SGM41522/SGM41522A Compact Switch, 2.5A Standalone Single-Cell Battery Charger with Safe and Reliable Charging

GENERAL DESCRIPTION

The SGM41522 and SGM41522A are compact switch standalone battery chargers for single-cell Li-Ion or Li-polymer battery. They are featured with resistor programmable maximum charge current, ordering selections of preset end of charge current and pre-charge current and floating time out. The SGM41522 and SGM41522A also have other safety features, such as over-voltage and over-current protections, fold-back retaining, input under-voltage lockout, battery temperature monitoring and thermal shutdown. These features ensure safe and reliable operation, ease of design and a comfortable user experience.

The SGM41522 and SGM41522A are available in a Green TDFN-2×3-8BL package. They operate over an ambient temperature range of -40℃ to +85℃.

APPLICATIONS

Portable Audio Speaker
Mobile Phone
Wearables
EPOS

FEATURES

- **Maximum 2.5A Charging for 4.1V to 4.45V Battery**
- **1.33MHz Switch Frequency**
- **Up to 95.4% Charge Efficiency**
- **92.8% Charge Efficiency at 1.5A from 5V Input**
- **90.1% Charge Efficiency at 1.5A from 9V Input**
- **Charging Voltage and Current Programmable**
- **CC/CV Interface for Charge Current and Battery Voltage Settings**
- **4.2V Input Voltage Regulation**
- **4.2V to 12V Operating Input Voltage Range**
- **Up to 18V Sustainable Voltage**
- **13.5V Over-Voltage Protection with 100ns Turn-Off Timer**
- **Output Voltage Fold-Back Retaining**
- **JEITA Guideline Compliance**
  - **T2 Threshold 10℃ (SGM41522)**
  - **T2 Threshold 15℃ (SGM41522A)**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in a Green TDFN-2×3-8BL Package**

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41522	TDFN-2×3-8BL	-40℃ to +85℃	SGM41522YTDC8G/TR	RE1 XXXX	Tape and Reel, 3000
SGM41522A	TDFN-2×3-8BL	-40℃ to +85℃	SGM41522AYTDC8G/TR	SHG XXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXX = Date Code and Trace Code.

YYY — Serial Number
XXXX
Trace Code
Date Code - Year

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

Voltage Range (with Respect to GND)
VBUS (Converter Not Switching) .... -2V to 18V
BTST (Converter Not Switching)...................... -0.3V to 18V
SW, BAT .... -2V to 14V
BTST to SW .... -0.3V to 6V
REGN, TS (Converter Not Switching)................ -0.3V to 6V
CC, CV... -0.3V to 6V
Package Thermal Resistance
TDFN-2×3-8BL, θ_{JA}... 55℃/W
Junction Temperature...+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s)............................+260℃
ESD Susceptibility
HBM..2000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range, V_{VBUS} ....4.2V to 12V
Input Current (VBUS), I_{IN} ....2.5A (MAX)
Output Current (SW), I_{SWOP}.................................2.5A (MAX)
Battery Voltage, V_{BATOP}.....................................4.45V (MAX)
Fast Charge Current, I_{CHGOP} ....2.5A (MAX)
Ambient Temperature Range..........................-40℃ to +85℃
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.

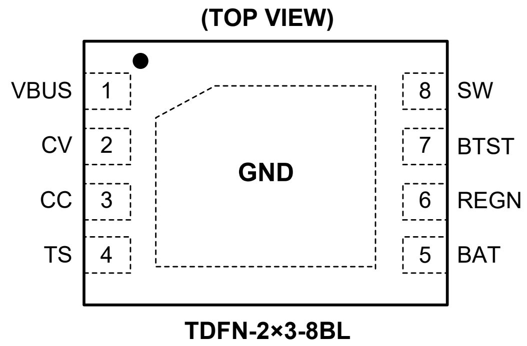
ESD SENSITIVITY CAUTION

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



PIN DESCRIPTION

PIN	NAME	TYPE [(1)]	FUNCTION
1	VBUS	P	Charger Input and Voltage Sense. Connect a 10μF ceramic capacitor from VBUS pin to GND close to device.
2	CV	AI	Charge Voltage Programming Input Pin. Connect a resistor between this pin and GND, for feeding different voltages to select 6 different charge voltages.
3	CC	AI	Charge Current Programming and Charging Inhibition Input Pin. Connect a resistor between this pin and GND for programming the constant charge current by $I_{CHGREG} = K \cdot V_{REF}/R_{CC}$. Pull up this pin to a voltage higher than V_{CC_H} (1.4V) to stop charging.
4	TS	AI	Temperature Sense Input Pin. Connect to the battery NTC thermistor that is grounded on the other side. To program operating temperature window, it can be biased by a resistor divider between REGN and GND. Charge suspends if TS voltage goes out of the programmed range. It is recommended to use a 103AT-2 type thermistor. If NTC or TS pin function is not needed, use a 10kΩ/10kΩ pair for the resistor divider.
5	BAT	P	Battery Positive Terminal Pin. Use a 22μF capacitor between BAT and GND pins close to the device.
6	REGN	P	LDO Output that Powers LSFET Driver and Internal Circuits. Internally, the REGN pin is connected to the anode of the bootstrap diode. Place a 1μF (10V rating) ceramic capacitor between REGN pin and GND. It is recommended to place the capacitor close to the REGN pin.
7	BTST	P	High-side Driver Positive Supply. It is internally connected to the bootstrap diode cathode. Use a 10nF ceramic capacitor from SW pin to BTST pin.
8	SW	P	Switching Node Output. Connect SW pin to the output inductor. Connect the 10nF bootstrap capacitor from SW pin to BTST pin.
Exposed Pad	GND	P	Thermal Pad and Ground Reference. It is the ground reference for the device and also the thermal pad to conduct heat from the device (not suitable for high current return). Tie externally to the PCB ground plane (GND). Thermal vias under the pad are needed to conduct the heat to the PCB ground planes.

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

ELECTRICAL CHARACTERISTICS

(V_{VBUS_UVLOZ} < V_{VBUS} < V_{VBUS_OV} and V_{VBUS} > V_{BAT} + V_{SLEEP}, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Quiescent Currents						
Battery Discharge Current (BAT)	I_{BAT}	V_{BAT} = 4.5V, V_{VBUS} < $V_{VBUS-UVLOZ}$ or no VBUS		0.1	1.0	μA
		V_{BAT} = 4.5V, V_{VBUS} = 5V, fold-back mode		4.5	7.0	μA
Input Supply Current (VBUS)	I_{VBUS}	V_{VBUS} = 5V, V_{VBUS} > V_{BAT}, converter not switching		1.4		mA
		V_{VBUS} = 12V, V_{VBUS} > V_{BAT}, converter not switching		1.7	2.2	mA
		V_{BAT} = 3.8V, V_{VBUS} > V_{BAT}, V_{VBUS} > V_{VBUS_UVLOZ}, converter switching		8		mA
BAT Pin and VBUS Pin Power-Up						
VBUS Operating Range	V_{VBUS_OP}	V_{VBUS} rising	4.2		13.2	V
VBUS for Device Active, No Battery Sense VBUS Pin Voltage	V_{VBUS_UVLOZ}	V_{VBUS} rising, T_J = +25℃		3.32	3.46	V
Device Active Hysteresis	$V_{VBUS\_UVLOZ\_HYS}$	V_{VBUS} falling from above V_{VBUS_UVLOZ}		70		mV
Sleep Mode Falling Threshold	V_{SLEEP}	V_{VBUS} - V_{BAT}, $V_{VBUSMIN}$ ≤ V_{BAT} ≤ V_{REGN}, V_{VBUS} falling, T_J = +25℃		80	165	mV
Sleep Mode Rising Threshold	V_{SLEEPZ}	V_{VBUS} - V_{BAT}, $V_{VBUSMIN}$ ≤ V_{BAT} ≤ V_{REGN}, V_{VBUS} rising, T_J = +25℃	100	175	260	mV
VBUS 13V Over-Voltage Rising Threshold	$V_{VBUS\_OV\_RISE}$	V_{VBUS} rising	12.78	13.4	13.90	V
VBUS 13V Over-Voltage Hysteresis	$V_{VBUS\_OV\_HYS}$	V_{VBUS} falling		355		mV
Bad Adapter Detection Falling Threshold	$V_{VBUSMIN}$	V_{VBUS} falling	3.52	3.70	3.89	V
Bad Adapter Detection Hysteresis	$V_{VBUSMIN\_HYS}$			250		mV
Bad Adapter Detection Current Source	I_{BAD_SRC}	Sink current from VBUS to GND, T_J = +25℃	17	24	30	mA
Power Path Management						
Total High-side MOSFET On-Resistance - (Q1 + Q2)	R_{ON_HSFET}	V_{REGN} = 5V		150		mΩ
Low-side Switching MOSFET On-Resistance - Q3	R_{ON_LSFET}	V_{REGN} = 5V		110		mΩ
Battery Charger						
Charge Voltage Program Range	V_{BATREG_RANGE}	T_J = +25℃	4.10		4.45	V
Charge Voltage Step	V_{BATREG_STEP}			50		mV
Charge Voltage Setting	V_{BATREG}	R_{CV} = 0Ω or floating (4.2V), T_J = +25℃	4.174	4.200	4.265	V
		R_{CV} = 0Ω or floating (4.2V), T_J = -40℃ to +85℃	4.162	4.200	4.272	V
		R_{CV} = 22.1kΩ (4.35V), T_J = +25℃	4.320	4.347	4.416	V
		R_{CV} = 22.1kΩ (4.35V), T_J = -40℃ to +85℃	4.308	4.347	4.423	V
Charge Current Regulation Range	I_{CHGREG_RANGE}		0		2500	mA
Charge Current Regulation Setting	I_{CHGREG}	V_{BAT} = 3.8V, I_{CHGREG} = 0.515A, T_J = +25℃	0.450	0.510	0.580	A
			-10.8		12.8	%
		V_{BAT} = 3.8V, I_{CHGREG} = 1.235A, T_J = +25℃	1.155	1.235	1.315	A
			-6.08		6.08	%
		V_{BAT} = 3.8V, I_{CHGREG} = 1.535A, T_J = +25℃	1.470	1.535	1.600	A
		V_{BAT} = 3.8V, I_{CHGREG} = 1.535A, T_J = -40℃ to +85℃	1.450	1.535	1.620	A
Pre-Charge Current Regulation Setting	I_{PRECHG}	V_{BAT} = 2.6V, T_J = +25℃, I_{PRECHG} is 10% of I_{CHGREG}; I_{CHGREG} = 0.515A		55	115	mA
		V_{BAT} = 2.6V, T_J = +25℃, I_{PRECHG} is 10% of I_{CHGREG}; I_{CHGREG} = 1.235A		130	190	mA

ELECTRICAL CHARACTERISTICS (continued)

(V_{VBUS_UVLOZ} < V_{VBUS} < V_{VBUS_OV} and V_{VBUS} > V_{BAT} + V_{SLEEP}, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Battery Charger							
Battery LOW Falling Threshold	V_{BATLOW_FALL}	I_{CHGREG} = 600mA, T_J = +25℃		2.68	2.79	2.91	V
Battery LOW Rising Threshold	V_{BATLOW_RISE}	Pre-charge to fast charge			3.10		V
Termination Current Regulation Setting	I_{TERM}	V_{BAT} = 4.1V, T_J = +25℃, I_{TERM} is 10% of I_{CHGREG}	I_{CHGREG} = 0.515A		51		mA
			I_{CHGREG} = 1.235A		123		
Battery Short Voltage	V_{SHORT}	V_{BAT} falling, T_J = +25℃		2.01	2.05	2.11	V
	V_{SHORTZ}	V_{BAT} rising, T_J = +25℃		2.14	2.19	2.25	
Battery Short Current	I_{SHORT}	V_{BAT} < V_{SHORTZ}			33.5		mA
Fold-Back Mode Threshold below V_{BATREG}	$V_{FOLDBACK}$	V_{BAT} falling			90		mV
Recharge Threshold below V_{BATREG}	V_{RECHG}	V_{BAT} falling, T_J = +25℃		85	140	190	mV
Charge Current Amplification Ratio	K				10300		
Constant Current Control Reference Voltage	V_{REF}				1		V
Input Voltage Regulation							
Input Voltage Regulation Limit	V_{INDPM}	LVDPM version			4.16		V
BAT Pin Over-Voltage Protection							
Battery Over-Voltage Threshold	V_{BATOVP_RISE}	As percentage of V_{BATREG}, T_J = +25℃	V_{BAT} rising	103	104.5	106	%
	V_{BATOVP_FALL}		V_{BAT} falling	101	102.5	104	
Thermal Regulation and Thermal Shutdown							
Junction Temperature Regulation Threshold	$T_{JUNCTION\_REG}$	Temperature increasing			110		℃
Thermal Shutdown Rising Temperature	T_{SHUT}	Temperature increasing			150		℃
Thermal Shutdown Hysteresis	T_{SHUT_HYS}				10		℃
JEITA Thermistor Comparator							
T1 (0℃) Threshold Voltage on TS Pin	V_{T1}	Charger suspends if temperature T is below T1 (T < T1), as percentage to V_{REGN}			73.2		%
V_{T1} Falling		As percentage of V_{REGN}			71.3		%
T2 (10℃) Threshold Voltage on TS Pin	V_{T2}	Charge back to I_{CHGREG}/10 and V_{BATREG} - 100mV if T1 < T <T2, as percentage of V_{REGN} (SGM41522)			68.1		%
V_{T2} Falling		As percentage of V_{REGN} (SGM41522)			66.6		%
T2 (15℃) Threshold Voltage on TS Pin	V_{T2}	Charge back to I_{CHGREG}/10 and V_{BATREG} - 100mV if T1 < T< T2, as percentage of V_{REGN} (SGM41522A)			65.1		%
V_{T2} Falling		As percentage of V_{REGN} (SGM41522A)			63.3		%
V_{T3} Rising	V_{T3}	As percentage of V_{REGN}			46.0		%
T3 (45℃) Threshold Voltage on TS Pin		Charge back to I_{CHGREG}/10 and V_{BATREG} - 100mV if T3 < T <T4, as percentage to V_{REGN}			44.2		%
V_{T4} Rising	V_{T4}	As percentage of V_{REGN}			35.8		%
T4 (60℃) Threshold Voltage on TS Pin		Charge suspended if T > T4, as percentage of V_{REGN}			34.6		%

ELECTRICAL CHARACTERISTICS (continued)

(V_{VBUS_UVLOZ} < V_{VBUS} < V_{VBUS_OV} and V_{VBUS} > V_{BAT} + V_{SLEEP}, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

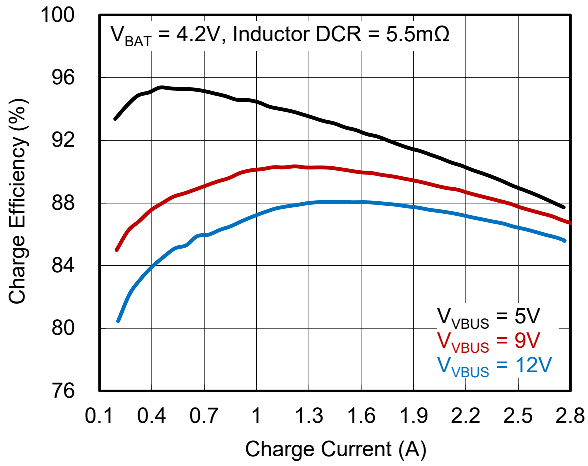
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Charge Over-Current Comparator (Cycle-by-Cycle)						
HSFET Cycle-by-Cycle Over-Current Threshold	I_{HSFET_OCP}			4		A
Charge Under-Current Comparator (Cycle-by-Cycle)						
LSFET Under-Current Falling Threshold	V_{LSFET_UCP}	From sync mode to non-sync mode		100		mA
PWM						
PWM Switching Frequency	f_{SW}	Oscillator frequency, Buck mode, T_J = +25℃	1.20	1.33	1.45	MHz
Maximum PWM Duty Cycle	D_{MAX}			98		%
REGN LDO						
REGN LDO Output Voltage	V_{REGN}	V_{VBUS} = 9V, I_{REGN} = 40mA	4.70	4.90	5.10	V
		V_{VBUS} = 5V, I_{REGN} = 20mA	4.79	4.86	4.92	
REGN LDO Maximum Output Current	I_{REGN_MAX}	V_{VBUS} = 5V	56	68	80	mA

TIMING REQUIREMENTS

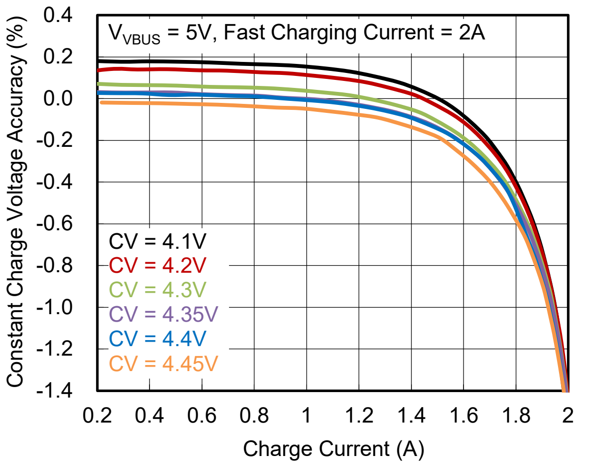
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{VBUS}/V_{BAT} Power-Up						
VBUS OVP Reaction Time	t_{ACOV}	V_{VBUS} rising above ACOV threshold to turn off Q2		100		ns
Wait Window for Bad Adapter Detection	t_{BAD_SRC}			42		ms
Battery Charger						
Deglitch Time for Charge Termination	t_{TERM_DGL}			168		ms
Deglitch Time for Recharge	t_{RECHG_DGL}			168		ms
Battery Over-Voltage Deglitch Time to Disable Charge	t_{BATOVP}			1		μs

TYPICAL PERFORMANCE CHARACTERISTICS

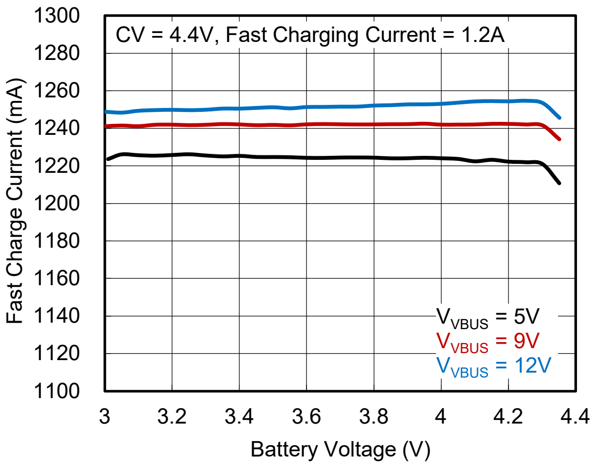
Charging Efficiency vs. Charge Current



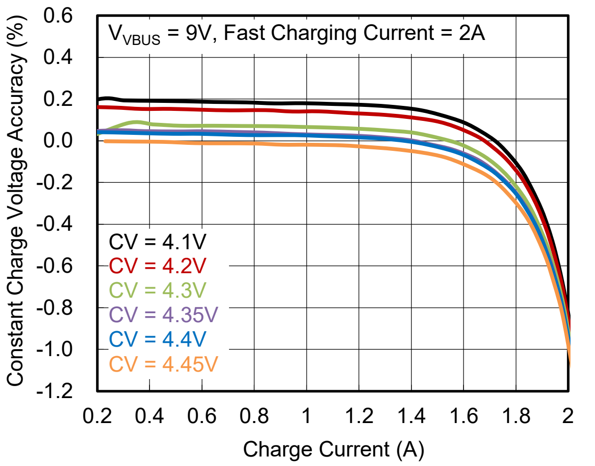
Constant Charge Voltage Accuracy vs. Battery Voltage



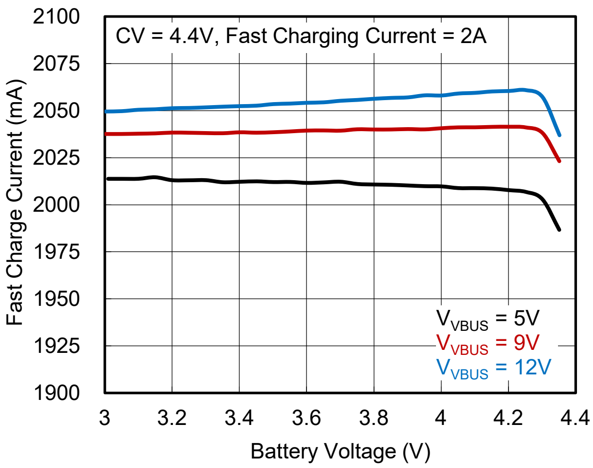
Fast Charge Current vs. Battery Voltage



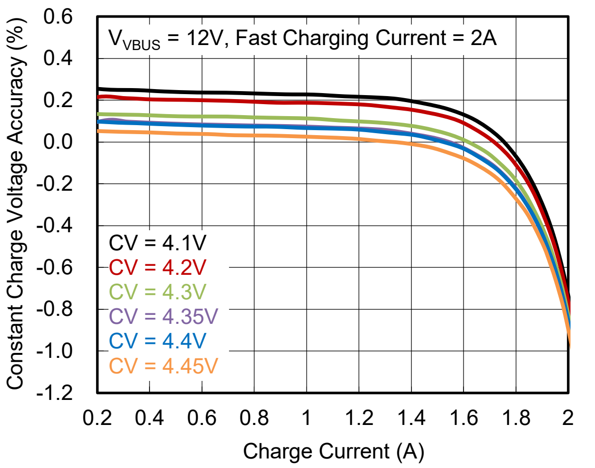
Constant Charge Voltage Accuracy vs. Battery Voltage



Fast Charge Current vs. Battery Voltage

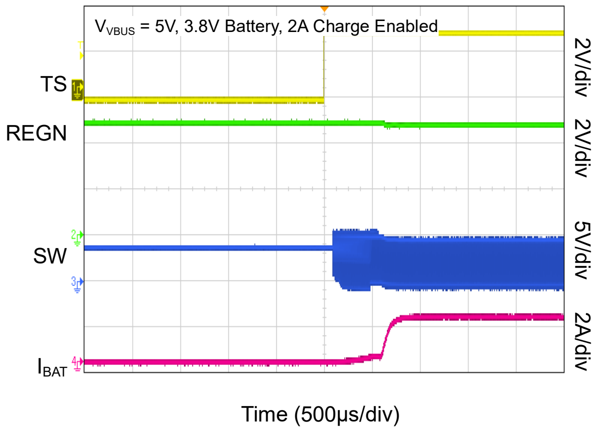


Constant Charge Voltage Accuracy vs. Battery Voltage

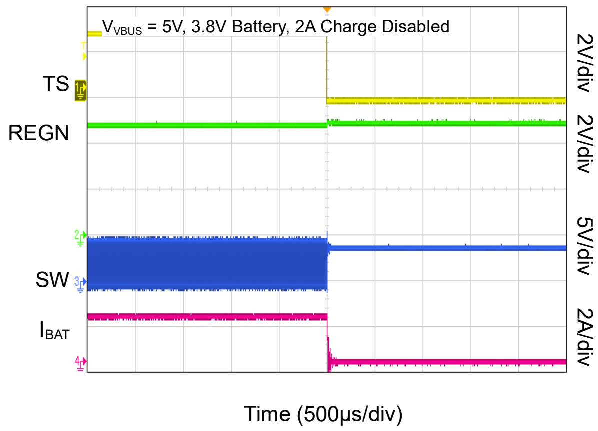


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

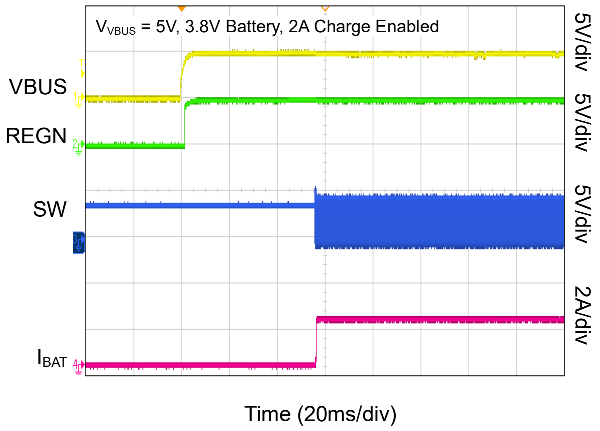
Charge Enabled



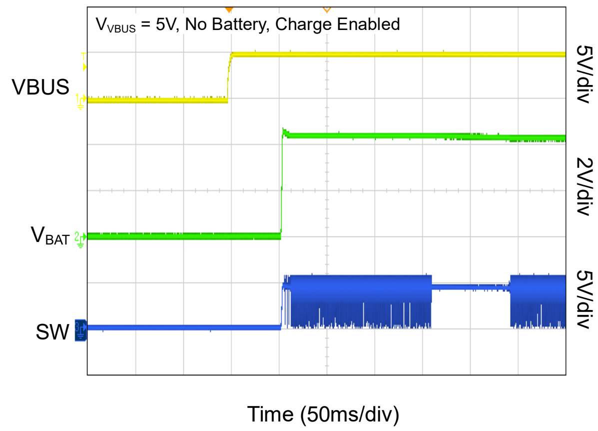
Charge Disabled



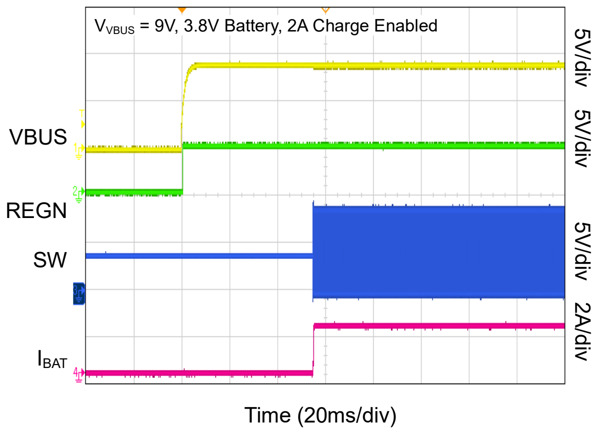
Power-Up with Charge Enabled



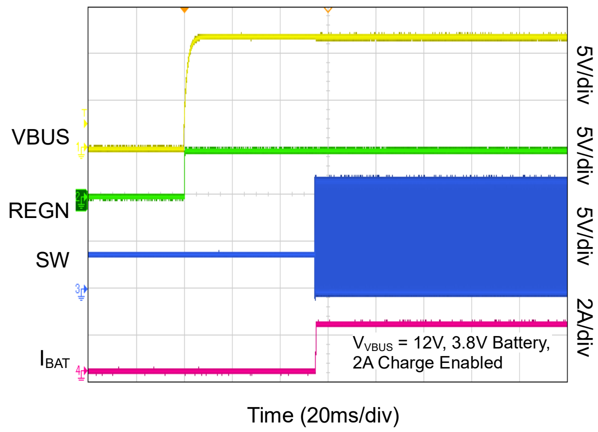
Power-Up with Charge Enabled



Power-Up with Charge Enabled



Power-Up with Charge Enabled



TYPICAL APPLICATION CIRCUIT

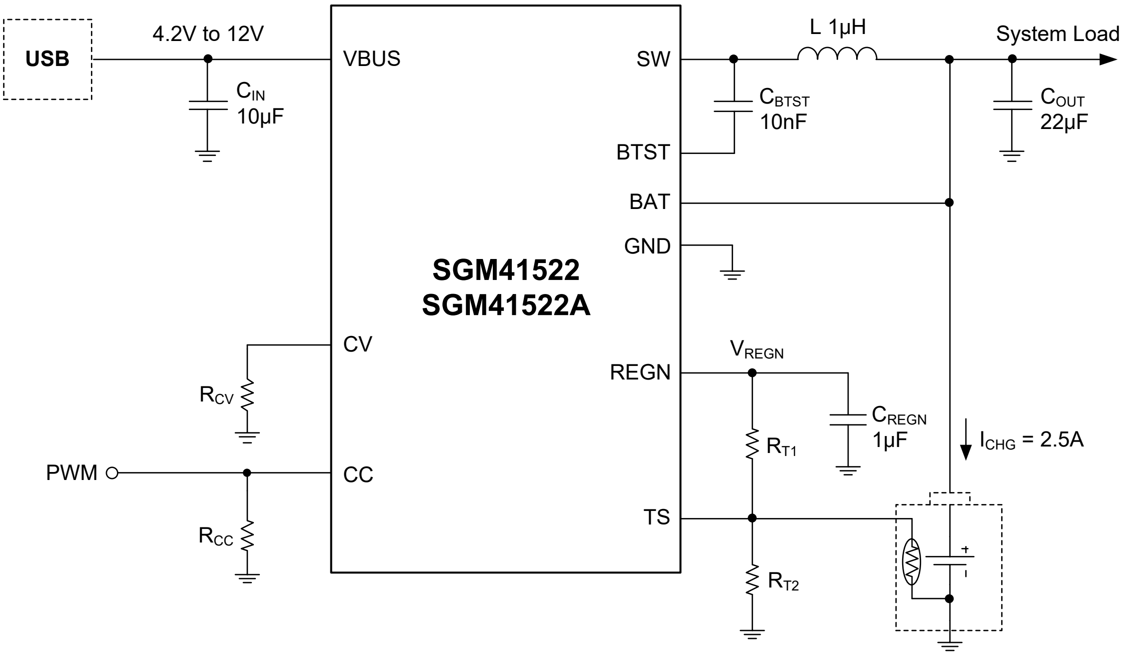


Figure 1. Typical Application Circuit

FUNCTIONAL BLOCK DIAGRAM

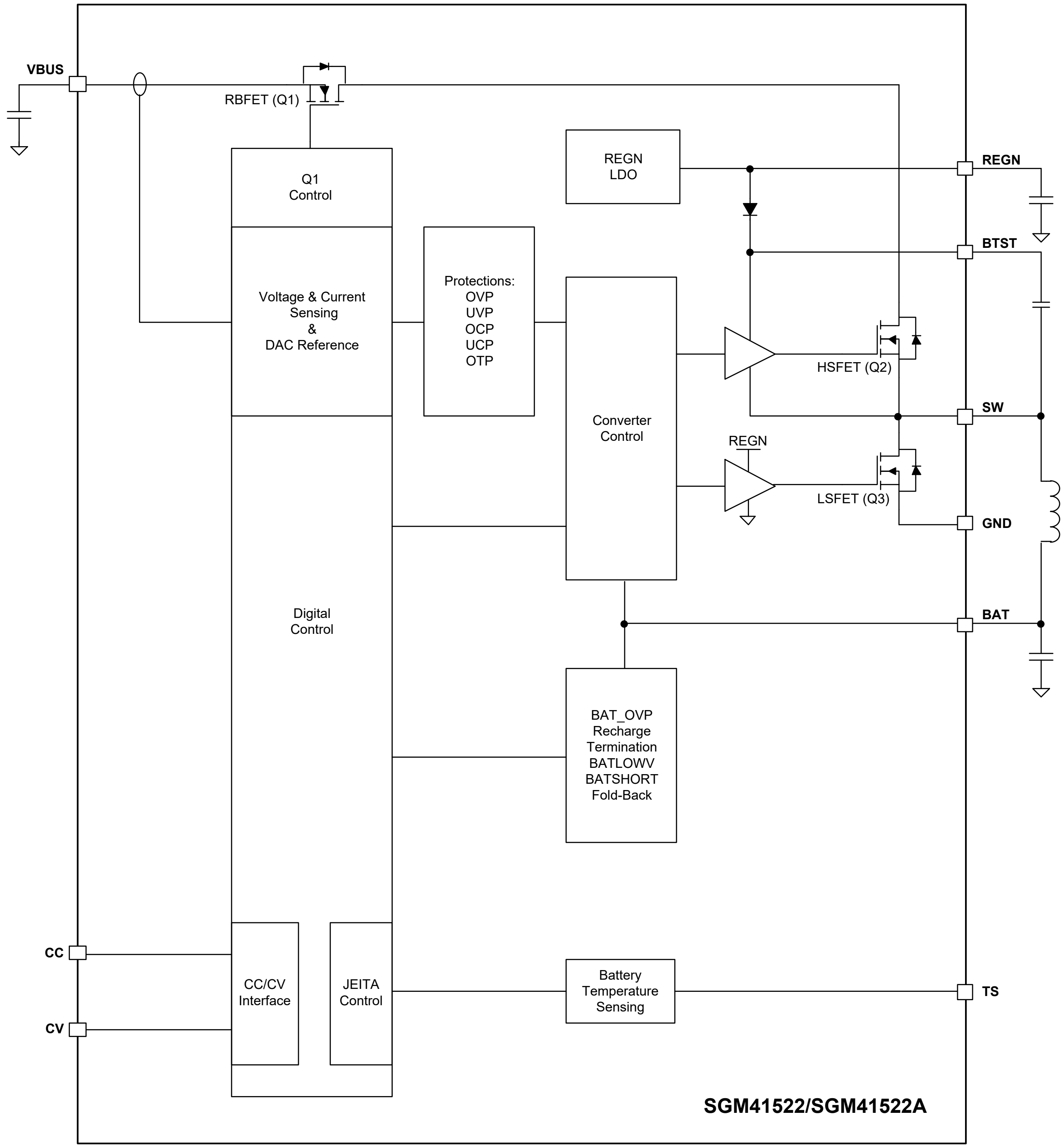


Figure 2. Block Diagram

DETAILED DESCRIPTION

Overview

The SGM41522 and SGM41522A are highly-integrated 2.5A switch-mode stand-alone battery charge management devices for applications such as cell phones, tablets and portable devices that use single-cell Li-Ion and Li-polymer batteries. The devices have a low impedance power path that improves the operation efficiency of the switch-mode, reduces the battery charging time and extends battery life in the discharging phase. The charging setting with the CC/CV interface makes the device a flexible solution. These devices include three main power switches: input reverse blocking FET (RBFET, Q1), high-side switching FET (HSFET, Q2) and low-side switching FET (LSFET, Q3). The bootstrap diode of the high-side gate drive is also integrated to simplify the system design.

The start and termination of a charging cycle can be accomplished without software control. The sensed battery voltage is used to decide the starting phase of charge in one of the three phases of charge cycle: pre-conditioning, constant current or constant voltage. When the charge current falls below a preset limit and the battery voltage is above recharge threshold, the charger function will automatically terminate and end the charging cycle. When the voltage of a charged battery is below the recharge threshold, the charger starts another charging cycle.

The SGM41522 and SGM41522A have several safety features, such as over-voltage and over-current protections, battery temperature monitoring, input UVLO and thermal shutdown. TS pin is connected to an NTC thermistor for battery temperature monitoring and protection in charge mode according to JEITA profile. This device also features thermal regulation in which the charge current is reduced if the junction temperature exceeds 110℃.

Power-On Reset (POR)

The internal circuit of the device is powered from the voltage V_{VBUS}. When the voltage of VBUS goes above its UVLO level ($V_{VBUS} > V_{VBUS\_UVLOZ}$), a POR happens and activates the sleep comparator. Upon activation, the CC/CV interface will also be ready for charge current and voltage settings.

Battery Charging Management

Battery Charging Profile

The SGM41522 and SGM41522A feature a full battery charging profile with five phases. In the beginning of the cycle, the battery voltage (V_{BAT}) is tested and appropriate current and voltage regulation levels are selected as shown in Table 1. Depending on the detected status of the battery, the proper phase is selected to start or for continuation of the charging cycle. The phases are trickle charge (V_{BAT} < 2.19V), pre-charge, fast-charge (constant current and constant voltage) and fold-back mode.

Table 1. Charge Current Setting Based on V_{BAT}

V_{BAT} Voltage	Charge Current
< 2.19V	I_{SHORT}
2.19V to 3V	I_{PRECHG}
> 3V	I_{CHGREG}

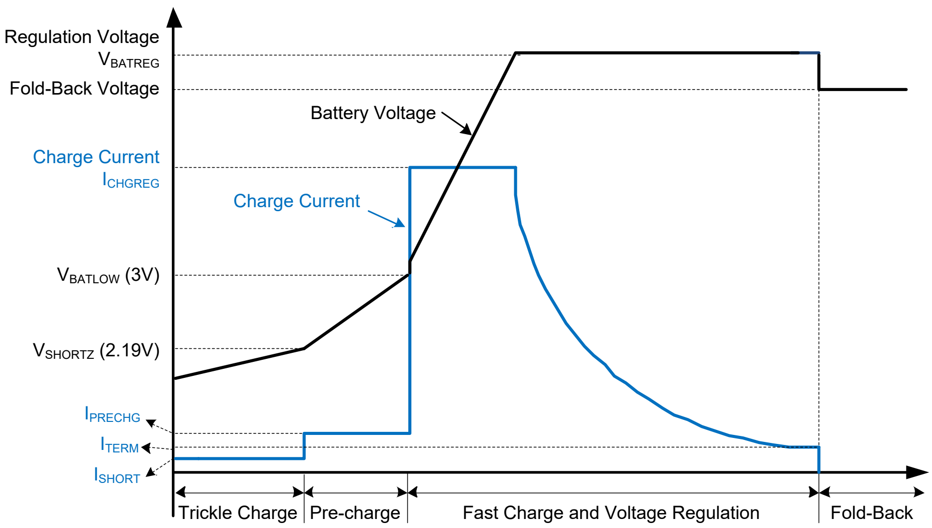


Figure 3. Battery Charging Profile

DETAILED DESCRIPTION (continued)

Charge Termination

A charge cycle is terminated when the battery voltage is higher than the recharge threshold and the charge current falls below the programmed termination current. The termination current is programmed to I_{CHGREG}/10 with a minimum clamped value of 50mA (TYP). To fully charge a battery, it is recommended to set the I_{CHGREG} to be much higher than 50mA. After the charging cycle is completed, the converter enters fold-back mode.

The SGM41522 and SGM41522A have no battery switch but provide an alternative way for battery safe and extended battery life, which is the voltage fold-back mode when a battery is fully charged while the input power is kept. This alternative has less energy loss as no switch in the discharge loop. The only penalty is that it could not support instant start if the battery voltage is excessive low, in which condition it takes a few more minutes for the load system to be ready for start. When the device operates in FBM, the output voltage is $V_{FOLDBACK}$ lower than V_{BATREG}, and the output current limit is $I_{CHGREG\_FOLDBACK}$ (2.4A).

Compliance with JEITA Guideline

JEITA guideline (April 20, 2007 release) is implemented in the device for safe charging of the Li-Ion battery. JEITA highlights the considerations and limits that should to be considered for charging at cold or hot battery temperatures. High charge current and voltage must be avoided outside normal operating temperatures (typically 0℃ and 60℃). This functionality can be disabled if not needed. Four temperature levels are defined by JEITA from T1 (minimum) to T4 (maximum). Outside this range, charging should be stopped. The corresponding voltages sensed by NTC are named V_{T1} to V_{T4}. Due to the sensor negative resistance, a higher temperature results in a lower voltage on TS pin. The battery cool range is between T1 and T2, and the warm range is between T3 and T4. Charge must be limited in the cool and warm ranges.

One of the conditions for starting a charge cycle is having the TS voltage within V_{T1} to V_{T4} window limits. If during the charge, battery gets too cold or too hot and TS voltage exceeds the T1 - T4 limits, charging is suspended (zero charge current) and the controller waits for the battery temperature to come back within the T1 to T4 window.

At cool temperature (T1 - T2) or at warm temperature (T3 - T4), the charge current reduces to 10% of the charge current, and the charge voltage is decreased by about 100mV automatically.

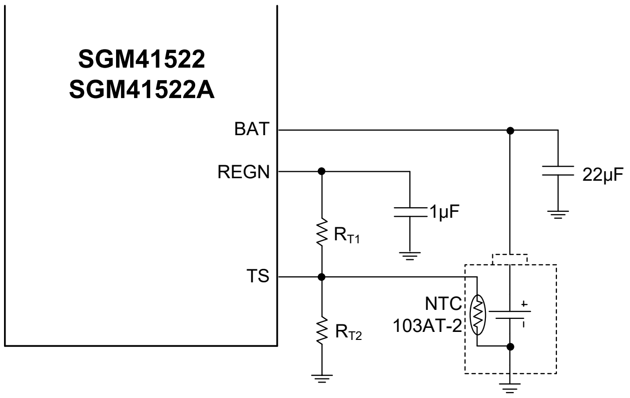


Figure 4. Battery Thermistor Connection and Bias Network

The resistor bias network (see Figure 4) can be calculated based on the following equations:

$$R_{T2} = \frac{R_{THCOLD} \times R_{THHOT} \times \left(\frac{1}{V_{T1}} - \frac{1}{V_{T4}}\right)}{R_{THHOT} \times \left(\frac{1}{V_{T4}} - 1\right) - R_{THCOLD} \times \left(\frac{1}{V_{T1}} - 1\right)} \quad (1)$$

$$R_{T1} = \frac{\left(\frac{1}{V_{T1}} - 1\right)}{\left(\frac{1}{R_{T2}}\right) + \left(\frac{1}{R_{THCOLD}}\right)} \quad (2)$$

where V_{T1} and V_{T4} are T_{COLD} and T_{HOT} threshold voltage on TS pin as percentage to V_{REGN}. Select T_{COLD} = 0℃ and T_{HOT} = 60℃ for Li-Ion or Li-polymer batteries. For a 103AT-2 type thermistor R_{THCOLD} = 27.28kΩ and R_{THHOT} = 3.02kΩ, the calculation results are: R_{T1} = 5.18kΩ and R_{T2} = 29.34kΩ. The standard value is 5.23kΩ for R_{T1} and 29.4kΩ for R_{T2}.

Table 2. Temperature Related Charging Control

Temperature Range	Charge Current	Charge Voltage
Lower than T1	/	/
T1 - T2	I_{CHGREG} × 10%	V_{BATREG} - 100mV
T2 - T3	I_{CHGREG}	V_{BATREG}
T3 - T4	I_{CHGREG} × 10%	V_{BATREG} - 100mV
Higher than T4	/	/

DETAILED DESCRIPTION (continued)

Protections Features

Input Over-Voltage

If VBUS voltage exceeds V_{VBUS_OV}, switching will stop immediately. Charger resumes its normal operation when the voltage comes back below OVP limit.

Thermal Regulation and Thermal Shutdown

Internal junction temperature (T_J) is always monitored to avoid overheating. A limit of +110℃ is considered for maximum IC surface temperature in Buck mode and if T_J intends to exceed this level, the device reduces the charge current to keep maximum temperature limited to +110℃ (thermal regulation mode). As expected, the actual charging current is usually lower than programmed value during thermal regulation.

If the junction temperature exceeds T_{SHUT} (+150℃), thermal shutdown protection arises in which the converter is turned off.

When the device recovers and T_J falls below the hysteresis band of T_{SHUT_HYS} (10℃ under T_{SHUT}), the converter resumes automatically.

Battery Over-Voltage Protection

The over-voltage limit for the battery is 4.5% above the battery regulation voltage setting. Charging will immediately disable if a battery over-voltage occurs.

Battery Over-Discharge Protection

To recover from over-discharge, an input source is required at VBUS pin. The battery is charged with I_{SHORT} (33.5mA TYP) when the $V_{BAT} < V_{SHORT}$, or with a pre-charge current when the battery voltage is between V_{SHORT} and V_{BATLOW}.

Charging Voltage Programming

Forcing a voltage on the CV pin, or grounding it with a resistor that presents a similar voltage against the constant current sourcing from the pin during charging selects 1 of 6 charging voltages, as shown in Table 3.

Charge Current Programming and Turn-Off

Charge current is programmed by using different R_{CC} resistance or by providing voltage difference on the R_{CC} by forcing a voltage on the other end, which could be generated by a DAC or PWM output.

Forcing the CC to a voltage higher than V_{CC_H} (1.4V) turns the device off.

Table 3. Conditions for Selecting a Charging Voltage

Charging Voltage (V)	Forcing Voltage (V)	Separation Thresholds (V)	Recommended Grounding Resistance (kΩ)
4.1	0.45	0.3 ~ 0.6	9.09
4.2	Grounding or Open	< 0.3 or > 2.0	Grounding or Floating
4.3	0.75	0.6 ~ 0.9	15
4.35	1.05	0.9 ~ 1.2	21
4.4	1.4	1.2 ~ 1.6	28
4.45	1.8	1.6 ~ 2.0	35.7

NOTE: Sourcing current out of the CV is typically 50μA.

DETAILED DESCRIPTION (continued)

Layout Guide

1. Place the input capacitor between VBUS and GND pins as close as possible to the chip with shortest copper connections (avoid vias).

2. Connect one pin of the inductor as close as possible to the SW pin of the device and minimize the copper area connected to the SW node to reduce capacitive coupling from SW area to nearby signal traces. This decreases the noise induced through parasitic stray capacitances and displacement currents to other conductors. SW connection should be wide enough to carry the charging current. Keep other signals and traces away from SW if possible.

3. Place output capacitor GND pin as close as possible to the GND pin of the device and the GND pin of input capacitor C_{IN}. It is better to avoid using vias for these connections and keep the high frequency currents paths very short and on the same layer. A GND copper layer under the component layer helps reducing noise emissions.

4. Solder the exposed thermal pad of the package to the PCB ground planes. Ensure that there are enough thermal vias directly under the IC, connecting to the ground plane on the other layers for better heat dissipation and cooling of the device.

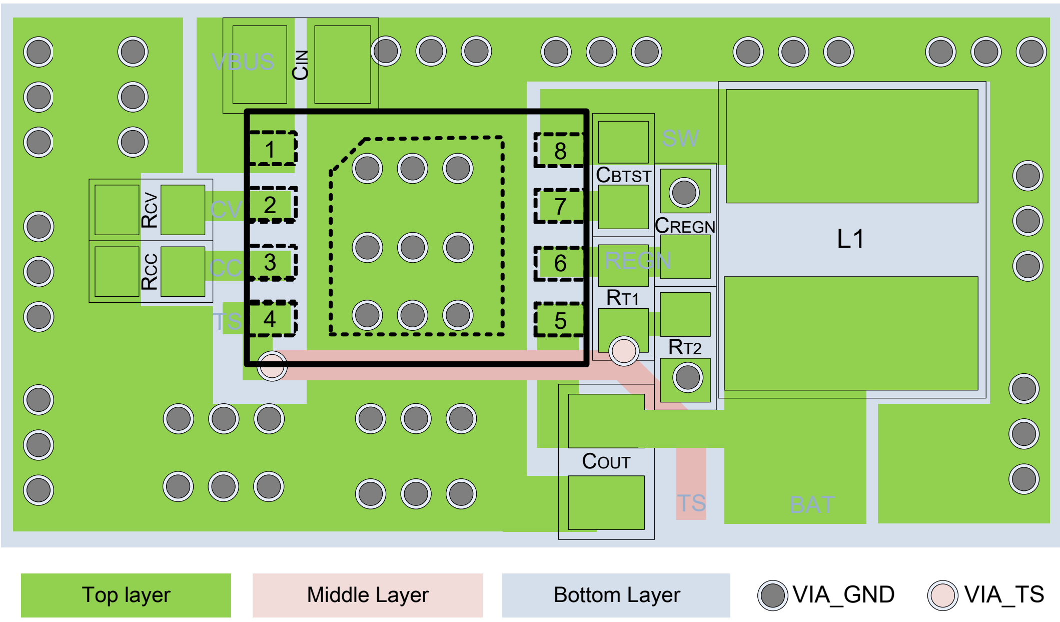


Figure 5. PCB Layout

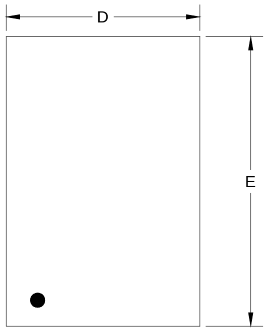
REVISION HISTORY

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

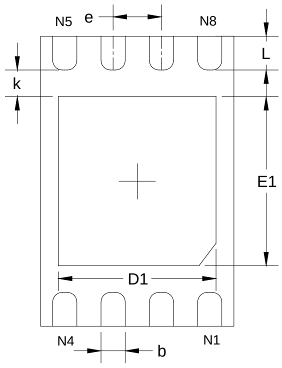
Changes from Original (AUGUST 2022) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

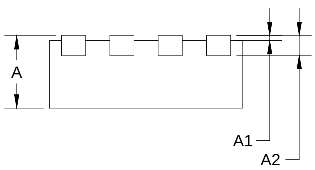
TDFN-2×3-8BL



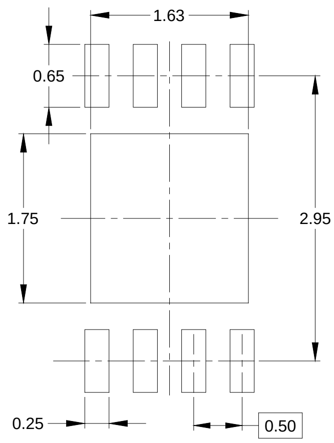
TOP VIEW



BOTTOM VIEW



SIDE VIEW



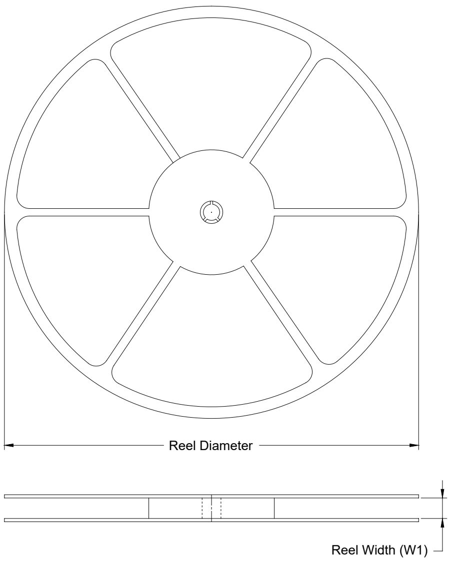
RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.950	2.050	0.077	0.081
D1	1.530	1.730	0.060	0.068
E	2.950	3.050	0.116	0.120
E1	1.650	1.850	0.065	0.073
b	0.200	0.300	0.008	0.012
e	0.500 BSC		0.020 BSC	
k	0.250 REF		0.010 REF	
L	0.300	0.450	0.012	0.018

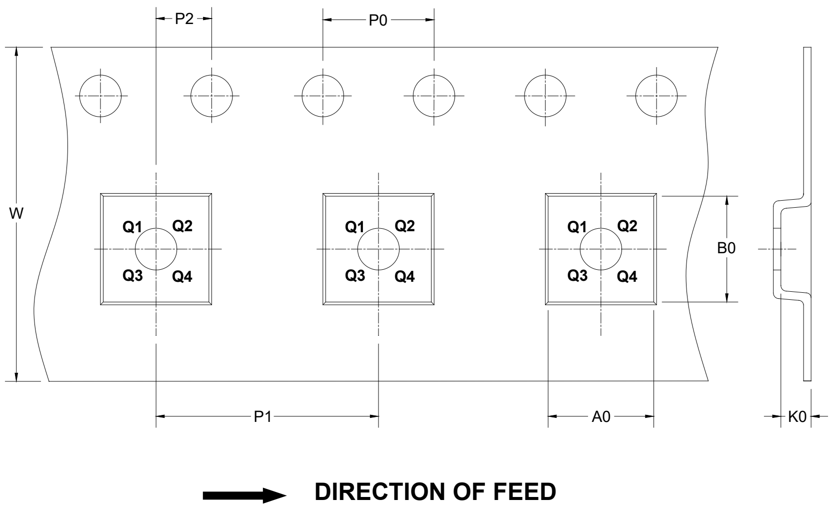
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



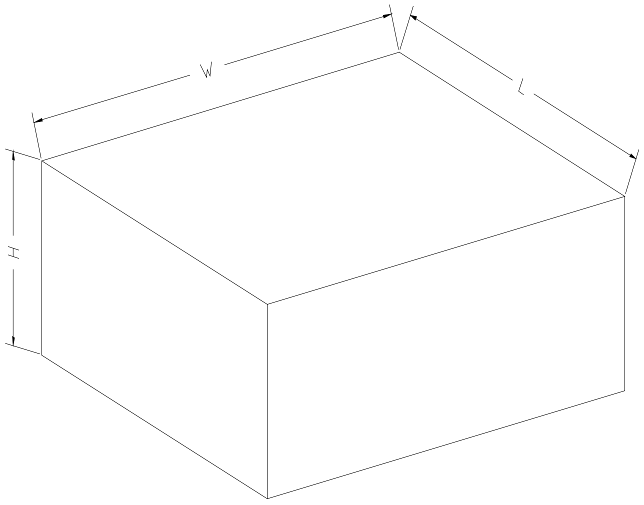
NOTE: The picture is only for reference. Please make the object as the standard.

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
TDFN-2×3-8BL	7″	9.5	2.30	3.30	1.10	4.0	4.0	2.0	8.0	Q2

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
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002