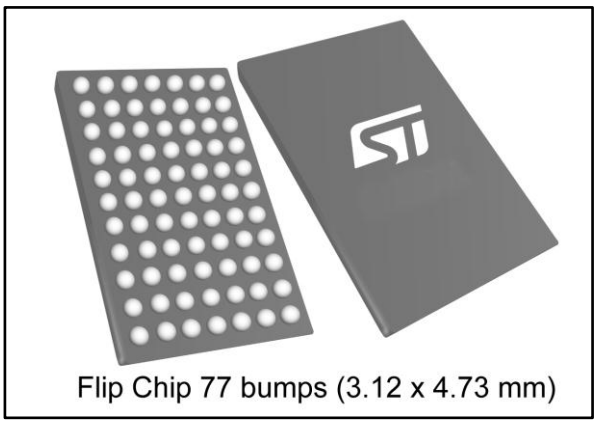
STWLC04

Qi based, 1 W optimized wireless power receiver

Data brief



Features

- 1 W output power
- Qi 1.1 wireless standard communication protocol based
- Integrated high efficiency synchronous rectifier
- 800 kHz programmable step-down converter with input current and input voltage regulation loop
- Step-down converter efficiency up to 90%
- Simplified Li-Ion/Polymer charger function
- 32-bit, 16 MHz embedded microcontroller with 16 kB ROM and 2 kB RAM memory
- 2 kB NVM for customization
- Integrated driver for external supply switch
- Precise voltage and current measurements for received power calculation
- I^2C interface
- Configurable GPIO output
- Rx coil NTC protection
- Thermal protection
- Low power dissipative rectifier overvoltage clamp
- Flip Chip 77 bumps (3.12x4.73 mm)

Applications

- Wearable applications
- Smart watches
- Glasses
- Medical and healthcare instrumentation

Description

The STWLC04 is an integrated wireless power receiver suitable for wearable applications. The device is designed for 1-watt power transfer based on the Qi protocol, with digital control and precise analog control loops ensuring stable operation. The I^2C interface allows a high degree of customization and settings can be stored in the embedded non-volatile memory.

The STWLC04 can deliver the output power in two modes: as a power supply with configured output voltage or as a simple CC/CV battery charger with configurable charging current, charging voltage and termination current. The STWLC04 can detect the external (wired) power supply connection and drive an external power switch.

Table 1: Device summary

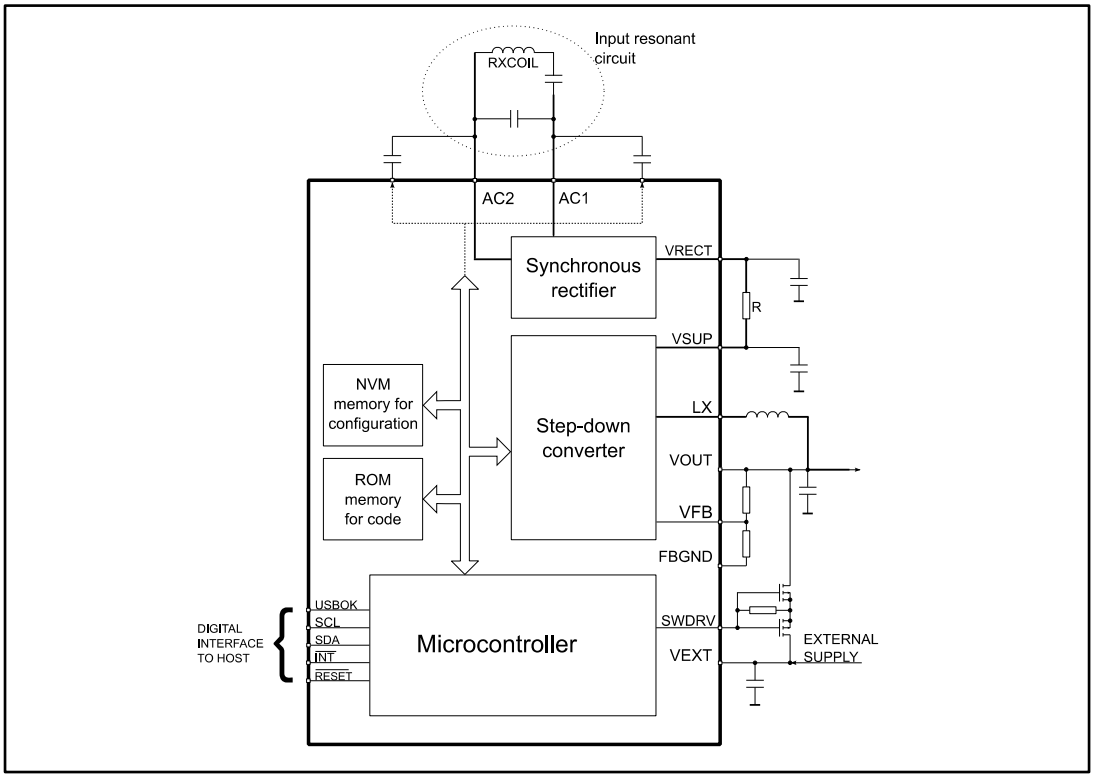
Order code	Description	Package	Packing
STWLC04JR	Wearable optimized 1 W output	Flip Chip 77 bumps (3.12x4.73 mm)	Tape and reel

Contents

1 Introduction

The STWLC04 is an advanced, integrated receiver IC for wireless power transceiver in wearable applications optimized for 1 W. It works as a voltage source with regulated output voltage, typically 5 V and can also be reconfigured into a simple battery charger mode (CC/CV) to charge directly Li-Ion or Li-pol batteries. The STWLC04 can operate fully autonomously or can be controlled through I^2C by the host system. See the figure below.

Figure 1: Simplified block schematic



2 Pin configuration

Figure 2: Pin configuration Flip Chip 77 bumps (3.12x4.73 mm)

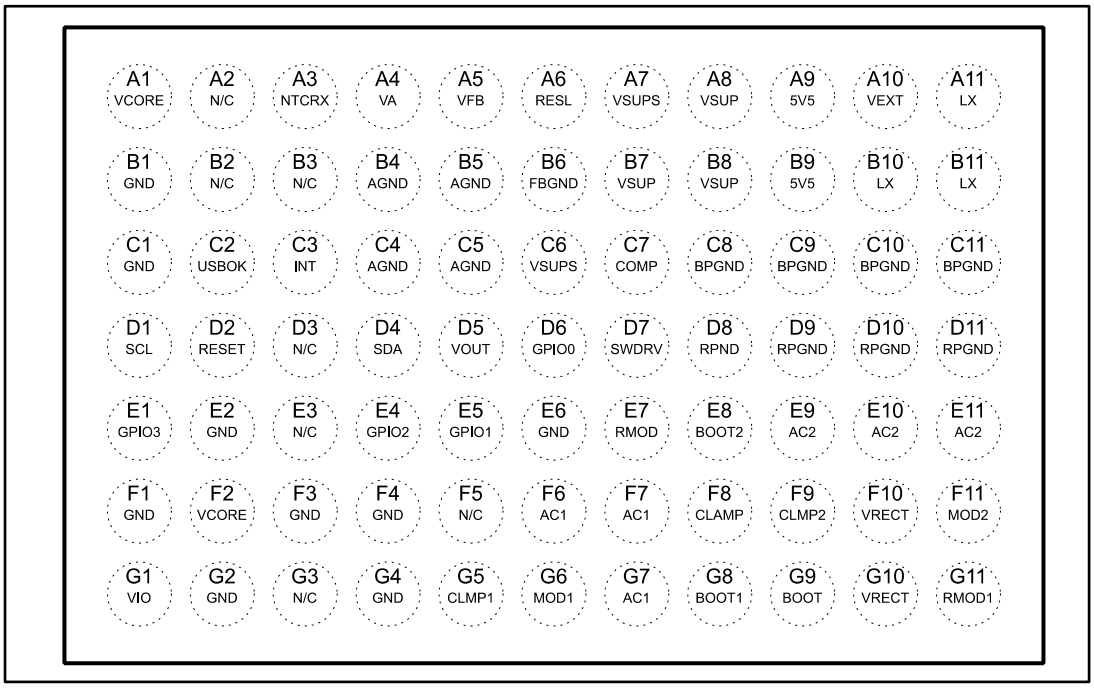


Table 2: Pin description

Pin name	Pin position	Description
	CSP 77L	
AC1	F6, F7, G7	RX coil circuit terminal connection
AC2	E9, E10, E11	RX coil circuit terminal connection
MOD1	G6	Load modulation capacitor 1 connection
MOD2	F11	Load modulation capacitor 2 connection
CLMP1	G5	Clamping capacitor/resistor 1 connection
CLMP2	F9	Clamping capacitor/resistor 2 connection
RMOD	E7	Modulation current sink connection, internally connected to VRECT
RMOD1	G11	Load modulation external resistor connection. RM resistor is not necessary for most applications
VRECT	F10, G10	Synchronous rectifier output
BOOT1	G8	Bootstrap capacitor connection for the rectifier
BOOT2	E8	Bootstrap capacitor connection for the rectifier
BOOT	G9	Bootstrap capacitor connection for the step-down converter
CLAMP	F8	Low power clamp connection
VSUP	A8, B8, B7	Power supply input for the step-down converter

Pin name	Pin position	Description
VSUPS	A7, C6	Sensing terminal of the external current sensing resistor
RESL	A6	Sensing terminal of the external current sensing resistor
VOUT	D5	Step-down output voltage
VFB	A5	Step-down feedback input
FBGND	B6	Ground connection of the resistor feedback divider for step-down converter
LX	A11, B11, B10	Step-down converter coil connection
NTCRX	A3	Comparator input for RX coil temperature sensing
		NTC thermistor has to be placed close to RX coil
VA	A4	LDO1 output to filtering capacitor. ADC supply and sensitive analog circuitries are connected to this LDO; any external circuit cannot be connected to this node
VCORE	F2	LDO2 output to filtering capacitor. The microcontroller core and logic supply. VCORE voltage can be used as a reference voltage for the RX coil NTC divider
V5V	A9, B9	LDO3 output to filtering capacitor
VIO	G1	VIO, power supply for the digital interface, can be connected to VCORE or provided externally
SCL	D1	I^2C clock input
SDA	D4	I^2C data
GPIO0	D6	General purpose push-pull I/O pin. This function depends on firmware configuration
GPIO1	E5	General purpose push-pull I/O pin. This function depends on firmware configuration
GPIO2	E4	General purpose push-pull I/O pin. This function depends on firmware configuration
GPIO3	E1	Open drain output only pin. This function depends on firmware configuration
RESET	D2	Chip reset input, active low
INT	C3	Open drain interrupt output to the host platform
RPGND	D8, D9, D10, D11	Rectifier power ground
BPGND	C8, C9, C10, C11	Step-down converter power ground
GND	G2, F3	Digital ground
AGND	B4, C4, B5, C5	Analog ground
VEXT	A10	Detection of the external power supply voltage – adapter/USB voltage, 30 V spike tolerant
SWDRV	D7	External P-channel switch control to connect the adapter/USB voltage to VOUT
USBOK	C2	Digital input for the USBOK signal from platforms
COMP	C7	Step-down converter soft-start capacitor connection

Pin name	Pin position	Description
GND	G4, F4	Reserved. Connect to ground
VCORE	A1	Reserved. Connect to VCORE
N/C	G3	Reserved. Do not connect
GND	B1, E2, E6, F1	Reserved. Connect to ground
N/C	B2, B3, D3, E3	Reserved. Do not connect
GND	C1	Reserved. Connect to ground
N/C	A2, F5	Reserved. Do not connect

3 Maximum ratings

Table 3: Absolute maximum ratings

Pin	Parameter	Value	Unit
AC1, AC2	Input AC voltage	-0.3 to 20	V
MOD1, MOD2	Modulation transistor voltage	-0.3 to 20	V
CLMP1, CLMP2	Clamp transistor voltage	-0.3 to 20	V
BOOT1, BOOT2	Voltage on bootstraps	AC1, AC2 -0.3; AC1, AC2 + 6	V
BOOT	Voltage on bootstrap	VRECT-0.3; VRECT + 6	V
VRECT	Rectified voltage	-0.3 to 20	V
VRESL, VSUPS	Current sensing resistor connection voltage	-0.3 to 20	V
VRESL-VSUPS	Voltage on the current sensing resistor	-0.3 to 2	V
VSUP	Input voltage of the buck converter	-0.3 to 20	V
LX	Buck converter switching node voltage	-0.3 to 20	V
RMOD, RMOD1	Resistive modulation current source and transistor voltage	-0.3 to 20	V
FBGND	Internal feedback transistor VDS voltage	-0.3 to 20	V
VOUT	Output voltage range	-0.3 to 20	V
VFB	Buck converter feedback voltage	-0.3 to 3	V
VEXT, SWDRW	Detection pin for the external voltage and driver output for the external transistor	-0.3 to 30	V
NTCRX	RX coil NTC voltage	-0.3 to 2.3	V
VA, VCORE	LDO1, 2 voltages	-0.3 to 2.3	V
V5V	LDO 3 voltage	-0.3 to 6	V
VIO	VIO voltage	-0.3 to 6	V
SCL, SDA, USBOK, INT, RESET	Digital interface voltage	-0.3 to VIO+0.3	V
GPIO0, GPIO1, GPIO2, GPIO3	General purpose I/O voltage	-0.3 to VIO+0.3	V
T_{STG}	Storage temperature range	-40 to 150	°C
T_{OP}	Operating ambient temperature range	-40 to +85	°C
T_J	Maximum junction temperature	+125	°C
ESD	Machine model	±100	V
	Charged device model	±500	V
	Human body model	±2000	V

Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

Table 4: Thermal data

Package	Symbol	Parameter	Value	Unit
CSP 3.12x4.73 77L	RTHJA	Junction to ambient thermal resistance(1)	35	°C/W

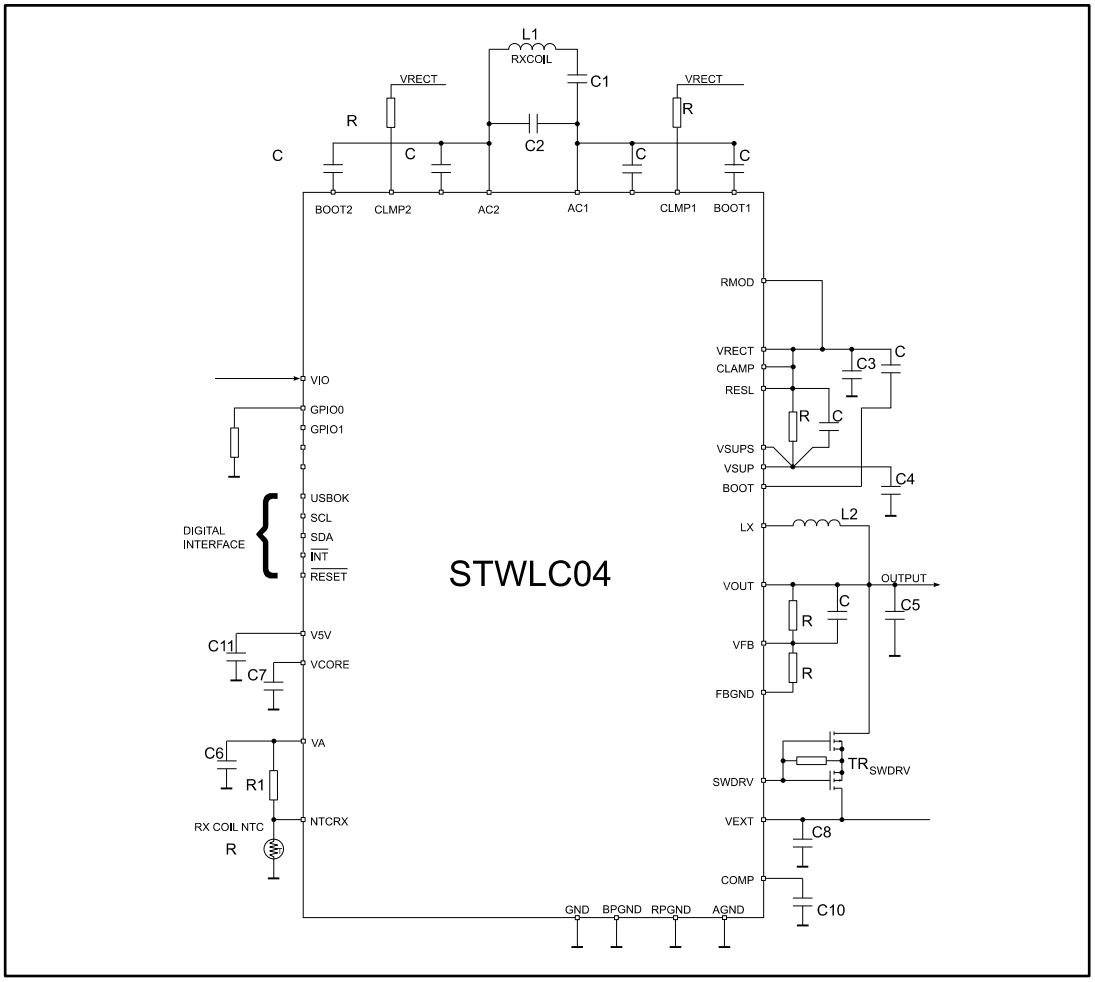
Notes:

(1)This parameter corresponds to the PCB board, 4-layers with 1 inch^2 of cooling area.

4 Application information

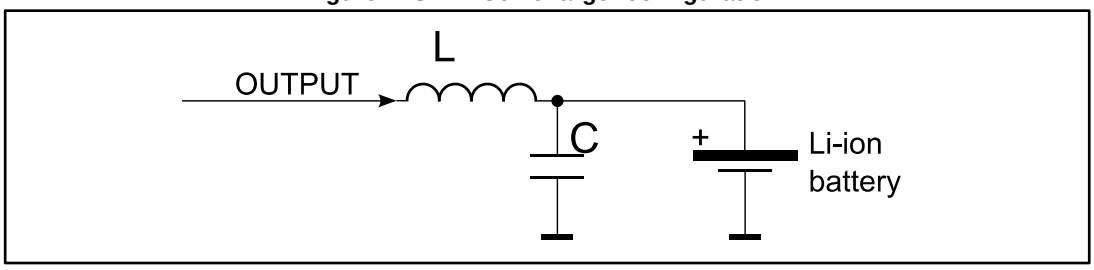
4.1 Application schematic and recommended external components

Figure 3: STWLC04 application schematic



C8 and TRSWDRV are optional if VEXT detection is disabled.

Figure 4: STWLC04 charger configuration



Before connecting the battery, the STWLC04 has to be configured as a battery charger in NVM.

Table 5: STWLC04 recommended external components

Component	Manufacturer	Part Number	Value	Size
L1	Wurth	760308101208	13 uH	d10x1.68 mm
	TDK	WR111118-36-F5-B1	18 µH	d11x1.4 mm
L2	TOKO	MFD160806-1R0	1 µH/600 mA	0603
C1	MURATA	4x GRM155R61H473KE19	47nF/X7R	0402
C2	MURATA	GRM155R71H332KA01	3.2 nF/C0G	0402
C3, C5	MURATA	GRM155R61A106ME11	10 µF/10 V	0402
C4	MURATA	GRM155R61A105KE15D	1 µF/10 V	0402
CBOOT1, CBOOT2, CBOOT, C11	MURATA	GRM033R61A104KE84D	100 nF/10 V	0201
C6, C7, C13	MURATA	GRM033R60J105MEA2D	1 µF/6.3 V	0201
C10	MURATA	GRM035R60J475ME15D	4.7 uF/6.3 V	0201
CM1	MURATA	GRM155R71H473KA12	47 nF/50 V	0402
CM2	MURATA	GRM155R71H472KA12	4.7 nF/50 V	0402
RCL1, RCL2	PANASONIC	ERJ-PA2J150V	15R	0402
CFB	MURATA	GRM0335C1H150JA01	15 pF	0201
RS	PANASONIC	P.10AKCT	0.1 Ω/1%	0402
R1			51 kΩ	0201
RFB1	STACKPOLE	RGC0201DTD150K-ND	150 kΩ	0201
RFB2	TE-CONNECTIVITY	7-2176074-1	30.9 kΩ	0201
RNTC	MURATA		100 kΩ	0402
CCHG (filter)	MURATA	3x GRM155R61A106ME11	10 µF/10 V	0402
LCHG (filter)	MURATA	LQB15NNR47J10D	470 nH	0402
RLOAD			100 Ω	0201

All the above components refer to a typical application. Operation of the device is not limited to the choice of these external components.

Figure 5: VIO and digital interface in standalone application schematic

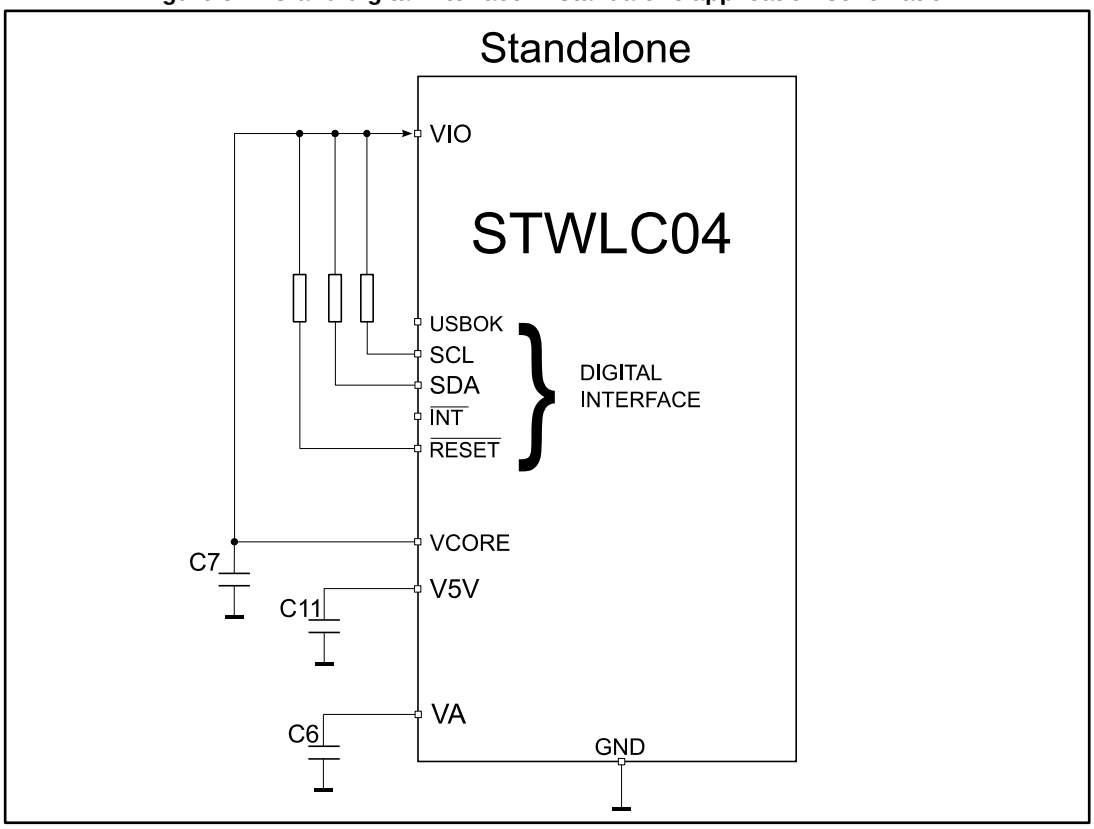
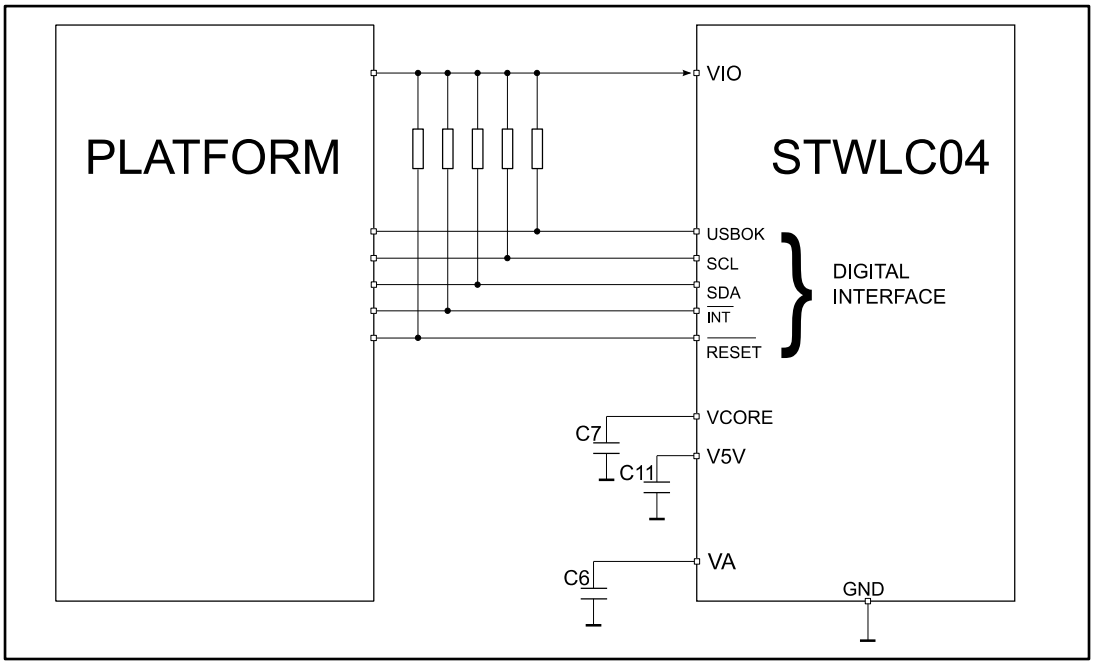


Figure 6: VIO and digital interface in platform application schematic



4.2 External passive component selection

4.2.1 Input resonant circuit component selection (L1, C1, C2)

RX coil selection should be optimized by the requested transferred power. The inductance of the coil together with C_1 and C_2 capacitors create an input resonant circuit. Components have to be carefully selected both to keep the resonant frequency compliant with the wireless standard specification and also to deliver the power. For more details please see wireless standard specifications.

The following equations list the resonant frequencies:

Equation 1:

$$f_s = \frac{1}{2 * \pi * \sqrt{L_1 * C_1}}$$

Equation 2:

$$f_D = \frac{1}{2 * \pi * \sqrt{L_1 * \left(\frac{1}{C_1} + \frac{1}{C_2}\right)}}$$

It is recommended high grade ceramic capacitors to be used with C0G dielectrics type. X5R, X7R capacitors can be used for 5 W output power applications.

4.2.2 Voltage clamp resistor selection (RCL1, RCL2)

The purpose of these resistors is to load the rectifier output by decreasing the rectified voltage below overvoltage threshold – hysteresis (V_{OVP}-$V_{OVPHYST}$), when V_{OVP} is reached. 0.2 W resistors with pulse-withstanding character are recommended for this application.

4.2.3 Load modulation capacitor selection (CM1, CM2)

These capacitors fulfill the backscatter modulation of the communication from the receiver to the transmitter. X5R dielectrics type capacitors are suitable for this purpose.

4.2.4 Feedback resistor divider component selection (RFB1, RFB2)

Feedback voltage divider gives the ratio between the desired step-down converter output voltage and the given feedback reference voltage. The R_{FB1} and R_{FB2} resistors should be 0.1% or 0.5% precision.

4.2.5 Rx NTC circuit component selection (RNTC, R1)

To protect the receiver coil from overtemperature, the STWLC04 is equipped with a comparator input. If the input voltage crosses a certain level, the STWLC04 reacts terminating the power transfer and sending an interrupt to the host system – depending on the configuration. The input voltage is given as a ratio from R_{NTC} thermistor and R_1 common resistor divider. The divider can be supplied from LDO1 (VA pin) filtering capacitor.

4.2.6 Soft-start capacitor selection (C10)

The soft-start capacitor C10 connected to COMP pin influences the ramp-up time of the step-down converter. The nominal V_{REF} voltage is 1.2 V and the time needed to reach the nominal voltage is given by the following equation:

Equation 3:

$$t_{SOFTSTART} = C \cdot 10^6 \cdot VREF[s, F, -, V]$$

Example: 470 nF ~ 560 ms

4.2.7 External supply transistor selection

The device contains the function of the connection external voltage supply directly to V_{OUT} by the external dual P-channel transistor back-to-back connected so to avoid the leakage from V_{OUT} to the external voltage supply.

4.3 Reference PCB layout

Figure 7: Top overlay

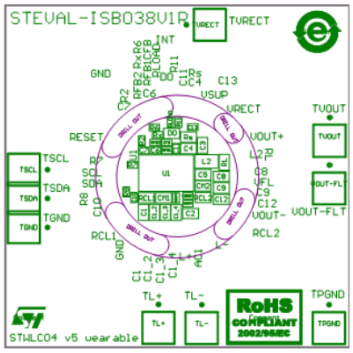


Figure 8: Top layer

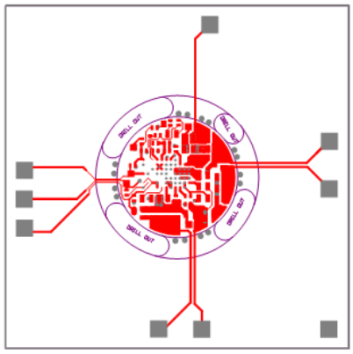


Figure 9: Mid layer 1

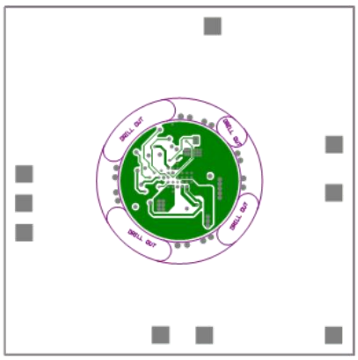


Figure 10: Mid layer 2

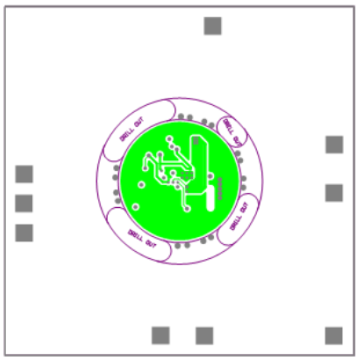
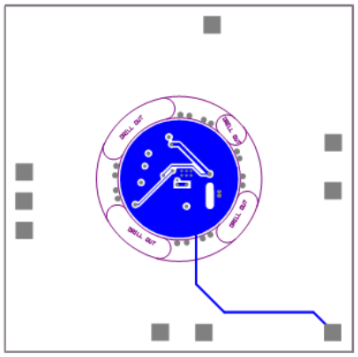


Figure 11: Bottom layer



5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: ***www.st.com***. ECOPACK® is an ST trademark.

5.1 Flip Chip 77 bumps (3.12x4.73 mm) package information

Figure 12: Flip Chip 77 bumps (3.12x4.73 mm) package outline

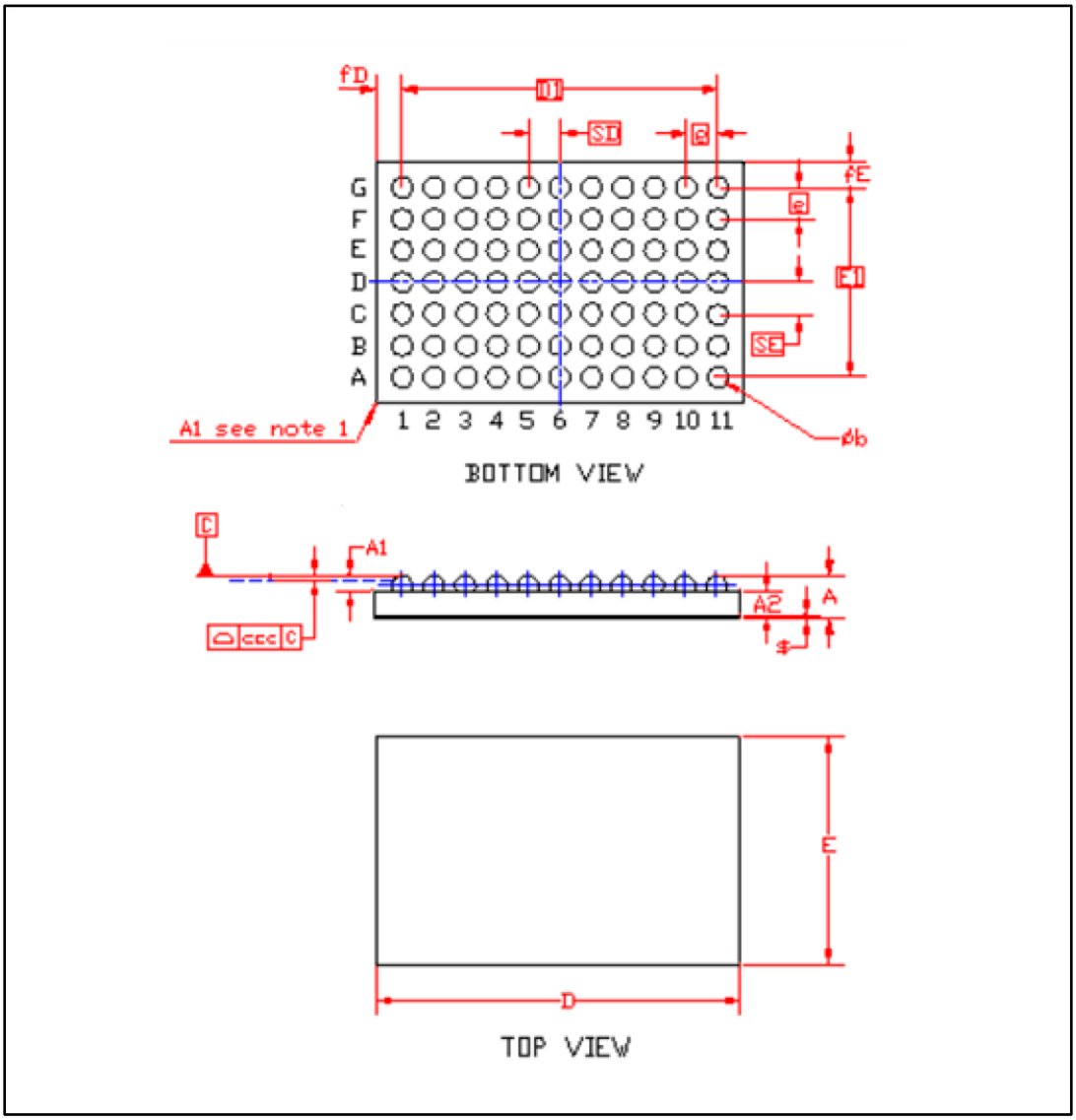
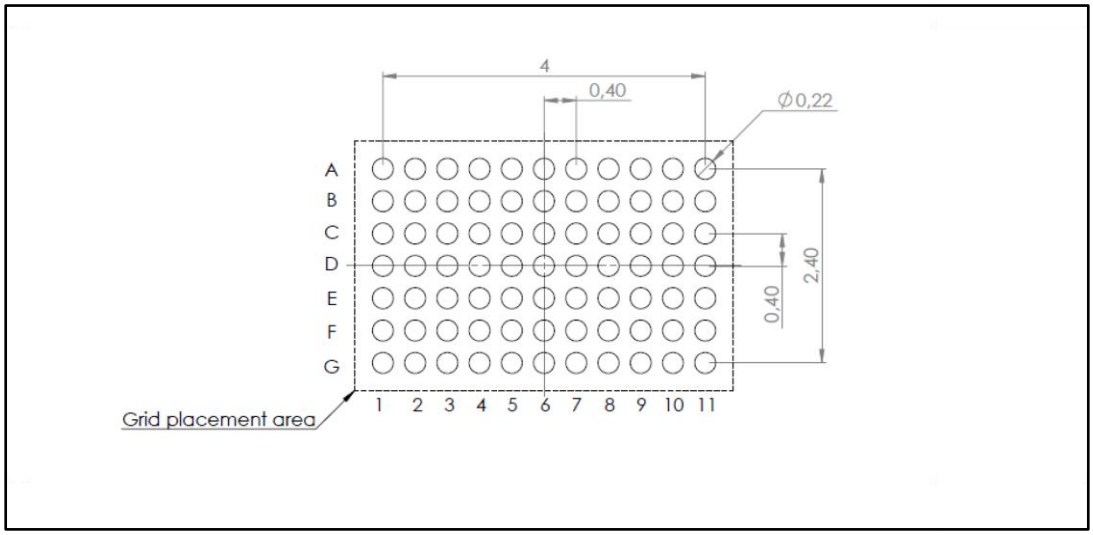


Table 6: Flip Chip 77 bumps (3.12x4.73 mm) package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	0.50	0.55	0.60
A1	0.17	0.20	0.23
A2	0.28	0.30	0.32
b	0.23	0.26	0.29
D	4.67	4.70	4.73
D1		4.00	
E	3.06	3.09	3.12
E1		2.40	
e		0.40	
SD		0.20	
SE		0.20	
fD		0.352	
fE		0.346	
$		0.05	
ccc		0.075	

The terminal A1 on the bump side is identified by a distinguishing feature (for instance by a circular "clear area", typically 0.1 mm diameter) and/or a missing bump. The terminal A1 on the backside of the product is identified by a distinguishing feature (for instance by a circular "clear area", typically between 0.1 and 0.5 mm diameter, depending on the die size).

Figure 13: Flip Chip 77 bumps (3.12x4.73 mm) recommended footprint



6 Revision history

Table 7: Document revision history

Date	Revision	Changes
10-Aug-2016	1	Initial release.
06-Sep-2016	2	Updated the cover image, the *Section "Features"* and the *Section "Description"* .

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