TS51224
Wireless Power Receiver and Battery Charger

WIRELESS CHARGING

Features

- 40V maximum input voltage
- Single-cell Li-Ion or Li-Polymer charger with programmable charging current and topoff voltage
- System rail available with deeply discharged battery
- Integrated switches for narrow VDC power path management
- Supports Qi, AirFuel Inductive and Resonant (PMA, A4WP) and proprietary charging standards
- Up to 2W combined system/battery power
- Better than 87% AC-DC efficiency to the system
- Better than 83% AC-DC efficiency to the battery
- Integrated switches for load modulation
- Integrated frequency detection to support bidirectional communication
- TX to RX CPU alert or reset signal
- Integrated minimum load current sink
- Thermal shutdown at 130°C junction temperature and over-current protection
- Low external component count
- Junction operating temperature -40°C to 125°C
- Product is lead-free, halogen-free, RoHS / WEEE compliant

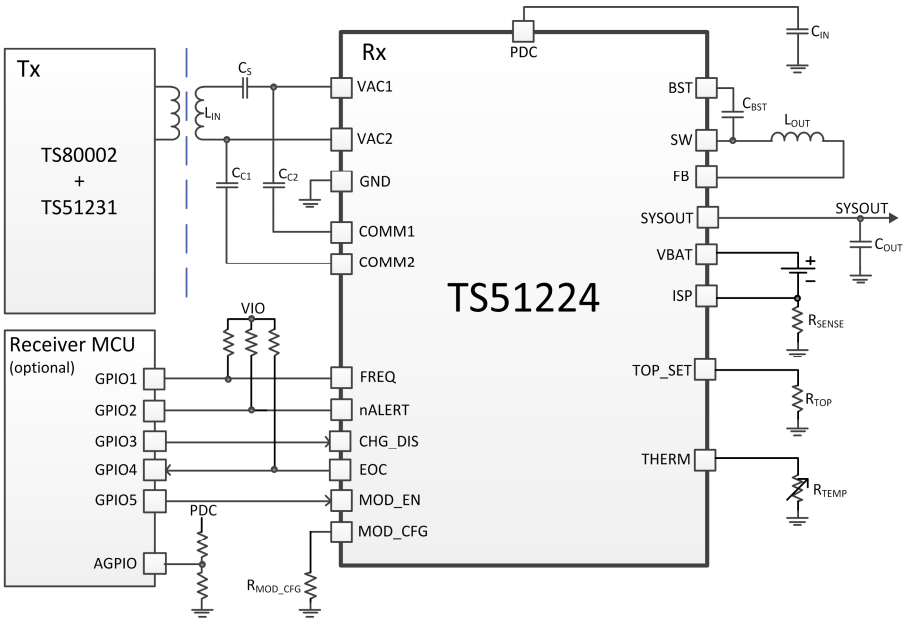
Description

TS51224 is a fully-integrated wireless power receiver and battery charger for low-power, wearable applications that require a low-cost and space-saving solution. The TS51224 can operate by itself as a single-chip wireless power receiver in proprietary applications. It can also operate in conjunction with a wireless power controller or an application microcontroller to support the Qi, PMA or A4WP wireless charging standards as well as proprietary standards up to 2W combined system/battery power.

Applications

- Wearables
  - Watches
  - Bracelets
  - Fitness Bands
  - Smart Jewelry
  - Smart Glasses
- Health Monitors
- Electric Toothbrushes
- Tablets
- Wireless Keyboard and Mouse
- Medical Applications
- Wireless Headsets
- ID Tags
- Augmented Reality

Typical Application Circuit



Ball Configuration

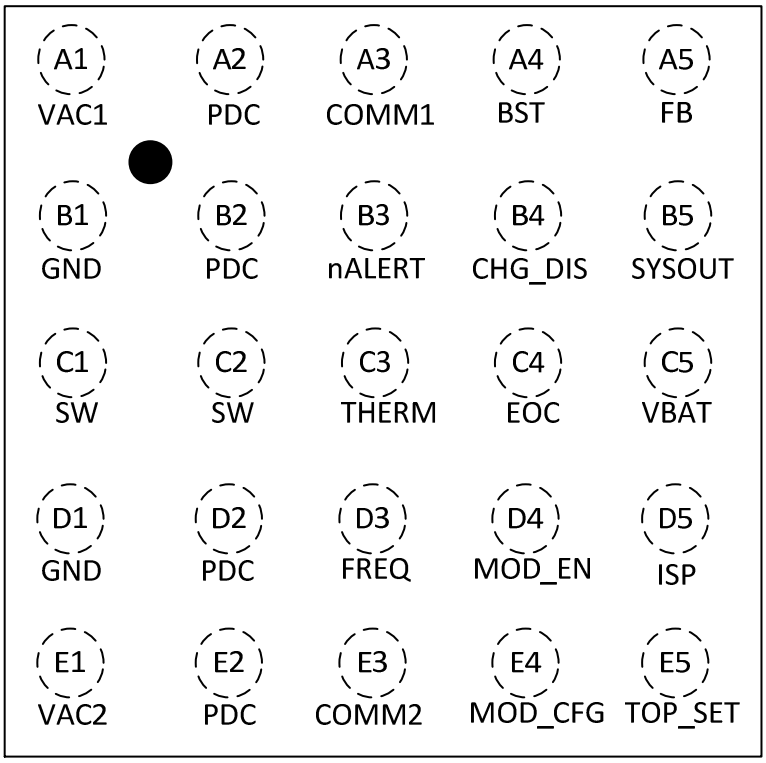


Figure 1: TS51224 Ball Configuration
(Top view with ball 1 designator)

Ball Description

Ball Number	Ball Name	Function	Description
A4	BST	Bootstrap capacitor	Bootstrap capacitor for buck regulator high-side driver, capacitor between BST pin and SW pin
B4	CHG_DIS	Charge disable	Disables battery charging when pulled high
A3	COMM1	Load modulation switch	Pull-down for VAC1 modulation capacitor
E3	COMM2	Load modulation switch	Pull-down for VAC2 modulation capacitor
C4	EOC	End-of-Charge indicator	Toggles low when the charger gets to the end-of-charge state
A5	FB	Feedback input	BUCK feedback input and blocking FET input
D3	FREQ	Frequency detector output	Open drain output signal, divided-by-8 version of the frequency of the input AC power signal
B1, D1	GND	Power ground	Ground
D5	ISP	Current Sense	Negative battery terminal connection and current sensing node
E4	MOD_CFG	Modulation configuration	Configures the internal modulator to start up in standalone mode or in bypass mode. Also configures the PDC voltage in standalone mode.
D4	MOD_EN	MCU modulation input	Active high input to the modulator selection logic, with internal 100kΩ pull-down. If repeated transitions are detected on this pin, the integrated modulator is bypassed and MOD_EN controls the COMM switches.
B3	nALERT	MCU interrupt output/reset signal	Active low open drain output activated when TX sends an ALERT command
A2, B2, D2, E2	PDC	Input power	Rectified input voltage
C1, C2	SW	Switching node	BUCK regulator switching node
B5	SYSOUT	System output power	System output power connection
C3	THERM	Thermistor connection	Thermistor connection used for system temperature monitoring
E5	TOP_SET	Topoff voltage configuration	Configures the topoff voltage of the charger
A1	VAC1	Coil input	AC power input from the resonator coil
E1	VAC2	Coil input	AC power input from the resonator coil
C5	VBAT	Battery node	Positive battery terminal connection

Functional Block Diagram

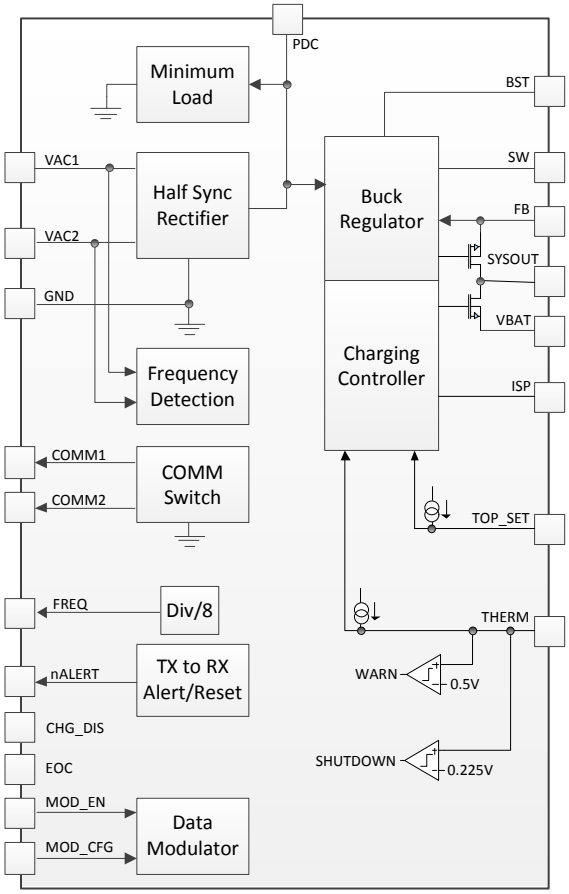


Figure 2: TS51224 Block Diagram

Absolute Maximum Ratings

Over operating free–air temperature range unless otherwise noted [1, 2]

Parameter	Value	Unit
COMM1, COMM2, PDC, VAC1, VAC2	-0.3 to 42	V
BST	-0.3 to (SW+6)	V
SW	-1 to 42	V
CHG_DIS, EOC, FB, FREQ, nALERT, MOD_EN, MOD_CFG, SYSOUT, THERM, TOP_SET, VBAT	-0.3 to 6	V
ISP	-0.7 to 0.7	V
Electrostatic Discharge—Human Body Model	±2	kV
Electrostatic Discharge—Machine Model	±500	V
Peak IR Reflow Temperature (10 to 30 seconds)	260	°C

Notes:

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to network ground terminal GND.

Recommended Operating Conditions

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
PDC Capacitance [1]	C_{IN}		2.2	10		µF
BUCK Output Capacitance[1]	C_{OUT}	F_{SW}=1.3MHz, I_{OUT_MAX}= 50mA	8.8	44		µF
BUCK Output Capacitance[1]	C_{OUT}	F_{SW}=1.3MHz, I_{OUT_MAX} = 400mA	20	44		µF
BUCK Bootstrap Capacitor	C_{BST}		17.6	47		nF
Output Filter Inductor	L_{OUT}	F_{SW}=1.3MHz, I_{OUT_MAX} = 50mA	1.5	3.3		µH
Output Filter Inductor	L_{OUT}	F_{SW}=1.3MHz, I_{OUT_MAX} = 400mA	1.5	4.7		µH
RX Coil	L_{IN}	F_{BR} = 1MHz		11		µH
RX Series Resonant Capacitor	C_s	F_{BR} = 1MHz		10		nF
COMM Modulation Capacitors	C_{C1}, C_{C2}	F_{BR} = 1MHz		1		nF
Rectified Voltage	V_{PDC}		3.5	12	40	V
Bridge Current	I_{BR}			50	300	mA
Rectification Frequency	F_{BR}		100	1000	6780	kHz
COMM Current	I_{COMM}				50	mA
Charger Output Current	I_{RANGE}				500	mA
Topoff Voltage Range	V_{TOP_RANGE}	Valid set point range	4.1		4.4	V
TOP_SET Pin Range	$V_{TOP\_SET\_RANGE}$	Valid TOP_SET pin voltage range	0		3	V
Buck Regulator Output Current	I_{OUT_MAX}				500	mA
High Level Input Voltage	V_{IH}	CHG_DIS, MOD_EN	1.3		5.5	V
Low Level Input Voltage	V_{IL}	CHG_DIS, MOD_EN	0		0.54	V

Notes:

(1) Specified capacitance includes allowance for voltage derating, tolerance, temperature, and aging. Select capacitors that meet the specified minimum capacitance.

Electrical Characteristics

Electrical Characteristics, T_J = -40°C to 85°C, unless otherwise noted

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Synchronous Rectifier						
Low-Side Bridge FET Drain-Source On-State Resistance	R_{DSON_BR}			400		mΩ
High-Side Bridge Diode Forward Voltage	V_{D_BR}	I_{BR} = 150mA		500		mV
Capacitive Modulation Switches						
COMM FET Drain-Source On-State Resistance	R_{DSON_COMM}	I_{COMM} = 50mA		10		Ω
Power On Reset						
Power On Reset Voltage	$V_{PDC-POR}$	Internal logic reset clear, internal logic/modulator ready	2.7	3.0	3.4	V
Power On Reset Hysteresis	$V_{PDC-POR\_HYST}$	(1)		0.35		V
Quiescent Current						
Quiescent Current, PWM mode	Idd_{PWM}	PDC current, Buck Regulator PWM mode, V_{PDC}=12V, VAC1=VAC2=0V, I_{LOAD}=0A, MOD_EN=0, external feedback resistors, R_{TOTAL}=1MΩ		15		mA
Quiescent Current, PFM mode	Idd_{PFM}	PDC current, Buck Regulator PFM mode, V_{PDC}=12V, VAC1=VAC2=0V, I_{LOAD}=0A, MOD_EN=0, external feedback resistors, R_{TOTAL}=1MΩ		4		mA
Quiescent Current, Buck Off, 10mA Current Source Off	$Idd_{BK\_10mA\_OFF}$	PDC current, Buck Regulator OFF, V_{PDC}=4.5V, VAC1=VAC2=0V, MOD_EN=0, 10mA current source off, external feedback resistors, R_{TOTAL}=1MΩ		3		mA
Quiescent Current, Buck Off, 10mA Current Source On	Idd_{BK_OFF}	PDC current, Buck Regulator OFF, V_{PDC}=4.5V, VAC1=VAC2=0V, MOD_EN=0, 10mA current source on, external feedback resistors, R_{TOTAL}=1MΩ		13		mA

Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Charger						
ISP Voltage	V_{ISP_1C}	1C mode	20	25	30	mV
	V_{ISP_0p5C}	0.5C mode	10	12.5	15	mV
	V_{ISP_0p1C}	Precharge (0.1C) mode	1.5	2.5	3.5	mV
1C Charge Voltage Threshold	V_{1C_Charge}	VBAT rising	3.05	3.15	3.25	V
Charger Dropout	V_{Drop_CHG}	SYSOUT-VBAT in 1C charging mode, PWM mode		100		mV
On Resistance	$R_{ON,CHG}$	(1)			100	mΩ
Temperature Sense						
THERM Output Current	I_{THERM}		18	20	22	µA
WARN Voltage	$V_{WARN,FALLING}$	V_{THERM} falling	0.485	0.505	0.525	V
	$V_{WARN,RISING}$	V_{THERM} rising	0.776	0.805	0.834	V
SHUTDOWN Voltage	$V_{STOP,FALLING}$	V_{THERM} falling	0.22	0.235	0.25	V
	$V_{STOP,RISING}$	V_{THERM} rising	0.32	0.335	0.35	V
Blocking Switch						
On Resistance	$R_{ON,BLK}$	(1)		50	100	mΩ
Off State Leakage	I_{OFF}				1	µA
Topoff						
TOP_SET Pin Set Point Current	I_{TOP}	$T_J = 25^0C$	17	20	23	µA
Topoff Voltage Offset	V_{TOP_OFFSET}	$R_{TOP\_SET} = 0\Omega$	4.08	4.1	4.12	V

Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Buck Regulator Input						
PDC Under-voltage Lockout	$V_{PDC-UVLO}$	Buck Regulator = Off		4.3		V
PDC Under-voltage Lockout Hysteresis	$V_{PDC-UVLO-HYST}$	Buck Regulator = Off		180		mV
CHG_DIS, MOD_EN Digital Inputs						
Pull-Down Resistance	R_{PD}		68	100	144	kΩ
EOC, FREQ, nALERT Open Drain Output						
EOC High Level Output Leakage	$I_{OH\_LEAK\_EOC}$	VIO = 5V		5		µA
FREQ, nALERT High Level Output Leakage	I_{OH_LEAK}	VIO = 5V		0.01	1	µA
Low Level Output Voltage	V_{OD_OL}	I_{SINK} = 3mA (2)			0.4	V
Thermal Protection Thresholds						
Thermal Shutdown Junction Temperature	T_{SD}	(1)		130	146	°C
Thermal Shutdown Hysteresis	T_{SD_HYST}	(1)		10		°C

Notes:
(1) This parameter is not tested in production.
(2) nALERT only tested as pass / fail.

Regulator Characteristics

Electrical Characteristics, T_J = -40°C to 85°C, V_{PDC}=12V, F_{SW}=1.3MHz, L_{OUT}=4.7µH, C_{OUT}=44µF, C_{BST}=22nF, unless otherwise noted

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
SYSOUT Precharge Voltage	$V_{OUT-PWM}$	VBAT < 3.1V, PWM mode	3.2	3.3	3.5	V
High-Side Switch ON Resistance	R_{DSON_HS}	I_{SW} = -0.15A (1)		450		mΩ
Low-Side Switch ON Resistance	R_{DSON_LS}	I_{SW} = 0.15A (1)		300		mΩ
Output Over Current Detect	I_{OCD}			1320		mA
Buck Switching Frequency	F_{sw}		1.17	1.33	1.46	MHz
Soft Start Ramp Time	T_{SS}	(2)		2.5		ms

Notes:
(1) R_{DSON} is characterized at 500mA and tested at lower current in production.
(2) This parameter is not tested in production.

Functional Description

TS51224 is a fully-integrated wireless power receiver that can operate as a single-chip solution in proprietary applications. It can also operate in conjunction with a wireless charger controller or an application microcontroller to support the Qi, PMA or A4WP standards as well as proprietary standards up to 2W for 5V output and up to 5W for higher output voltages. Operating in conjunction with TS80002 as a wireless power transmitter and with a charging controller on the RX side, TS51224 can support bidirectional communication for data upload from the RX to the TX side. A TX to RX alert or reset function is also included so TS80002 can issue an interrupt or a reset signal to the RX MCU if the RX MCU becomes unresponsive.

Rectifier

TS51224 includes a high-efficiency rectifier to convert the input AC power signal to a DC output level for powering a high-efficiency step-down DC-DC converter and an integrated data modulator. The rectifier bridge is built to minimize power dissipation across load current of interest. The primary side of the bridge can stand-off up to 40V with AC input running at 6.78MHz. On the secondary side, a capacitive load on the PDC pin is used to filter the voltage signal on both sides of the bridge rectifier. The integrated data modulator and the external MCU communicate to the transmitter side using the capacitive modulation scheme.

Integrated Modulator

The integrated Data Modulator can be configured to operate in standalone or bypass mode. In standalone mode, the integrated modulator sends data messages to the TX side using a proprietary protocol to control the rectified voltage level on the PDC pin. In bypass mode, the external MCU controls the data packets to the TX side. For example, if the device is configured for standalone mode at power up, the system can receive power without external MCU support, and once PDC is high enough to operate the buck regulator and the MCU, the MCU can take over the communication with the transmitter by bypassing the integrated modulator. Modulator mode reverts back to the standalone mode when the MCU communication with the transmitter stalls. When the PDC output load current is low (buck regulator is off), an internal 10mA load is enabled to allow data communication to take place in optimal conditions.

40V Input Buck Regulator

The integrated Buck regulator is a current-mode synchronous step-down power supply with integrated power switches, internal compensation, and fault protection. It is powered by the DC output of the Wireless power receiver bridge. The regulator is designed to handle a wide range of input and output voltages. The regulator is optimized for high efficiency power conversion with low R_{DSON} integrated synchronous switches. Low power at light output loads is attained by the regulator automatic transitions between PFM and PWM modes. The regulator will automatically turn off when the RX AC power input is removed.

Blocking FET

An integrated low impedance FET in the TS51224 provides blocking from SYSOUT to FB. In cases where AC power is not applied, the battery is directly connected to SYSOUT. In this condition, the blocking FET is off, preventing conduction from SYSOUT to PDC. If AC power is applied and PDC is greater than the batter voltage, then the blocking FET will be on and the SMPS will regulate the SYSOUT voltage.

Charger

TS51224 includes a linear regulator to manage battery charging current. The charger operates by sensing the voltage drop across a sense resistor and regulating this to a DC value. Battery charging is controlled by the integrated state machine. When charging at a 1C rate, the SMPS will regulate SYSOUT to be sufficiently higher than VBAT to allow full charging currents. When the battery is very low (<3.3V), the SMPS will regulate SYSOUT to be equal to 3.3V and the charger will regulate the battery current to the 0.1C rate.

Device Power Up Timing

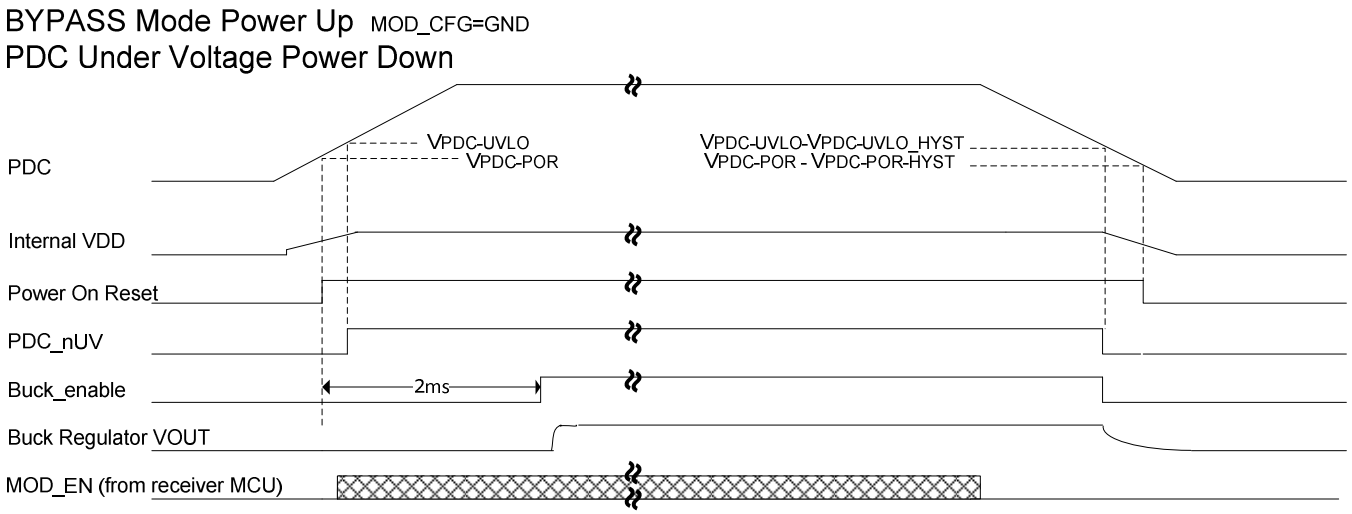


Figure 3: Bypass Mode Power Up

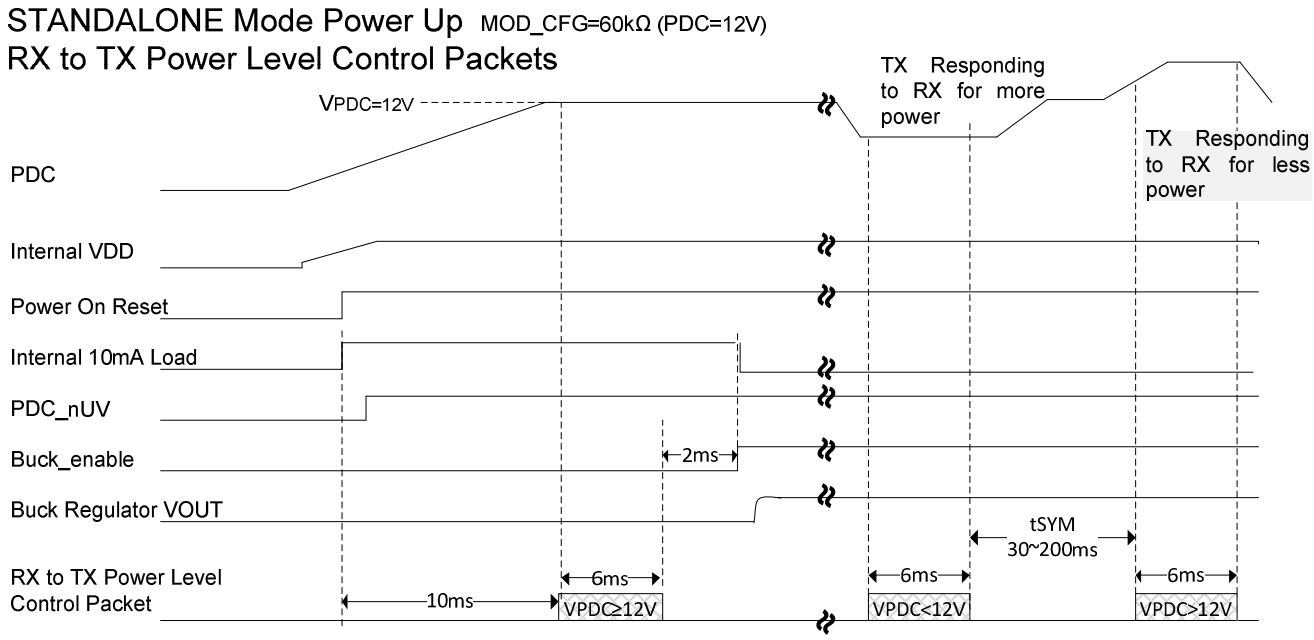


Figure 4: Standalone Mode Power Up

Operation Diagrams

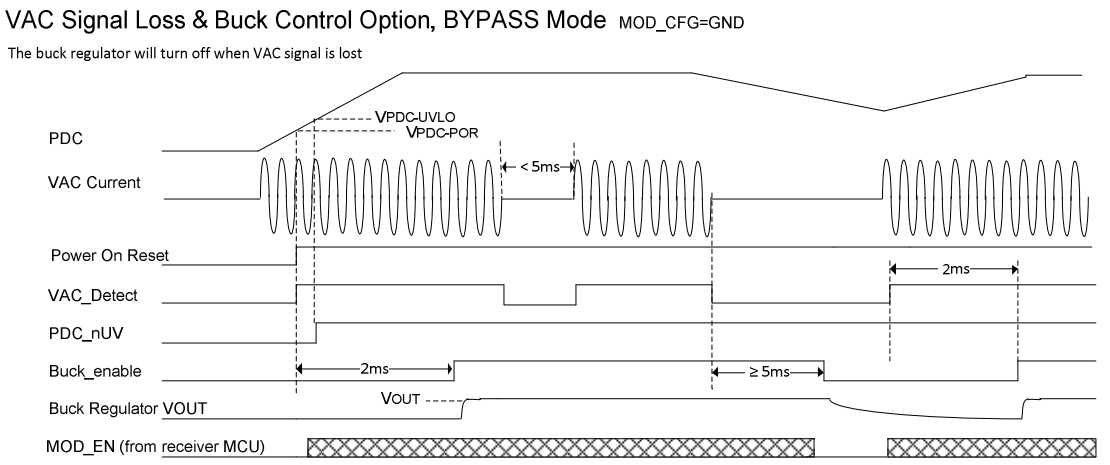


Figure 5: VAC Signal Loss & Buck Control

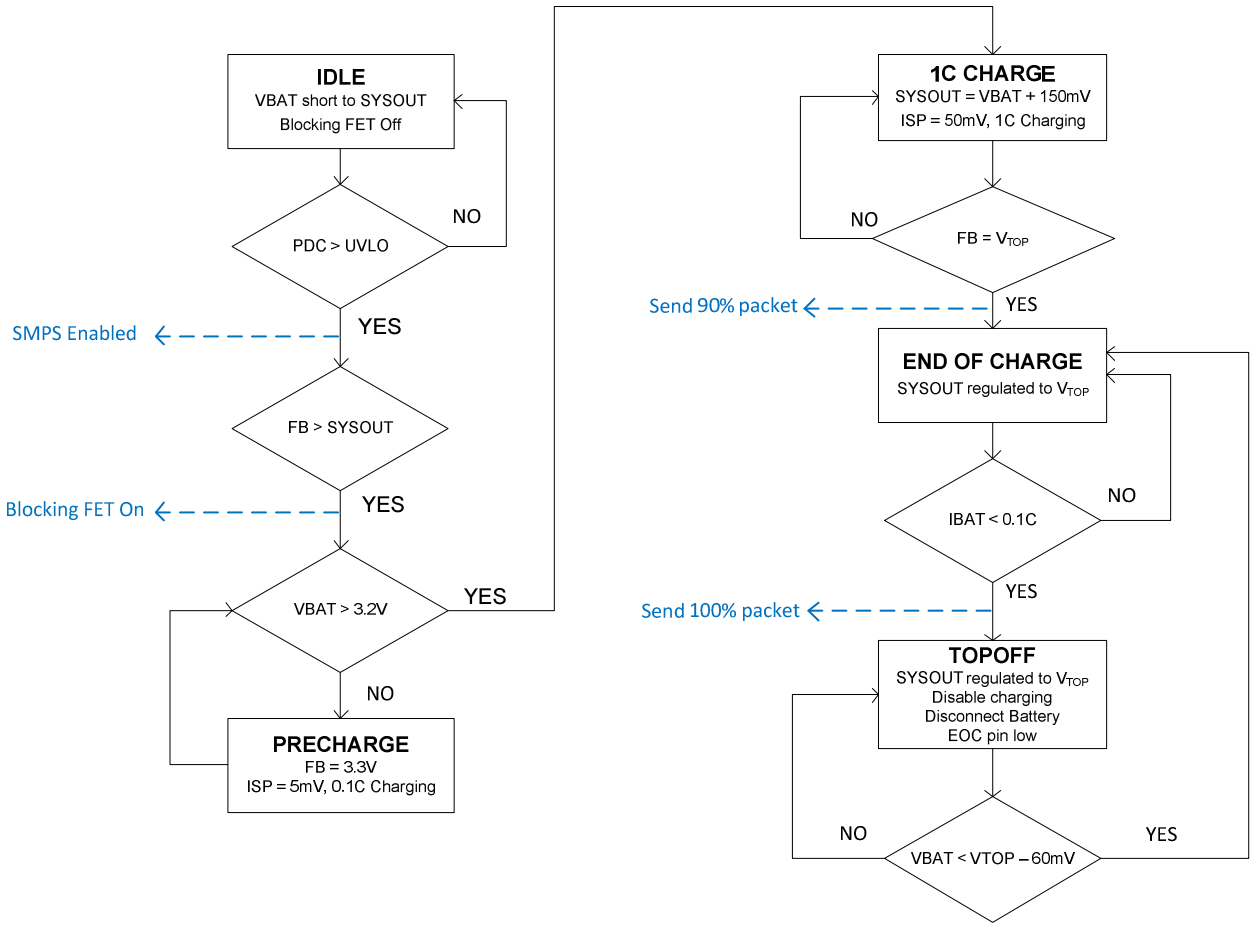


Figure 6: Battery Charging State Diagram

Detailed Ball Description

BST – Bootstrap input
This terminal provides the bootstrap voltage required for the high-side NMOS switch of the buck regulator. An external ceramic capacitor placed between the BST and SW pins will provide the necessary gate drive voltage for the high-side switch. In normal operation, the capacitor is re-charged on every low-side synchronous switching action. For the case where the switch mode approaches 100% duty cycle for the high-side FET, the buck regulator will automatically reduce the duty cycle to a minimum off time on every 8th cycle to allow the BST capacitor to re-charge.

CHG_DIS – Charge disable signal
This input terminal allows an external microcontroller to disable charging by pulling the pin high.

COMM1, COMM2 – Modulation capacitor switches
COMM1 and COMM2 pins are momentarily grounded when the system or the device communicates to the wireless power transmitter. When the COMM1/2 switches close, this shifts the impedance seen by the RX coil L_{IN} and this shift is in turn reflected as a change in TX coil current that can be detected by the transmitter's demodulator. Depending on the MOD_CFG pin configuration and activity on the MOD_EN pin, the integrated modulator or the MOD_EN pin controls the COMM1/2 switches.

EOC – End of charge indicator
When charging, this pin will be pulled low by an integrated NMOS. When the battery is fully charged, the NMOS will release. An external resistor should be connected to a system rail to allow this voltage to pull to the rail.

FB – Buck regulator output feedback
This is the input terminal for the buck regulator output voltage feedback and the power input for the blocking FET. The SMPS will regulate the FB voltage at all times when enabled.

FREQ – Frequency detector output
This is an open drain output which outputs a clock reference running at the frequency of the input AC power signal divided by 8.

GND – Ground
Ground reference. This pin will conduct both correlated and uncorrelated switching currents during power transfer mode from the COMM1/2 pins switching and the buck operating in PWM mode, as well as switching current from the internal oscillator and the integrated modulator. PCB layout must provide low resistance to the ground plane for stable operation.

ISP – Charging current sense node
This terminal is the negative battery terminal. A sense resistor placed between ISP and ground will set the 1C charging current. The integrated charger will regulate the voltage on the ISP pin to set the charging current.

Detailed Ball Description

MOD_CFG – Modulation configuration

PDC voltage and modulation control scheme for communication are configured by the MOD_CFG pin.

Bypass Mode

When the MOD_CFG pin is grounded (voltage < 250mV), the internal data modulator is bypassed and the external MCU is required to drive the MOD_EN pin to control the communication with the power transmitter. Thus, the MCU must be fully active prior to the device generating a stable output voltage V_{OUT}. The external MCU will set V_{PDC} by sending data packets to the transmitter.

Stand-alone Mode

If the MOD_CFG pin is grounded through an external precision resistor (voltage > 250mV), the voltage on the MOD_CFG pin determines the nominal rectified voltage on the PDC pin. In this mode, the integrated modulator generates the wireless power control packets and drives the COMM1/2 switches after power-on reset. This mode is referred to as the stand-alone mode as it does not require an external MCU to control the communication with the transmitter during receiver power up and for normal operation.

While in stand-alone mode, the device also monitors the MOD_EN pin to detect if the external MCU wants to take control of the communication with the power transmitter. If at least 8 pulses with a delay of less than 25ms between each pulse are detected on the MOD_EN pin, the device enters the (integrated modulator) bypass mode. Once in bypass mode and the MOD_EN pin activity stalls (less than 8 pulses in a 250 ms window), the device exits the bypass mode and returns to stand-alone mode and the integrated modulator resumes communication with the power transmitter.

MOD_CFG Pin Connection	RX Data Communication Modulator	COMM1/2 Pin Drive	V_{PDC}	Internal Modulator Bypass	Internal Modulator Fallback
Grounded	External MCU	MOD_EN	Set by External MCU's power control data packet	Integrated modulator always bypassed	Integrated modulator always bypassed
Resistor R_{MOD_CFG} to Ground	Integrated modulator	Integrated modulator	R_{MOD_CFG} / 5000	If MOD_EN pin pulses 8 times with delay < 25ms between pulses, COMM1/2 pins responsive to MOD_EN input	If MOD_EN pin pulses less than 8 times within 250ms window, COMM1/2 pins responsive to the integrated modulator

MOD_EN – MCU modulation input

This is an active high CMOS input to drive the COMM1 and COMM2 pins to modulate the coil current to communicate with the wireless power transmitter. MOD_EN signal is generated by the external MCU and its output swing must conform to the input levels specified in the Electrical Characteristics section for the MOD_EN pin. Activity on the MOD_EN is also sampled by the control logic to transition between Stand-alone and Bypass modes as outlined in the MOD_CFG pin description.

nALERT – MCU reset/interrupt

nALERT is an open drain output which is asserted low when the transmitter sends an ALERT command to the receiver to reset the MCU or to generate an interrupt. During the power up sequence, nALERT pin is pulled high by the external pull-up resistor, thus only the power transmitter ALERT command is allowed to assert this pin low.

Detailed Ball Description

PDC – Rectified input signal
This terminal is the rectified output of the RX AC input voltage and serves as the DC supply for the device. It is recommended that a 10µF bypass capacitor rated for the maximum PDC voltage (> 2.2µF capacitance accounting for voltage derating, aging, and tolerance) be placed close to the device for best performance. Since this is the main power supply for the IC, good layout practices need to be followed for this connection.

SW – Switching output
This is the switching node of the buck regulator. It should be connected directly to the output filter inductor L_{OUT} and bootstrap capacitor with a short, wide trace. SW pin switches between V_{PDC} and GND at the switching frequency, thus it is considered a noise source on the PCB. Route high impedance and quiet traces away from the SW trace.

SYSOUT – System output supply
This terminal is the system power supply. When AC input power is not available, SYSOUT is shorted to VBAT through the integrated charger FET. When AC power is applied, SYSOUT will be regulated to either 3.3V when the battery is low or ~150mV above battery up to the topoff voltage.

THERM – Thermistor connection
This terminal allows temperature monitoring of the external system using a thermistor. When the system temperature reaches the warning level, the 1C charging level will be cut in half. At the shutdown level, charging will stop.

TOP_SET – Topoff voltage setpoint
The battery topoff voltage is set by placing a resistor to ground on this pin. The IC will provide a 20µA DC output current. The topoff voltage will be set according to the following equation.

$$V_{TOP} = V_{TOP\_OFFSET} + I_{TOP} * (R_{TOP\_SET} / 10)$$

VAC1, VAC2 – AC Power input from resonant LC network
These terminals are connected to the wireless power supply receiver coil and resonant capacitor. It is recommended that the PCB traces are robust to handle high peak currents during power up maximum power transfer.

VBAT – Battery connection
This pin is the positive battery terminal. The charger will supply output current to this pin during charging.

Regulator Internal Protection Details

Regulator Output Current Limit

The current through the high-side FET is sensed on a cycle by cycle basis and if current limit is reached, it will turn off the high-side FET in mid-cycle. In addition, the device senses the FB pin to identify hard short conditions and will direct the SW output to skip 4 cycles if current limit occurs when FB is low. This allows current built up in the inductor during the minimum on-time to decay sufficiently. Current limit is always active when the regulator is enabled and the soft start function ensures current limit does not prevent regulator startup.

Under extended over-current conditions (such as a short), the buck regulator switching will automatically be disabled. Once the over current condition is removed, the device automatically returns to normal operation.

Thermal Shutdown

If the die temperature exceeds T_{SD}, SW outputs will tri-state to protect the device and its load from damage. Once the device cools to $T_{SD} - T_{SD\_HYST}$, the buck regulator will attempt to start up again.

Reference Soft Start

Internal references are ramped to prevent the output from overshoot during initial startup. During the soft start ramp, current limit is still active, and protects the device in case of a shorted output.

Output Overvoltage

If the output of the regulator exceeds 3% of the set regulation voltage, the SW output tri-states to protect the device from damage. This check occurs at the start of each switching cycle. If overvoltage occurs mid-cycle, the switching for that cycle completes and the SW output tri-states on the next cycle.

PDC Under-Voltage Lockout

Buck regulator is off until PDC is over 4V with 300mV hysteresis.

Application Schematics

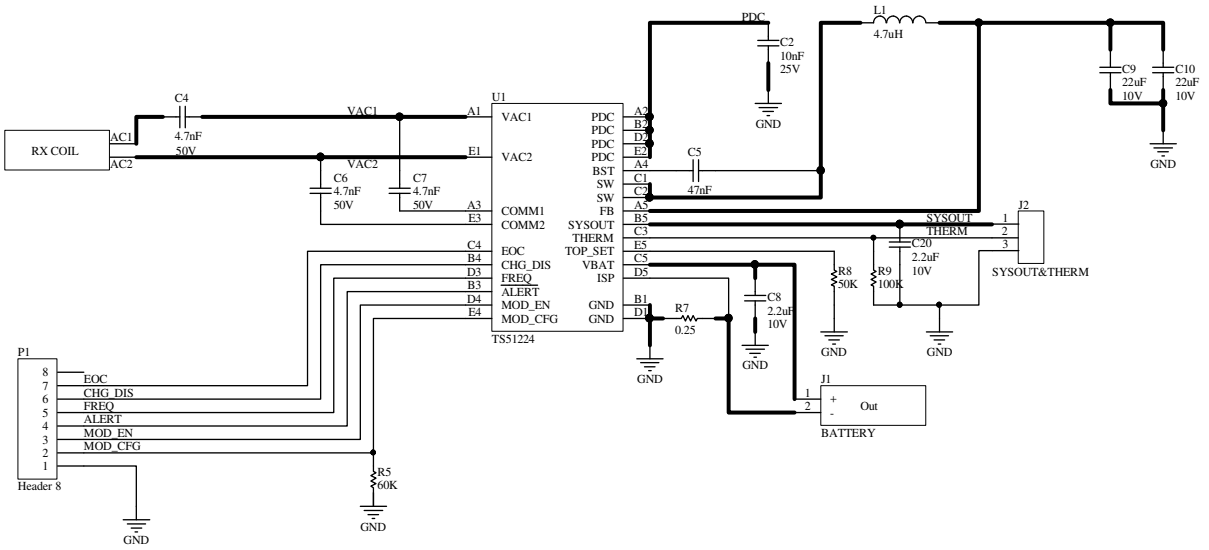


Figure 7: Minimal PCB Area Configuration
(V_{PDC}=12V, V_{OUT}=5V, I_{OUT}=50mA)

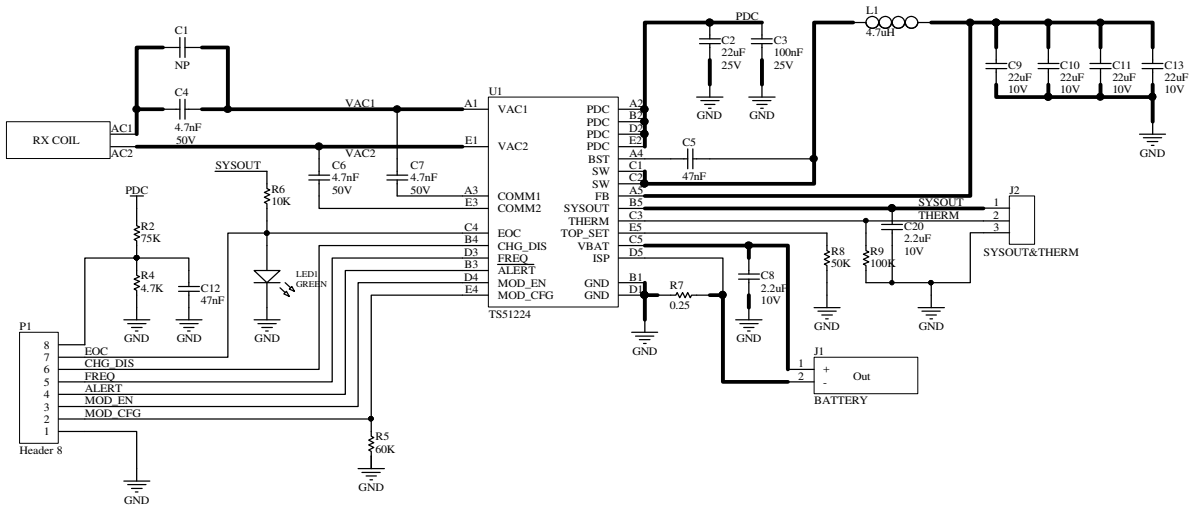
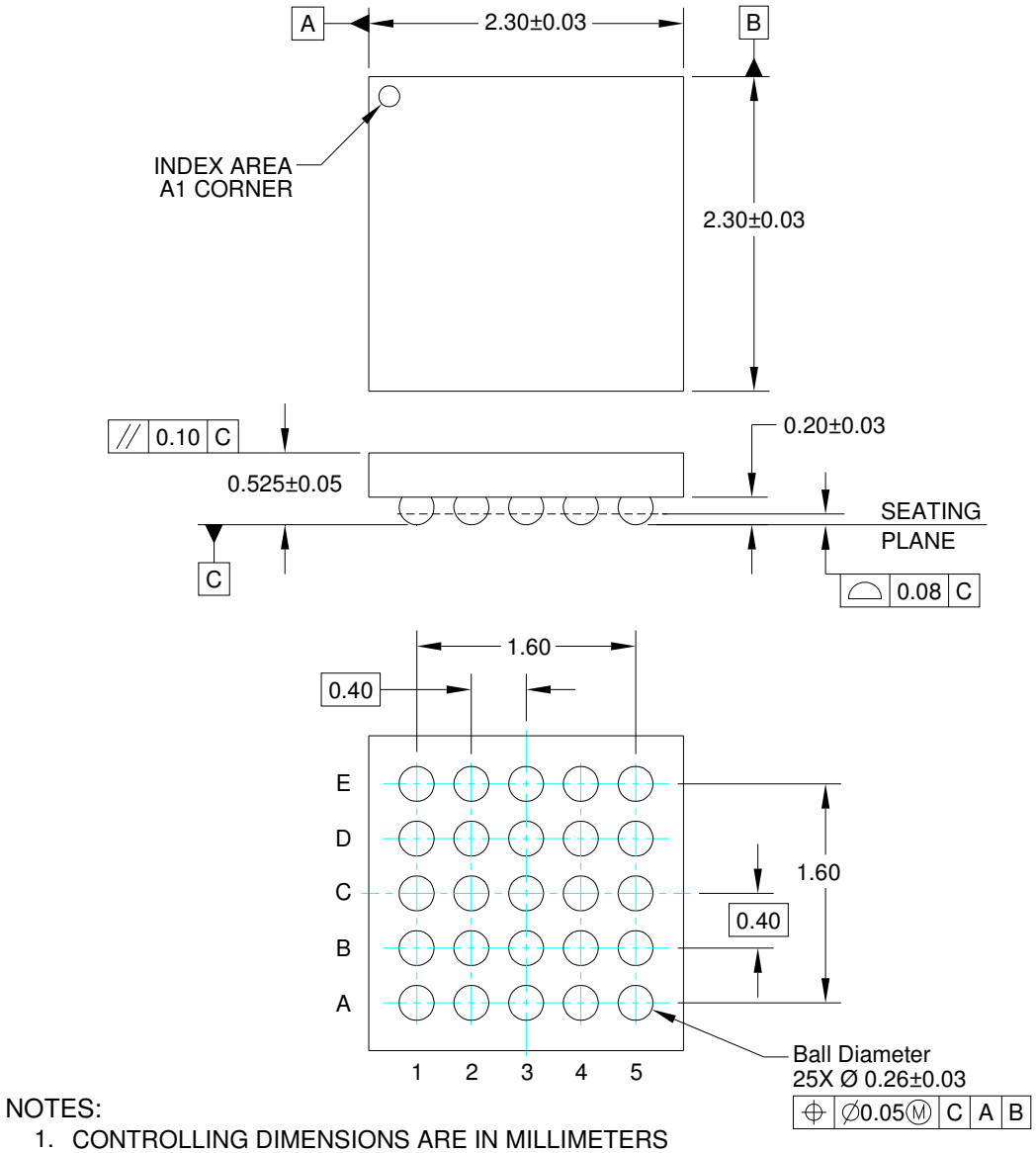


Figure 8: Standard Configuration
(V_{PDC}=12V, V_{OUT}=5V, I_{OUT}=100-500mA)



NOTES:
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS

Figure 9: Package Outline Drawing

Package Information

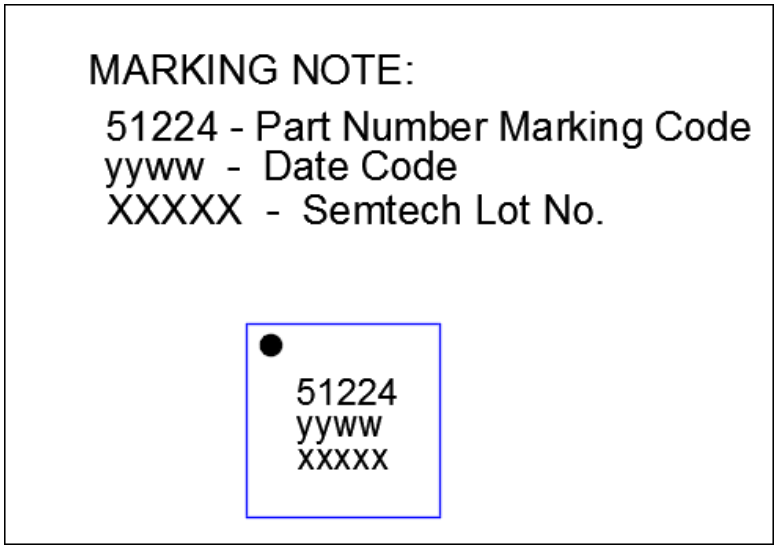
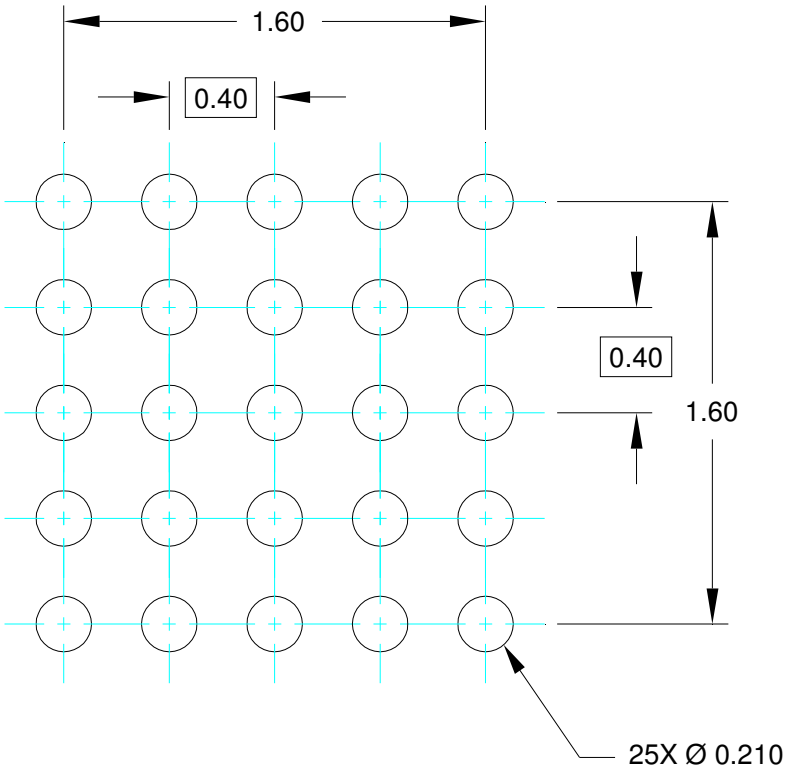


Figure 10: Device Symbolization



NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

Figure 11: Recommended Board Layout Land Pattern

Ordering Information

Device Part Number	Description	25 Ball WCSP Package (5x5 ball array, 0.4mm ball pitch)
TS51224-M000WCSR	Wireless Power Receiver, external resistor feedback	Tape & Reel (3000 parts/reel)

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