R-Link Watch Operation Description

Power Supply Circuit

The R-Link Watch is powered by a rechargeable 3.7V 320mAh Lithium Polymer battery which has a built-in protection module for preventing over-charge, over-discharge, over current and includes a 10k NTC thermistor which is used by the battery charge controller chip to prevent charging at temperatures above +40C.

The battery power output terminals and NTC interface with the main PCB assembly using connector J5. This interface connects to U4 which is a TI BQ25150 battery charge controller device. The battery input is fuse protected by F1.

U4 the BQ25150 contains several registers which are used to configure the charging current, end of charge current and other parameters such as when interrupt outputs are generated. Firmware also monitors the battery voltage and controls powering off the Watch based on the battery voltage reducing from 4.2V (fully charged) to 3.5V.

The BQ25150 is configured under firmware control using an I2C interface. The I2C master device which programs the registers is U1, the Murata LBUA5QJ2AB UWB and BLE combo radio module. This module contains a microcontroller which is the main processing device which the embedded firmware runs on.

The BQ25150 battery charger controller provides a power output, VSYS, which is used to power the system. When the external 5V DC charging power is connected to the Watch via the SP1, SP2 and SP3 contact pins VSYS will be at 5V DC. When the charging power is disconnected the VSYS rail is connected to the battery output by the BQ25150.

A second power output from the BQ25150, +1.8V is provided for a level shifter device but it is not used as the 9 Axis IMU feature which requires the +1.8V/+3.0V level shifter was dropped.

The firmware can power down the system by sending commands to the BQ25150 device over the I2C communication interface. When powered down the only way to power up the Watch is by connecting it to an R-Link Charger or a charging bay of the R-Link 2 Bay Gateway. Charging is only possible using R-Link series products, charging by 3rd party devices is not supported.

All of the devices with the exception of the Buzzer are powered from +3.0V DC. The +3.0V power rail is generated by U5 which is an ISL91107 high efficiency switched mode regulator. Although it is a buck boost device, only buck mode is ever used as the firmware switches off the Watch when the battery voltage reaches 3.5V.

There are a few signals from U4 which connected to U1 which does the main processing. CHG.INT provides interrupts which are configured by firmware, connecting and disconnecting charging power causes interrupts to be generated to U1. CHG_PG indicates that the charging power input is good. The CHG.CE signal is set low to enable charging of the battery.

TVS1 and TVS2 provide protection to ESD and short duration voltage spikes at the charging power input and battery terminals of the PCB assembly. FB1 is used to reduce EMI.

Main Processing and UWB and BLE

U1 is a certified (IC: 772C-LB2AB) Murata LBUA5QJ2AB UWB and BLE Radio module. It contains a microcontroller, Flash memory and SRAM memory. Using these resources it runs the embedded firmware which controls the operation of the product.

There are three RF ports on this module, one for BLE and two for UWB radio functions. The BLE port is connected to a Molex 2119640001 BLE chip antenna, the first UWB port is connected to a Molex 2119969050 UWB Flex antenna via a UFL connector. The other UWB RF port is unused and is terminated into a 50 ohms resistor. The BLE port has an alternative option for connection to an antenna via a UFL connector but this option is not used. The BLE operates at the standard Bluetooth range of 2402MHz to 2480MHz. The UWB can operate on channel 5 which has a centre frequency of 6489.6MHz or Channel 9 which has a centre frequency of 7987.2GHz. UWB has a channel bandwidth of 500MHz. The Reactec firmware only uses Channel 5.

Test points are provided for the USB_D_P, USB_D_N, USB_VBUS, UART_TX, UART_RX, JTAG_SWDIO, JTAG_SWDCLK, +3.0V, nRESET and GND signals for programming, debug and test purposes only.

A switch on R-C reset is provided by R16 and C16, this holds the nRESET signal low for a few milliseconds of time to allow the +3.0V power rail to settle at the power on time before booting the system.

The Murata module interfaces with several peripheral devices using a combination of general purpose IO pins, a serial peripheral (SPI) interface and an Inter-Integrated Circuit (I2C) interface. The details of the circuits controlled by these interfaces and IO pins will be described in the later sections of this document.

In the Schematic sheet with the Murata module another integrated circuit device, U2, is shown. This is an ST M41T62LC6F Real Time Clock with built in oscillator. This device is not populated as the feature was dropped during development.

Inertial Motion Units and Pressure Sensor

U8 is an ST LSM6DSOXTR inertial motion unit (IMU) used for sensing 3 axis acceleration and 3 axis rotation. This IMU is configured by the Murata module using the SPI interface which consists of a clock (SPI.CLK), 2 way serial data (SPI.MISO and SPI.MOSI). A general purpose IO pin is used for the chip selection (SPI.IMU_6_CS). Each SPI device has a Chip Select to allow the Murata module to select which device it is communicating with when the SPI interface is active. The data from this device is read using the SPI bus. There are two interrupt outputs IMU.6_INT1 and IMU6_INT2 which are configured by firmware to alert the Murata module via its general purpose IO pins when certain conditions have been sensed.

U9 is an Infineon DPS310 barometric pressure sensor which is used for atmospheric pressure sensing. This device is also configured by the Murata module using the SPI interface. The chip select is SPI.PRESS_CS. The data from this device is read using the SPI bus.

U7 is a TDK Invensense ICM-20948 9 axis IMU but the feature it was intended to provide was dropped during development and it is not populated. U10 which is a TI TXB0108 level shifter is required to interface U7 with U1 but it is also not populated for the same reason.

RFID Function

U6 an NXP CLRC66303 provides an RFID reader function for reading Mifare RFID cards and ISO 15693 RFID tags used to identify Watch users and vibrating power tools being operated by the Watch user. The RFID is inactive until a button on the Watch is pressed. It is then activated for around 10 seconds or until a card or tag is presented and read.

The signal RFID.PDOWN is used by the Murata module (U1) to activate or deactivate the power saving mode. The RFID.IRQ signal is used to interrupt the Murata module when a card or tag is read.

U6 is configured by the firmware running on the Murata module using the SPI bus previously described. SPI.RFID_CS is the chip select signal used by the Murata module to enable SPI communication with the RFID reader device. Data is also read from this device using the SPI bus.

An impedance matching and filter circuit is connected between the RXP/RXN, TXP/TXN, TX1/TX2 and TVSS terminals of U6 and the Molex 1462360111 RFID flex antenna which is connected to J6 and J7 terminals. L2 with C42/C43 and L3 with C46/C47 form an the EMI filter. The other passive components C38, C40, C41, C44-45, C48-49, C51-C53, form the antenna matching circuit. The values of these components are obtained using a spreadsheet provided by NXP.

X1 a 27.12MHz crystal is connected to U6 which forms part of an internal oscillator circuit which the device uses as it's main clock.

L4 is used to prevent EMI getting onto the main +3.0V rail and potentially radiated from the Watch.

Display

The display which is a JDI LPM013M126C memory in pixel device connects to connectors J1 and J2 of the PCB assembly. J1 provides the main interface for the Murata module to control the display content. J2 is a backlight interface which provides access to a simple white LED backlight.

The SPI interface signals SPI.CLK and SPI.MOSI are used to write data to the display and SPI.DISP_CS is used to enable and disable the display appropriately during SPI communication.

The Murata module also controls the DISP_EXTCOMIN and DISP_EXTMODE signals which are used to set the data sync mode and sync timing.

The Display is powered by the +3.0V rail and is always powered when the Watch is powered. The Backlight on/off control is done by Murata module using the DISP_BL_EN signal. Q2 connects the backlight white LEDs anodes (J2) to the +3.0V power rail when the backlight is on. R6 and R7 are used to set the current through the White LEDs to obtain an appropriate backlight level.

R9 and R10 ensures that the backlight is off when the Murata module IO pins are not yet configured at initialisation.

Buzzer

For audible alerts a CUI CMT-7525S2.73KHz buzzer is controlled by the Murata module using signal PWM.BUZZER signal. This signal is pulsed at 2.73KHz to operate the buzzer and the duty cycle varied for volume control, 50/50 being the maximum volume. Q1 is switched on and off by the PWM.BUZZER signal, it connects one side of the buzzer to GND when on. The other side of the buzzer connects to the VSYS power rail via a reverse protection diode. VSYS is at the same voltage as the battery when the Watch is off charge, it is +5V when the Watch is on charge.

C2 is for EMI suppression, R2 pulls up to VSYS when Q1 is off. R4 ensures Q1 is off when the Murata module GPIO pins are not configured. D2 provides a path for the reverse current generated when the buzzer is switched off. This ensures any reverse voltage is limited and will not damage Q1.

Vibration Motor

For vibration alerts a Precision Microdrives 304-103 motor is controlled by the Murata module using signal PWM.VIBRO signal. This signal set high to constantly operate the motor which will alert a user though light vibration on the wrist. The PWM.VIBRO signal can also be pulsed with the duty cycle varied for vibration level control. Q3 is switched on and off by the PWM.VIBRO signal, it connects one side of the motor to GND when on. The other side of the motor connects to the +3.0V power rail.

C6 is for EMI suppression, R8 pulls up to +3.0V when Q3 is off. R11 ensures Q3 is off when the Murata module GPIO pins are not configured. D3 provides a path for the reverse current generated when the motor is switched off. This ensures any reverse voltage is limited and will not damage Q3.

Button Switches

The watch has user menu displays and the button switches on the side of the housing actuate SW1 and SW2 when pressed. The change of switch state is detected by the Murata Module (U1) and the appropriate action taken. R1 and R5 provide pull up to +3.0V when the switches are not pressed.

Flash Memory

U3 is a Cypress S25FL064LABNFI013 Flash memory device which is used for non volatile data storage. This is powered from +3.0V and can be written and read using the SPI bus which is controlled by the Murata Module (U1). The SPI.FLASH_CS signal is used to enable U3 for SPI communications. The SPI.CLK, SPI.MOSI and SPI.MISO are used for the clock and data signalling. MOSI being an input to U3 and MISO being an output.

FLASH_WP and FLASH_RST are permanently pulled up as these features are not required in the design.