Disabled	REG_RST
D[6:0]	IBAT_OCP[6:0]	101 0001	R/W	IBAT OCP Protection Threshold Setting Bits I_{BAT_OCP} = IBAT_OCP[6:0] × 125mA Offset: 0mA Range: 0mA (000 0000) –15875mA (111 1111) Default: 10125mA (101 0001)	REG_RST

REGISTER MAPS (continued)

REG0x03: IBATOCP_ALM Register [reset = 0x50]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	IBATOCP_ALM_DIS	0	R/W	IBAT OCP Alarm Disable Bit 0 = Enabled (Default) 1 = Disabled	REG_RST
D[6:0]	IBATOCP_ALM[6:0]	101 0000	R/W	IBAT OCP Alarm Rising Threshold Setting Bits $I_{BATOCP\_ALM\_R}$ = IBATOCP_ALM[6:0] × 125mA Offset: 0mA Range: 0mA (000 0000) –15875mA (111 1111) Default: 10000mA (101 0000) The IBAT OCP alarm rising threshold should be set lower than I_{BAT_OCP} to ensure proper operation.	REG_RST

REG0x04: RESERVED1 Register [reset = 0x28]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	Reserved	0010 1000	R/W	Reserved	REG_RST

REG0x05: CHARGER_CONTROL1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	IBUS_UCP_DIS	0	R/W	IBUS UCP Protection Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[6]	Reserved	0	R/W	Reserved	REG_RST
D[5]	IBUS_RCP_DIS	0	R/W	IBUS RCP Protection Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[4:3]	Reserved	00	R/W	Reserved	REG_RST
D[2]	VBUS_HI_DIS	0	R/W	VBUS High Voltage Detection Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[1:0]	Reserved	00	R/W	Reserved	REG_RST

REGISTER MAPS (continued)

REG0x06: VBUS_OVP Register [reset = 0x26]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VBUS_PDN_EN	0	R/W	VBUS Pull-Down Resistor Enable Bit 0 = Pull-down disabled (default) 1 = Pull-down enabled. When enabled, the VBUS is pulled down by 6.5kΩ R_{PDN_VBUS}. This bit will not be automatically reset. The host should write this bit to 0 if there is no need to pull down VBUS.	REG_RST
D[6:0]	VBUS_OVP[6:0]	010 0110	R/W	VBUS OVP Protection Rising Threshold Setting Bits. Voltage Divider Mode: $V_{BUS\_OVP\_R}$ = 14V + VBUS_OVP[6:0] × 100mV Offset: 14V Range: 14V (000 0000) - 22V (101 0000) Default: 17.8V (010 0110) If VBUS_OVP[6:0] ≥ 101 0000, $V_{BUS\_OVP\_R}$ = 22V Bypass Mode: $V_{BUS\_OVP\_R}$ = 7V + VBUS_OVP[6:0] × 50mV Offset: 7V Range: 7V (000 0000) - 12.75V (111 0011) Default: 8.9V (010 0110) If VBUS_OVP[6:0] ≥ 111 0011, $V_{BUS\_OVP\_R}$ = 12.75V	REG_RST

REG0x07: VBUSOVP_ALM Register [reset = 0x22]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VBUSOVP_ALM_DIS	0	R/W	VBUS OVP Alarm Disable Bit 0 = Enabled (Default) 1 = Disabled	REG_RST
D[6:0]	VBUSOVP_ALM[6:0]	010 0010	R/W	VBUS OVP Alarm Rising Threshold Setting Bits Voltage Divider Mode: $V_{BUSOVP\_ALM\_R}$ = 14V + VBUSOVP_ALM[6:0] × 100mV Offset: 14V Range: 14V (000 0000) – 26.7V (111 1111) Default: 17.4V (010 0010) Bypass Mode: $V_{BUSOVP\_ALM\_R}$ = 7V + VBUSOVP_ALM[6:0] × 50mV Offset: 7V Range: 7V (000 0000) – 13.35V (111 1111) Default: 8.7V (010 0010) The VBUS OVP alarm rising threshold should be set lower than $V_{BUS\_OVP\_R}$ to ensure proper operation.	REG_RST

REG0x08: IBUS_OCP Register [reset = 0x0D]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:5]	Reserved	000	R/W	Reserved	REG_RST
D[4:0]	IBUS_OCP[4:0]	0 1101	R/W	IBUS OCP Protection Threshold Setting Bits I_{BUS_OCP} = 1050mA + IBUS_OCP[4:0] × 262.5mA Offset: 1050mA Range in voltage divider mode: 1050mA (0 0000) – 6037.5mA (1 0011) Range in bypass mode: 1050mA (0 0000) – 8925mA (1 1110) Default: 4462.5mA (0 1101) If IBUS_OCP[4:0] ≥ 1 0011 in voltage divider mode, I_{BUS_OCP} = 6037.5mA	REG_RST

REGISTER MAPS (continued)

REG0x09: RESERVED2 Register [reset = 0x0C]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	Reserved	00001100	R	Reserved	N/A

REG0x0A: TEMP_CONTROL Register [reset = 0x60]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	TDIE_OTP_DIS	0	R/W	TDIE OTP Protection Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[6:5]	TDIE_OTP[1:0]	11	R/W	TDIE OTP Protection Rising Threshold Setting Bits $T_{DIE\_OTP\_R}$ = 80℃ + TDIE_OTP[1:0] × 20℃ 00 = +80℃ 01 = +100℃ 10 = +120℃ 11 = +140℃ (default)	REG_RST
D[4]	TDIEOTP_ALM_DIS	0	R/W	TDIE OTP Alarm Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[3]	TSBUS_FLT_DIS	0	R/W	TSBUS_FLT Protection Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[2]	TSBAT_FLT_DIS	0	R/W	TSBAT_FLT Protection Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[1:0]	Reserved	00	R/W	Reserved	REG_RST

REG0x0B: TDIE_ALM Register [reset = 0xC8]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	TDIEOTP_ALM[7:0]	1100 1000	R/W	TDIE OTP Alarm Rising Threshold Setting Bits $T_{DIEOTP\_ALM\_R}$ = 25℃ + TDIEOTP_ALM[7:0] × 0.5℃ Offset: 25℃ Range: 25℃ (0000 0000) – 150℃ (1111 1010) Default: 125℃ (1100 1000) If TDIEOTP_ALM[7:0] ≥ 1111 1010, $T_{DIEOTP\_ALM\_R}$ = 150℃ The TDIE OTP alarm rising threshold should be set lower than $T_{DIE\_OTP\_R}$ to ensure proper operation.	REG_RST

REGISTER MAPS (continued)

REG0x0C: TSBUS_FLT Register [reset = 0x15]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	TSBUS_FLT[7:0]	0001 0101	R/W	TSBUS Percentage Fault Threshold Setting Bits. $TS_{BUS\_FLT\_F}$ = TSBUS_FLT[7:0] × 0.19531% Offset: 0% Range: 0% (0000 0000) – 49.8041% (1111 1111) Default: 4.10151% (0001 0101)	REG_RST

REG0x0D: TSBAT_FLT Register [reset = 0x15]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	TSBAT_FLT[7:0]	0001 0101	R/W	TSBAT Percentage Fault Threshold Setting Bits. $TS_{BAT\_FLT\_F}$ = TSBAT_FLT[7:0] × 0.19531% Offset: 0% Range: 0% (0000 0000) - 49.8041% (1111 1111) Default: 4.10151% (0001 0101)	REG_RST

REG0x0E: VAC_OVP Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:5]	VAC1_OVP[2:0]	000	R/W	VAC1 OVP Protection Rising Threshold Setting Bits. 000 = 6.5V (default) 001 = 10.5V 010 = 12V 011 = 14V 100 = 16V 101 = 18V 110 = 22V 111 = 24V	REG_RST
D[4:2]	VAC2_OVP[2:0]	000	R/W	VAC2 OVP Protection Rising Threshold Setting Bits. 000 = 6.5V (default) 001 = 10.5V 010 = 12V 011 = 14V 100 = 16V 101 = 18V 110 = 22V 111 = 24V	REG_RST
D[1]	VAC1_PDN_EN	0	R/W	VAC1 Pull-Down Resistor Enable Bit 0 = Pull-down disabled (default) 1 = Pull-down enabled. When enabled, the VAC1 is pulled down by 150Ω R_{PDN_VAC}. Note that to prevent chip damage, the pull-down current is limited to 38mA. This bit will not be automatically reset. The host should write this bit to 0 if there is no need to pull down VAC1.	REG_RST
D[0]	VAC2_PDN_EN	0	R/W	VAC2 Pull-Down Resistor Enable Bit 0 = Pull-down disabled (default) 1 = Pull-down enabled. When enabled, the VAC2 is pulled down by 150Ω R_{PDN_VAC}. Note that to prevent chip damage, the pull-down current is limited to 38mA. This bit will not be automatically reset. The host should write this bit to 0 if there is no need to pull down VAC2.	REG_RST

REGISTER MAPS (continued)

REG0x0F: CHARGER_CONTROL2 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	REG_RST	0	R/W	Register Reset Bit 0 = No register reset (default) 1 = Reset registers to their default values. When enabled, the associated register bits are reset to their default values and then this bit is automatically reset to 0.	REG_RST
D[6]	EN_HIZ	0	R/W	HIZ Mode Enable Bit 0 = Disable HIZ mode (default) 1 = Enable HIZ mode	REG_RST
D[5]	EN_OTG	0	R/W	Power Path Control Enable Bit During OTG Mode 0 = Don't allow the AP to control ACDRV in OTG mode 1 = Allow the AP to control ACDRV in OTG mode	REG_RST or Watchdog
D[4]	CHG_EN	0	R/W	Charge Enable Bit 0 = Disabled (default) 1 = Enabled. If any fault has occurred, device returns to standby mode and this bit is automatically cleared to 0.	REG_RST or Watchdog
D[3]	EN_BYPASS	0	R/W	Bypass Mode Enable Bit 0 = Disable bypass mode (default) 1 = Enable bypass mode	REG_RST or Watchdog
D[2]	DIS_ACDRV_BOTH	0	R/W	Disable Bit for Both ACDRV When this bit is set, the device forces both ACDRV off. 0 = ACDRV1 and ACDRV2 are allowed to be turned on (default) 1 = ACDRV1 and ACDRV2 are forced off	N/A
D[1]	ACDRV1_STAT	0	R/W	Status and Control Bit of ACDRV1 Driver For dual input configurations with two sets of OVPFETs, this bit can be used for input swapping. 0 = ACDRV1 is turned OFF (default) 1 = ACDRV1 is turned ON	N/A
D[0]	ACDRV2_STAT	0	R/W	Status and Control Bit of ACDRV2 Driver For dual input configurations with two sets of OVPFETs, this bit can be used for input swapping. 0 = ACDRV2 is turned OFF (default) 1 = ACDRV2 is turned ON	N/A

REG0x10: CHARGER_CONTROL3 Register [reset = 0x80]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:5]	FSW_SET[2:0]	100	R/W	Switched-Cap Converter Switching Frequency Setting Bits 000 = 187.5kHz 001 = 250kHz 010 = 300kHz 011 = 375kHz 100 = 500kHz (default) 101 = 750kHz	N/A
D[4:3]	WDT_TIMER[1:0]	00	R/W	Watchdog Timer Setting Bits 00 = 0.5s (default) 01 = 1s 10 = 5s 11 = 30s	REG_RST
D[2]	WDT_DIS	0	R/W	Watchdog Timer Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[1:0]	Reserved	00	R/W	Reserved	REG_RST

REGISTER MAPS (continued)

REG0x11: CHARGER_CONTROL4 Register [reset = 0x71]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	IBAT_RSNS	0	R/W	External IBAT Current Sense Resistor Setting Bit 0 = 2mΩ (default) 1 = 5mΩ	REG_RST
D[6:4]	SS_TIMEOUT[2:0]	111	R/W	Soft Start Timeout Setting Bits After soft start timeout, the device checks if I_{BUS} is above IBUS UCP threshold. 000 = 6.25ms 001 = 12.5ms 010 = 25ms 011 = 50ms 100 = 100ms 101 = 400ms 110 = 1.5s 111 = 10s (default)	N/A
D[3:2]	IBUS_UCP_FALL_DEG[1:0]	00	R/W	IBUS UCP Protection Deglitch Time Setting Bits 00 = 0.01ms (default) 01 = 5ms 10 = 50ms 11 = 150ms	REG_RST
D[1:0]	Reserved	01	R/W	Reserved	REG_RST

REG0x12: CHARGER_CONTROL5 Register [reset = 0x60]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VOUT_OVP_DIS	0	R/W	VOUT OVP Protection Disable Bit 0 = Enabled (default) 1 = Disabled	REG_RST
D[6:5]	VOUT_OVP[1:0]	11	R/W	VOUT OVP Protection Rising Threshold Setting Bits $V_{OUT\_OVP\_R}$ = 9.4V + VOUT_OVP[1:0] × 200mV 00 = 9.4V 01 = 9.6V 10 = 9.8V 11 = 10.0V (default)	REG_RST
D[4:3]	FREQ_SHIFT[1:0]	00	R/W	Bits of Adjusting Switching Frequency 00/11 = Nominal frequency (default) 01 = Nominal frequency +10% 10 = Nominal frequency -10%	REG_RST
D[2]	Reserved	0	R/W	Reserved	REG_RST
D[1:0]	MS[1:0]	00	R	Primary, Secondary, Standalone Operation 00 = Standalone (default) 01 = Secondary 10 = Primary 11 = Reserved	N/A

REGISTER MAPS (continued)

REG0x13: STAT1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VBAT_OVP_STAT	0	R	VBAT OVP Fault Status Bit 0 = Device not in VBAT OVP fault status (default) 1 = Device in VBAT OVP fault status	REG_RST
D[6]	VBATOVP_ALM_STAT	0	R	VBAT OVP Alarm Status Bit 0 = Device not in VBAT OVP alarm status (default) 1 = Device in VBAT OVP alarm status	REG_RST
D[5]	VOUT_OVP_STAT	0	R	VOUT OVP Fault Status Bit 0 = Device not in VOUT OVP fault status (default) 1 = Device in VOUT OVP fault status	REG_RST
D[4]	IBAT_OCP_STAT	0	R	IBAT OCP Fault Status Bit 0 = Device not in IBAT OCP fault status (default) 1 = Device in IBAT OCP fault status	REG_RST
D[3]	IBATOCP_ALM_STAT	0	R	BAT OCP Alarm Status Bit 0 = Device not in IBAT OCP alarm status (default) 1 = Device in IBAT OCP alarm status	REG_RST
D[2]	Reserved	0	R	Reserved	REG_RST
D[1]	VBUS_OVP_STAT	0	R	VBUS OVP Fault Status Bit 0 = Device not in VBUS OVP fault status (default) 1 = Device in VBUS OVP fault status	REG_RST
D[0]	VBUSOVP_ALM_STAT	0	R	VBUS OVP Alarm Status Bit 0 = Device not in VBUS OVP alarm status (default) 1 = Device in VBUS OVP alarm status	REG_RST

REG0x14: STAT2 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	IBUS_OCP_STAT	0	R	IBUS OCP Fault Status Bit 0 = Device not in IBUS OCP fault status (default) 1 = Device in IBUS OCP fault status	REG_RST
D[6]	Reserved	0	R	Reserved	REG_RST
D[5]	IBUS_UCP_STAT	0	R	IBUS UCP Fault Status Bit 0 = Device not in IBUS UCP fault status (default) 1 = Device in IBUS UCP fault status	REG_RST
D[4]	IBUS_RCP_STAT	0	R	IBUS RCP Fault Status Bit 0 = Device not in IBUS RCP fault status (default) 1 = Device in IBUS RCP fault status	REG_RST
D[3]	VBUS_SCP_STAT	0	R	VBUS SCP Fault Status Bit 0 = Device not in VBUS SCP fault status (default) 1 = Device in VBUS SCP fault status	REG_RST
D[2]	CFLY_SHORT_STAT	0	R	CFLY Short Detection Fault Status Bit 0 = CFLY not shorted (default) 1 = CFLY shorted	REG_RST
D[1]	Reserved	0	R	Reserved	REG_RST
D[0]	VBUS_LO_STAT	0	R	VBUS Low Voltage Fault Status Bit 0 = Device not in VBUS low voltage fault status (default) 1 = Device in VBUS low voltage fault status	REG_RST

REGISTER MAPS (continued)

REG0x15: STAT3 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VAC1_OVP_STAT	0	R	VAC1 OVP Fault Status Bit 0 = Device not in VAC1 OVP fault status (default) 1 = Device in VAC1 OVP fault status	REG_RST
D[6]	VAC2_OVP_STAT	0	R	VAC2 OVP Fault Status Bit 0 = Device not in VAC2 OVP fault status (default) 1 = Device in VAC2 OVP fault status	REG_RST
D[5]	VOUT_PRESENT_STAT	0	R	VOUT Present Status Bit 0 = VOUT not present (default) 1 = VOUT present	REG_RST
D[4]	VAC1_PRESENT_STAT	0	R	VAC1 Present Status Bit 0 = VAC1 not present (default) 1 = VAC1 present	REG_RST
D[3]	VAC2_PRESENT_STAT	0	R	VAC2 Present Status Bit 0 = VAC2 not present (default) 1 = VAC2 present	REG_RST
D[2]	VBUS_PRESENT_STAT	0	R	VBUS Present Status Bit 0 = VBUS not present (default) 1 = VBUS present	REG_RST
D[1]	ACRB1_CONFIG_STAT	0	R	ACFET1-RBFET1 Configuration Detection Status Bit 0 = ACFET1-RBFET1 is not placed (default) 1 = ACFET1-RBFET1 is placed	REG_RST
D[0]	ACRB2_CONFIG_STAT	0	R	ACFET2-RBFET2 Configuration Detection Status Bit 0 = ACFET2-RBFET2 is not placed (default) 1 = ACFET2-RBFET2 is placed	REG_RST

REG0x16: STAT4 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	ADC_DONE_STAT	0	R	ADC Conversion Status Bit In 1-shot conversion mode, this bit is set to 1 after ADC conversion of all enabled channels is completed. 0 = Conversion not complete (default) 1 = Conversion complete	REG_RST
D[6]	SS_TIMEOUT_STAT	0	R	Soft Start Timeout Status Bit 0 = Device not in soft timeout (default) 1 = Device in soft timeout	REG_RST
D[5]	TSBUS_TSBAT_ALM_STAT	0	R	TSBUS and TSBAT Alarm Status Bit 0 = TSBUS or TSBAT threshold is not within 5% of the TSBUS_FLT or TSBAT_FLT set threshold (default) 1 = TSBUS or TSBAT threshold is within 5% of the TSBUS_FLT or TSBAT_FLT set threshold	REG_RST
D[4]	TSBUS_FLT_STAT	0	R	TSBUS_FLT Status Bit 0 = Device not in TSBUS_FLT status (default) 1 = Device in TSBUS_FLT status	REG_RST
D[3]	TSBAT_FLT_STAT	0	R	TSBAT_FLT Status Bit 0 = Device not in TSBAT_FLT status (default) 1 = Device in TSBAT_FLT status	REG_RST
D[2]	TDIE_OTP_STAT	0	R	TDIE Over-Temperature Fault Status Bit 0 = Device not in TDIE over-temperature fault status (default) 1 = Device in TDIE over-temperature fault status	REG_RST
D[1]	TDIEOTP_ALM_STAT	0	R	TDIE Over-Temperature Alarm Status Bit 0 = Device not in TDIE over-temperature alarm status (default) 1 = Device in TDIE over-temperature alarm status	REG_RST
D[0]	WDT_STAT	0	R	Watchdog Timer Status Bit 0 = Normal (default) 1 = Watchdog timer expired	REG_RST

REGISTER MAPS (continued)

REG0x17: STAT5 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	REGN_GOOD_STAT	0	R	REGN_GOOD Status Bit 0 = REGN not good (default) 1 = REGN good	REG_RST
D[6]	CONV_ACTIVE_STAT	0	R	Converter Active Status Bit 0 = Converter not running (default) 1 = Converter running	REG_RST
D[5]	Reserved	0	R	Reserved	REG_RST
D[4]	VBUS_HI_STAT	0	R	VBUS High Voltage Fault Status Bit 0 = Device not in VBUS high voltage fault status (default) 1 = Device in VBUS high voltage fault status	REG_RST
D[3:0]	Reserved	0000	R	Reserved	REG_RST

REG0x18: FLAG1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VBAT_OVP_FLAG	0	R	VBAT OVP Fault Flag Bit 0 = No VBAT OVP fault (default) 1 = VBAT OVP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[6]	VBATOVP_ALM_FLAG	0	R	VBAT OVP Alarm Flag Bit 0 = No VBAT OVP alarm (default) 1 = VBAT OVP alarm has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[5]	VOUT_OVP_FLAG	0	R	VOUT OVP Fault Flag Bit 0 = No VOUT OVP fault (default) 1 = VOUT OVP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[4]	IBAT_OCP_FLAG	0	R	IBAT OCP Fault Flag Bit 0 = No IBAT OCP fault (default) 1 = IBAT OCP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[3]	IBATOCP_ALM_FLAG	0	R	IBAT OCP Alarm Flag Bit 0 = No IBAT OCP alarm (default) 1 = IBAT OCP alarm has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[2]	Reserved	0	R	Reserved	REG_RST
D[1]	VBUS_OVP_FLAG	0	R	VBUS OVP Fault Flag Bit 0 = No VBUS OVP fault (default) 1 = VBUS OVP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[0]	VBUSOVP_ALM_FLAG	0	R	VBUS OVP Alarm Flag Bit 0 = No VBUS OVP alarm (default) 1 = VBUS OVP alarm has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST

REGISTER MAPS (continued)

REG0x19: FLAG2 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	IBUS_OCP_FLAG	0	R	IBUS OCP Fault Flag Bit 0 = No IBUS OCP fault (default) 1 = IBUS OCP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[6]	Reserved	0	R	Reserved	REG_RST
D[5]	IBUS_UCP_FLAG	0	R	IBUS UCP Fault Flag Bit 0 = No IBUS UCP fault (default) 1 = IBUS UCP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[4]	IBUS_RCP_FLAG	0	R	IBUS RCP Fault Flag Bit 0 = No IBUS RCP fault (default) 1 = IBUS RCP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[3]	VBUS_SCP_FLAG	0	R	VBUS SCP Fault Flag Bit 0 = No VBUS SCP fault (default) 1 = VBUS SCP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[2]	CFLY_SHORT_FLAG	0	R	CFLY Short Detection Fault Flag Bit 0 = No CFLY short fault (default) 1 = CFLY short fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[1]	Reserved	0	R	Reserved	REG_RST
D[0]	VBUS_LO_FLAG	0	R	VBUS Low Voltage Fault Flag Bit 0 = No VBUS low voltage fault (default) 1 = Device in VBUS low voltage fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST

REG0x1A: FLAG3 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VAC1_OVP_FLAG	0	R	VAC1 OVP Fault Flag Bit 0 = No VAC1 OVP fault (default) 1 = VAC1 OVP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[6]	VAC2_OVP_FLAG	0	R	VAC2 OVP Fault Flag Bit 0 = No VAC2 OVP fault (default) 1 = VAC2 OVP fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[5]	VOUT_PRESENT_FLAG	0	R	VOUT Present Flag Bit 0 = No VOUT present event (default) 1 = VOUT present event has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[4]	VAC1_PRESENT_FLAG	0	R	VAC1 Present Flag Bit 0 = No VAC1 present event (default) 1 = VAC1 present event has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[3]	VAC2_PRESENT_FLAG	0	R	VAC2 Present Flag Bit 0 = No VAC2 present event (default) 1 = VAC2 present event has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[2]	VBUS_PRESENT_FLAG	0	R	VBUS Present Flag Bit 0 = No VBUS present event (default) 1 = VBUS present event has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[1]	ACRB1_CONFIG_FLAG	0	R	ACFET1-RBFET1 Configuration Detection Flag Bit 0 = Normal (default) 1 = ACFET1-RBFET1 configuration status changed. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[0]	ACRB2_CONFIG_FLAG	0	R	ACFET2-RBFET2 Configuration Detection Flag Bit 0 = Normal (default) 1 = ACFET2-RBFET2 configuration status changed. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST

REGISTER MAPS (continued)

REG0x1B: FLAG4 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	ADC_DONE_FLAG	0	R	ADC Conversion Complete Event Flag Bit In 1-shot conversion mode, this bit is set to 1 after ADC conversion of all enabled channels is completed. 0 = Normal (default) 1 = ADC conversion has completed. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[6]	SS_TIMEOUT_FLAG	0	R	Soft-Start Timeout Flag Bit 0 = No soft-start timeout event (default) 1 = Soft-start timeout event has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[5]	TSBUS_TSBAT_ ALM_FLAG	0	R	TSBUS_TSBAT Alarm Flag Bit 0 = No TSBUS_TSBAT alarm (default) 1 = TSBUS_TSBAT alarm has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[4]	TSBUS_FLT_FLAG	0	R	TSBUS_FLT Flag Bit 0 = No TSBUS Fault (default) 1 = TSBUS fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[3]	TSBAT_FLT_FLAG	0	R	TSBAT_FLT Flag Bit 0 = No TSBAT Fault (default) 1 = TSBAT fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[2]	TDIE_OTP_FLAG	0	R	TDIE Over-Temperature Fault Flag Bit 0 = No TDIE over-temperature fault (default) 1 = TDIE over-temperature fault has occurred. It generates an interrupt on nINT pin if unmasked. Reading this bit will reset it to 0.	REG_RST
D[1]	TDIEOTP_ALM_FLAG	0	R	TDIE Over-Temperature Alarm Flag Bit 0 = No TDIE over-temperature alarm (default) 1 = TDIE over-temperature alarm has occurred. It generates an interrupt on nINT pin if unmasked. Reading this bit will reset it to 0.	REG_RST
D[0]	WDT_FLAG	0	R	Watchdog Timeout Fault Flag Bit 0 = No watchdog timeout fault (default) 1 = Watchdog timeout fault has occurred. It generates an interrupt on nINT pin if unmasked. Reading this bit will reset it to 0.	REG_RST

REG0x1C: FLAG5 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	REGN_GOOD_FLAG	0	R	REGN_GOOD Event Flag Bit 0 = No REGN_GOOD event (default) 1 = REGN_GOOD event has occurred. When the REGN_GOOD status bit has changed, it generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[6]	CONV_ACTIVE_FLAG	0	R	Converter Active Event Flag Bit 0 = No converter active event (default) 1 = Converter active event has occurred. When the converter active status bit has changed, it generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[5]	Reserved	0	R	Reserved	REG_RST
D[4]	VBUS_HI_FLAG	0	R	VBUS High Voltage Fault Flag Bit 0 = No VBUS high voltage fault (default) 1 = Device in VBUS high voltage fault has occurred. It generates an interrupt on nINT pin if unmasked. Read this bit to reset it to 0.	REG_RST
D[3:0]	Reserved	0000	R	Reserved	REG_RST

REGISTER MAPS (continued)

REG0x1D: MASK1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VBAT_OVP_MASK	0	R/W	Mask VBAT OVP Fault Interrupt 0 = VBAT OVP fault interrupt can work (default) 1 = Mask VBAT OVP fault interrupt. VBAT_OVP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[6]	VBATOVP_ALM_MASK	0	R/W	Mask VBAT OVP Alarm Interrupt 0 = VBAT OVP alarm interrupt can work (default) 1 = Mask VBAT OVP alarm interrupt. VBATOVP_ALM_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[5]	VOUT_OVP_MASK	0	R/W	Mask VOUT OVP Fault Interrupt 0 = VOUT OVP fault interrupt can work (default) 1 = Mask VOUT OVP fault interrupt. VOUT_OVP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[4]	IBAT_OCP_MASK	0	R/W	Mask IBAT OCP Fault Interrupt 0 = IBAT OCP fault interrupt can work (default) 1 = Mask IBAT OCP fault interrupt. IBAT_OCP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[3]	IBATOCP_ALM_MASK	0	R/W	Mask IBAT OCP Alarm Interrupt 0 = IBAT OCP alarm interrupt can work (default) 1 = Mask IBAT OCP alarm interrupt. IBATOCP_ALM_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[2]	Reserved	0	R	Reserved	REG_RST
D[1]	VBUS_OVP_MASK	0	R/W	Mask VBUS OVP Fault Interrupt 0 = VBUS OVP fault interrupt can work (default) 1 = Mask VBUS OVP fault interrupt. VBUS_OVP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[0]	VBUSOVP_ALM_MASK	0	R/W	Mask VBUS OVP Alarm Interrupt 0 = VBUS OVP alarm interrupt can work (default) 1 = Mask VBUS OVP alarm interrupt. VBUSOVP_ALM_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST

REG0x1E: MASK2 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	IBUS_OCP_MASK	0	R/W	Mask IBUS OCP Fault Interrupt 0 = IBUS OCP fault interrupt can work (default) 1 = Mask IBUS OCP fault interrupt. IBUS_OCP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[6]	Reserved	0	R/W	Reserved	REG_RST
D[5]	IBUS_UCP_MASK	0	R/W	Mask IBUS UCP Fault Interrupt 0 = IBUS UCP fault interrupt can work (default) 1 = Mask IBUS UCP fault interrupt. IBUS_UCP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[4]	IBUS_RCP_MASK	0	R/W	Mask IBUS RCP Fault Interrupt 0 = IBUS RCP fault interrupt can work (default) 1 = Mask IBUS RCP fault interrupt. IBUS_RCP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[3]	VBUS_SCP_MASK	0	R/W	Mask VBUS SCP Fault Interrupt 0 = VBUS SCP fault interrupt can work (default) 1 = Mask VBUS SCP fault interrupt. VBUS_SCP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[2]	CFLY_SHORT_MASK	0	R/W	Mask CFLY Short Fault Interrupt 0 = CFLY short fault interrupt can work (default) 1 = Mask CFLY short fault interrupt. CFLY_SHORT_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[1]	Reserved	0	R/W	Reserved	REG_RST
D[0]	VBUS_LO_MASK	0	R/W	Mask VBUS Low Voltage Fault Interrupt 0 = VBUS low voltage fault interrupt can work (default) 1 = Mask VBUS low voltage fault interrupt. VBUS_LO_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST

REGISTER MAPS (continued)

REG0x1F: MASK3 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VAC1_OVP_MASK	0	R/W	Mask VAC1 OVP Fault Interrupt 0 = VAC1 OVP fault interrupt can work (default) 1 = Mask VAC1 OVP fault interrupt. VAC1_OVP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[6]	VAC2_OVP_MASK	0	R/W	Mask VAC2 OVP Fault Interrupt 0 = VAC2 OVP fault interrupt can work (default) 1 = Mask VAC2 OVP fault interrupt. VAC2_OVP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[5]	VOUT_PRESENT_MASK	0	R/W	Mask VOUT Present Event Interrupt 0 = VOUT present event interrupt can work (default) 1 = Mask VOUT present event interrupt. VOUT_PRESENT_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[4]	VAC1_PRESENT_MASK	0	R/W	Mask VAC1 Present Event Interrupt 0 = VAC1 present event interrupt can work (default) 1 = Mask VAC1 present event interrupt. VAC1_PRESENT_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[3]	VAC2_PRESENT_MASK	0	R/W	Mask VAC2 Present Event Interrupt 0 = VAC2 present event interrupt can work (default) 1 = Mask VAC2 present event interrupt. VAC2_PRESENT_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[2]	VBUS_PRESENT_MASK	0	R/W	Mask VBUS Present Event Interrupt 0 = VBUS present event interrupt can work (default) 1 = Mask VBUS present event interrupt. VBUS_PRESENT_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[1]	ACRB1_CONFIG_MASK	0	R/W	Mask ACFET1-RBFET1 Configuration Status Change Event Interrupt 0 = ACRB1_CONFIG status bit change event interrupt can work (default) 1 = Mask ACRB1_CONFIG status bit change event interrupt. ACRB1_CONFIG_FLAG is set after the event, but the interrupt signal is not generated.	REG_RST
D[0]	ACRB2_CONFIG_MASK	0	R/W	Mask ACFET2-RBFET2 Configuration Status Change Event Interrupt 0 = ACRB2_CONFIG status bit change event interrupt can work (default) 1 = Mask ACRB2_CONFIG status bit change event interrupt. ACRB2_CONFIG_FLAG is set after the event, but the interrupt signal is not generated.	REG_RST

REGISTER MAPS (continued)

REG0x20: MASK4 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	ADC_DONE_MASK	0	R/W	Mask ADC Complete Event Interrupt 0 = ADC_DONE event interrupt can work (default) 1 = Mask ADC_DONE event interrupt. ADC_DONE_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[6]	SS_TIMEOUT_MASK	0	R/W	Mask Soft-Start Timeout Event Interrupt 0 = SS_TIMEOUT event interrupt can work (default) 1 = Mask SS_TIMEOUT event interrupt. SS_TIMEOUT_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[5]	TSBUS_TSBAT_ ALM_MASK	0	R/W	Mask TSBUS_TSBAT Alarm Interrupt 0 = TSBUS_TSBAT alarm interrupt can work (default) 1 = Mask TSBUS_TSBAT alarm interrupt. TSBUS_TSBAT_ALM_ FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[4]	TSBUS_FLT_MASK	0	R/W	Mask TSBUS_FLT Interrupt 0 = TSBUS_FLT interrupt can work (default) 1 = Mask TSBUS_FLT interrupt. TSBUS_FLT_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[3]	TSBAT_FLT_MASK	0	R/W	Mask TSBAT_FLT Interrupt 0 = TSBAT_FLT interrupt can work (default) 1 = Mask TSBAT_FLT interrupt. TSBAT_FLT_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[2]	TDIE_OTP_MASK	0	R/W	Mask TDIE OTP Fault Interrupt 0 = TDIE OTP fault interrupt can work (default) 1 = Mask TDIE OTP fault interrupt. TDIE_OTP_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[1]	TDIEOTP_ALM_MASK	0	R/W	Mask TDIE OTP Alarm Interrupt 0 = TDIE OTP alarm interrupt can work (default) 1 = Mask TDIE OTP alarm interrupt. TDIEOTP_ALM_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[0]	WDT_MASK	0	R/W	Mask Watchdog Timeout Fault Interrupt 0 = Watchdog timeout fault interrupt can work (default) 1 = Mask watchdog timeout fault interrupt. WDT_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST

REG0x21: MASK5 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	REGN_GOOD_MASK	0	R/W	Mask REGN_GOOD Status Change Event Interrupt 0 = REGN_GOOD status change event interrupt can work (default) 1 = Mask REGN_GOOD status change event interrupt. REGN_GOOD_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[6]	CONV_ACTIVE_MASK	0	R/W	Mask Converter Active Status Change Event Interrupt 0 = Converter active status change event interrupt can work (default) 1 = Mask converter active status change event interrupt. CONV_ACTIVE_FLAG bit is set after the event, but the interrupt signal is not generated.	REG_RST
D[5]	Reserved	0	R/W	Reserved	REG_RST
D[4]	VBUS_HI_MASK	0	R/W	Mask VBUS High Voltage Fault Interrupt 0 = VBUS high voltage fault interrupt can work (default) 1 = Mask VBUS high voltage fault interrupt. VBUS_HI_FLAG bit is set after the fault, but the interrupt signal is not generated.	REG_RST
D[3:0]	Reserved	0000	R	Reserved	REG_RST

REGISTER MAPS (continued)

REG0x22: DEVICE_INFO Register [reset = 0x12]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:4]	DEVICE_VER[3:0]	R	0001	Device Version	N/A
D[3:0]	DEVICE_ID[3:0]	R	0010	Device ID 0010 = SGM41602	N/A

REG0x23: ADC_CTRL0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	ADC_EN	0	R/W	ADC Conversion Enable 0 = Disabled (default) 1 = Enabled Note: In 1-shot mode when the selected channel conversions are completed, the ADC_EN bit is automatically reset to 0. All channel conversions can be enabled even when the device is not during switching.	REG_RST or Watchdog
D[6]	ADC_RATE	0	R/W	ADC Conversion Mode Control 0 = Continuous conversion (default) 1 = 1-shot conversion	REG_RST
D[5]	ADC_AVG	0	R/W	ADC Average Enable Bit 0 = Single value (default) 1 = Running average	REG_RST
D[4]	ADC_AVG_INIT	0	R/W	ADC Average Initial Value Setting Bit 0 = Start average using the existing register value (default) 1 = Start average using a new conversion	REG_RST
D[3:2]	ADC_SAMPLE[1:0]	00	R/W	ADC Sample Speed 00 = 15 bit (default) 01 = 14 bit 10 = 13 bit 11 = 12 bit	REG_RST
D[1]	IBUS_ADC_DIS	0	R/W	IBUS ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[0]	VBUS_ADC_DIS	0	R/W	VBUS ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST

REGISTER MAPS (continued)

REG0x24: ADC_CTRL1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	VAC1_ADC_DIS	0	R/W	VAC1 ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[6]	VAC2_ADC_DIS	0	R/W	VAC2 ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[5]	VOUT_ADC_DIS	0	R/W	VOUT ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[4]	VBAT_ADC_DIS	0	R/W	VBAT ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[3]	IBAT_ADC_DIS	0	R/W	IBAT ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[2]	TSBUS_ADC_DIS	0	R/W	TSBUS ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[1]	TSBAT_ADC_DIS	0	R/W	TSBAT ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST
D[0]	TDIE_ADC_DIS	0	R/W	TDIE ADC Control 0 = Enable conversion (default) 1 = Disable conversion	REG_RST

REG0x25: IBUS_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	IBUS_ADC[15:8]	00000000	R	High Byte of the 16-bit ADC IBUS Data (resolution: 1mA, range: 0mA - 9000mA) MSB<7:0>: 32768mA, 16384mA, 8192mA, 4096mA, 2048mA, 1024mA, 512mA, 256mA	N/A

REG0x26: IBUS_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	IBUS_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC IBUS Data (resolution: 1mA, range: 0mA - 9000mA) LSB<7:0>: 128mA, 64mA, 32mA, 16mA, 8mA, 4mA, 2mA, 1mA	N/A

REG0x27: VBUS_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VBUS_ADC[15:8]	00000000	R	High Byte of the 16-bit ADC VBUS Data (resolution: 1mV, range: 3V - 24V) MSB<7:0>: 32768mV, 16384mV, 8192mV, 4096mV, 2048mV, 1024mV, 512mV, 256mV	N/A

REGISTER MAPS (continued)

REG0x28: VBUS_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VBUS_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC VBUS Data (resolution: 1mV, range: 3V - 24V) LSB<7:0>: 128mV, 64mV, 32mV, 16mV, 8mV, 4mV, 2mV, 1mV	N/A

REG0x29: VAC1_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VAC1_ADC[15:8]	00000000	R	High Byte of the 16-bit ADC VAC1 Data (resolution: 1mV, range: 3V - 24V) MSB<7:0>: 32768mV, 16384mV, 8192mV, 4096mV, 2048mV, 1024mV, 512mV, 256mV	N/A

REG0x2A: VAC1_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VAC1_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC VAC1 Data (resolution: 1mV, range: 3V - 24V) LSB<7:0>: 128mV, 64mV, 32mV, 16mV, 8mV, 4mV, 2mV, 1mV	N/A

REG0x2B: VAC2_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VAC2_ADC[15:8]	00000000	R	High Byte of the 16-bit ADC VAC2 Data (resolution: 1mV, range: 3V - 24V) MSB<7:0>: 32768mV, 16384mV, 8192mV, 4096mV, 2048mV, 1024mV, 512mV, 256mV	N/A

REG0x2C: VAC2_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VAC2_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC VAC2 Data (resolution: 1mV, range: 3V - 24V) LSB<7:0>: 128mV, 64mV, 32mV, 16mV, 8mV, 4mV, 2mV, 1mV	N/A

REG0x2D: VOUT_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VOUT_ADC[15:8]	00000000	R	High Byte of the 16-bit ADC VOUT Data (resolution: 1mV, range: 3V - 12V) MSB<7:0>: 32768mV, 16384mV, 8192mV, 4096mV, 2048mV, 1024mV, 512mV, 256mV	N/A

REGISTER MAPS (continued)

REG0x2E: VOUT_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VOUT_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC VOUT Data (resolution: 1mV, range: 3V - 12V) LSB<7:0>: 128mV, 64mV, 32mV, 16mV, 8mV, 4mV, 2mV, 1mV	N/A

REG0x2F: VBAT_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VBAT_ADC[15:8]	00000000	R	High Byte of the 16-bit ADC VBAT Data (resolution: 1mV, range: 3V - 12V) MSB<7:0>: 32768mV, 16384mV, 8192mV, 4096mV, 2048mV, 1024mV, 512mV, 256mV	N/A

REG0x30: VBAT_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	VBAT_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC VBAT Data (resolution: 1mV, range: 3V - 12V) LSB<7:0>: 128mV, 64mV, 32mV, 16mV, 8mV, 4mV, 2mV, 1mV	N/A

REG0x31: IBAT_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	IBAT_ADC[15:8]	00000000	R	High Byte of the 16-bit ADC IBAT Data (resolution: 1mA, range: 0A - 16A) MSB<7:0>: 32768mA, 16384mA, 8192mA, 4096mA, 2048mA, 1024mA, 512mA, 256mA	N/A

REG0x32: IBAT_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	IBAT_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC IBAT Data (resolution: 1mA, range: 0A - 16A) LSB<7:0>: 128mA, 64mA, 32mA, 16mA, 8mA, 4mA, 2mA, 1mA	N/A

REG0x33: TSBUS_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:2]	Reserved	000000	R	Reserved	N/A
D[1:0]	TSBUS_ADC[9:8]	00	R	Higher 2 Bits of the 10-bit ADC TSBUS Data (resolution: 0.09766%, range: 0% - 50%) MSB<2:0>: 50.00192%, 25.00096% Range: 0% - 50%	N/A

REGISTER MAPS (continued)

REG0x34: TSBUS_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	TSBUS_ADC[7:0]	00000000	R	Low Byte of the 10-bit ADC TSBUS Data (resolution: 0.09766%, range: 0% - 50%) LSB<7:0>: 12.50048%, 6.25024%, 3.12512%, 1.56256%, 0.78128%, 0.39064%, 0.19532%, 0.09766%	N/A

REG0x35: TSBAT_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:2]	Reserved	000000	R	Reserved	N/A
D[1:0]	TSBAT_ADC[9:8]	00	R	Higher 2 Bits of the 10-bit ADC TSBAT Data (resolution: 0.09766%, range: 0% - 50%) MSB<2:0>: 50.00192%, 25.00096% Range: 0% - 50%	N/A

REG0x36: TSBAT_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	TSBAT_ADC[7:0]	00000000	R	Low Byte of the 10-bit ADC TSBAT Data (resolution: 0.09766%, range: 0% - 50%) LSB<7:0>: 12.50048%, 6.25024%, 3.12512%, 1.56256%, 0.78128%, 0.39064%, 0.19532%, 0.09766%	N/A

REG0x37: TDIE_ADC1 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7]	TDIE_ADC_POL	0	R	Polarity of the 16-bit ADC TDIE Data 0 = Positive (default) 1 = Negative	N/A
D[6:0]	TDIE_ADC[14:8]	0000000	R	Higher 7 Bits of the 16-bit ADC TDIE Data (resolution: 0.5℃, range: -40℃ - +150℃) MSB<7:0>: 8192℃, 4096℃, 2048℃, 1024℃, 512℃, 256℃, 128℃	N/A

REG0x38: TDIE_ADC0 Register [reset = 0x00]

BITS	BIT NAME	DEFAULT	TYPE	DESCRIPTION	RESET BY
D[7:0]	TDIE_ADC[7:0]	00000000	R	Low Byte of the 16-bit ADC TDIE Data (resolution: 0.5℃, range: -40℃ - +150℃) LSB<7:0>: 64℃, 32℃, 16℃, 8℃, 4℃, 2℃, 1℃, 0.5℃	N/A

APPLICATION INFORMATION

Input Capacitors (C_{VAC1}, C_{VAC2}, C_{VBUS} and C_{PMID})

Input capacitors are selected by considering two main factors:

1. Adequate voltage margin above maximum surge voltage.
2. Not too large voltage margin in order to limit the peak currents drawn from the source and reduce the input noise.

For C_{VAC1}, C_{VAC2} and C_{VBUS}, use low ESR bypass ceramic capacitors to place close to the VAC1/VAC2/VBUS and GND pins respectively. The C_{PMID} are determined by the minimum capacitance needed for stable operation and the required ESR to minimize the voltage ripple and load step transients. Typically, a 4.7μF or larger X5R ceramic capacitors are sufficient to meet the C_{PMID} requirements of two channels. Consider the DC bias derating of the ceramic capacitors. The X5R and X7R capacitors are relatively stable against DC bias and high temperature. Note that the bias effect is more severe with smaller package sizes, so choose the largest affordable package size. Also consider a large margin for the voltage rating for the worst-case transient input voltages.

External OVPFETs (ACFET1-RBFET1 and ACFET2-RBFET2)

The maximum recommended input range is 22V. If the supplied VAC1 or VAC2 voltage is above 22V, two sets of back-to-back N-channel OVPFETs are recommended between the adapter inputs and the SGM41602. Choose a low R_{DSON} MOSFET for the OVPFET to minimize power losses.

Flying Capacitors (C_{FLY})

For selection of the C_{FLY} capacitors, the current rating, ESR and the bias voltage derating are critical parameters. The C_{FLY} capacitors are biased to different DC voltages according to the operation mode. To trade-off between efficiency and power density, set the C_{FLY} voltage ripple to the 2% of the V_{VOUT} as a good starting point. The C_{FLY} for each phase can be calculated by Equation 10:

$$C_{FLY} = \frac{I_{BAT}}{4 f_{SW} V_{CFLY\_RPP}} = \frac{I_{BAT}}{8\% f_{SW} V_{DC\_CFLY}} \quad (10)$$

where I_{BAT} is the charging current and V_{CFLY_RPP} is the peak-to-peak voltage ripple of the C_{FLY}.

Choosing a too small capacitor for C_{FLY} results in lower efficiency and high output voltage/current ripples. However choosing a too large C_{FLY} only provides minor efficiency and output ripple improvements.

The default switching frequency is f_{SW} = 500kHz. It can be adjusted by FSW_SET[2:0] bits in REG0x10. Lower frequency increases efficiency by reducing switching losses but requires larger capacitance to maintain low output ripple and low output impedance (R_{EFF}). An optimum switching frequency can be found for any selected C_{FLY} capacitor to minimize losses.

Output Capacitor (C_{VOUT})

C_{VOUT} selection criteria are similar to the C_{FLY} capacitor. Larger C_{VOUT} value results in less output voltage ripple, but due to the dual-phase operation, the C_{VOUT} RMS current is much smaller than C_{FLY}, so smaller capacitance value can be chosen for C_{VOUT} as given in Equation 11:

$$C_{VOUT} = \frac{I_{BAT} \times t_{DEAD}}{0.5 \times V_{VOUT\_RPP}} \quad (11)$$

where t_{DEAD} is the dead time between the two phases and V_{VOUT_RPP} is the peak-to-peak output voltage ripple and is typically set to the 2% of V_{OUT}.

C_{VOUT} is biased to the battery voltage and its nominal value should be derated for battery voltage DC bias. Typically a 22μF, X5R or better grade ceramic capacitors placed close to the VOUT and GND pins provide stable performance of two channels.

PCB Layout Guidelines

A good PCB layout is critical for stable operation of the SGM41602. Follow these guidelines for the best results:

1. Use short and wide traces for VBUS as it carries high current.
2. Minimize connectors wherever possible. Connector losses are significant especially at high currents.
3. Use solid thermal vias for better thermal relief.
4. Bypass VBUS, PMID and VOUT pins to GND with ceramic capacitors as close to the device pins as possible.
5. Place C_{FLY} capacitors as close as possible to the device with small pad areas to reduce switching noise and EMI.
6. CLFY pours of the two channels should be as symmetrical as possible.
7. Connect and reference all power signals to the GND pins (preferably the nearest ones).
8. Try not to interrupt or break the power planes by signal traces.

TYPICAL APPLICATION CIRCUIT

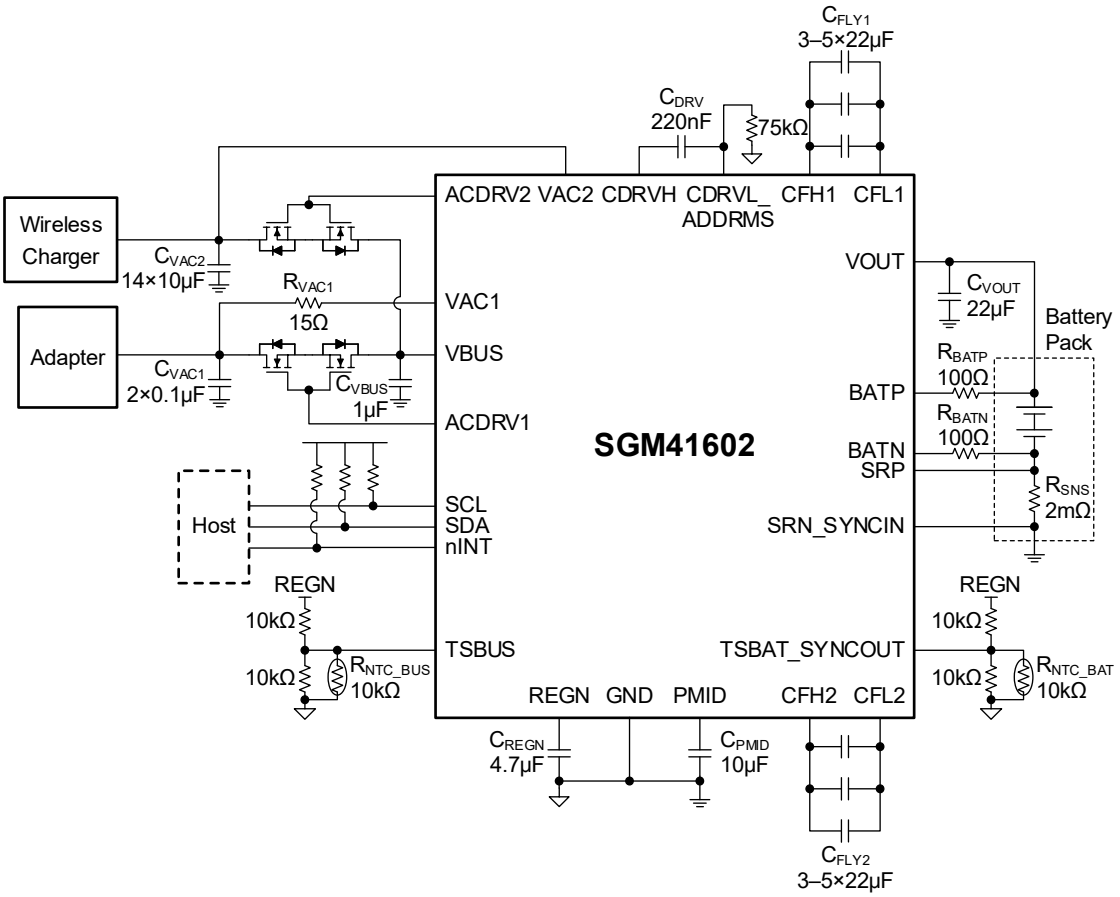


Figure 15. Typical Application Circuit of SGM41602

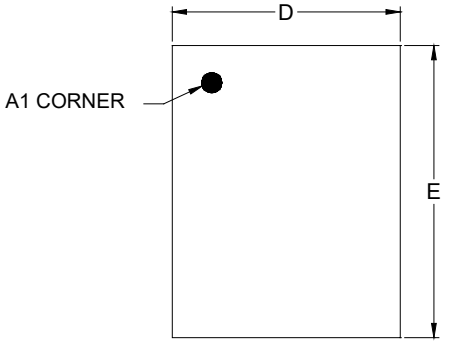
REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

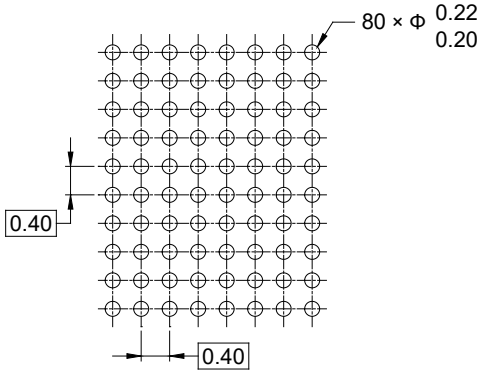
Changes from Original (JUNE 2025) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

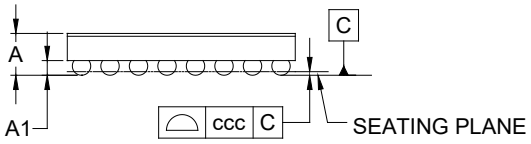
WLCSP-3.2×4.1-80B



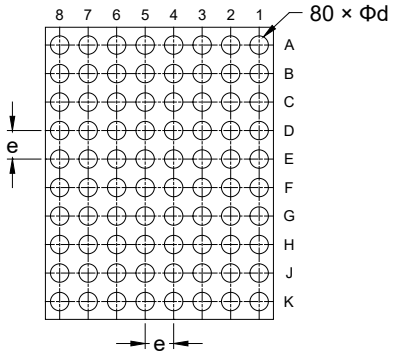
TOP VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



SIDE VIEW



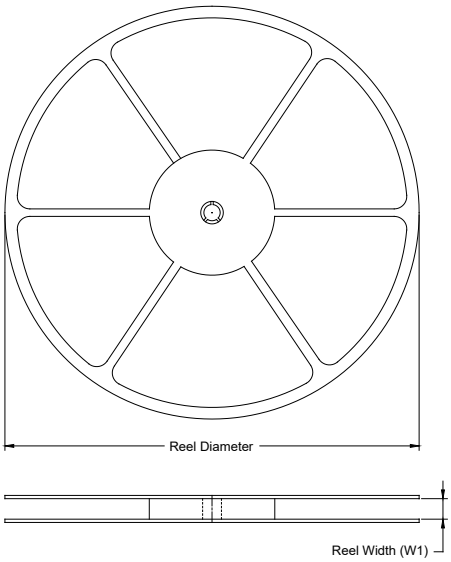
BOTTOM VIEW

Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	0.625
A1	0.190	-	0.230
D	3.170	-	3.230
E	4.070	-	4.130
d	0.228	-	0.288
e	0.400 BSC		
ccc	0.050		

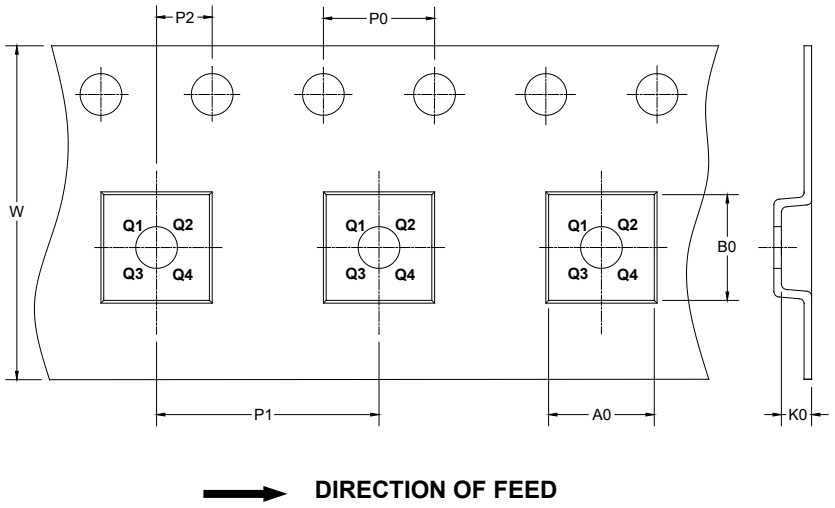
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



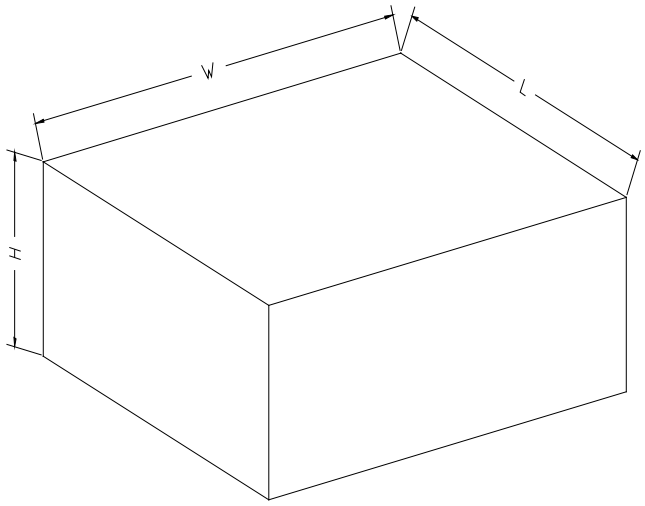
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
WLCSP-3.2×4.1-80B	13"	12.4	3.60	4.36	0.76	4.0	8.0	2.0	12.0	Q1

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
13″	386	280	370	5

DD0002