AVR2037: RCB Key Remote Control - Hardware User Manual

8-bit AVR® Microcontrollers

Application Note

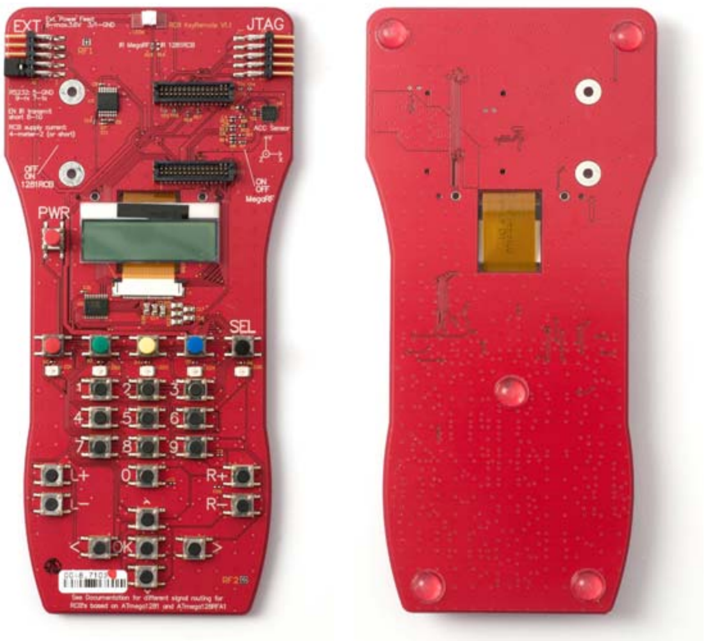
Features

- Connector interface to adapt various radio controller boards (RCB)
- RCB battery powered, hand-held evaluation, and development platform
- 25 keys
- 5 LEDs
- 128 x 32 graphic display
- Analog, three-axis acceleration sensor
- 980nm IR transmitter
- RS232 and JTAG interfaces

1 Introduction

This application note provides a detailed hardware description for the individual function blocks of the RCB Key Remote Control (KeyRemote) board. The KeyRemote is used in conjunction with an Atmel® RCB in order to evaluate remote control applications.

Figure 1-1. RCB Key Remote Control board.



Rev. 8356A-AVR-02/11

2 Disclaimer

Typical values contained in this application note are based on simulations and testing of individual examples.

Any information about third-party materials or parts is included in this document for convenience. The vendor may have changed the information since publication. Check the individual part information for the latest changes.

3 Overview

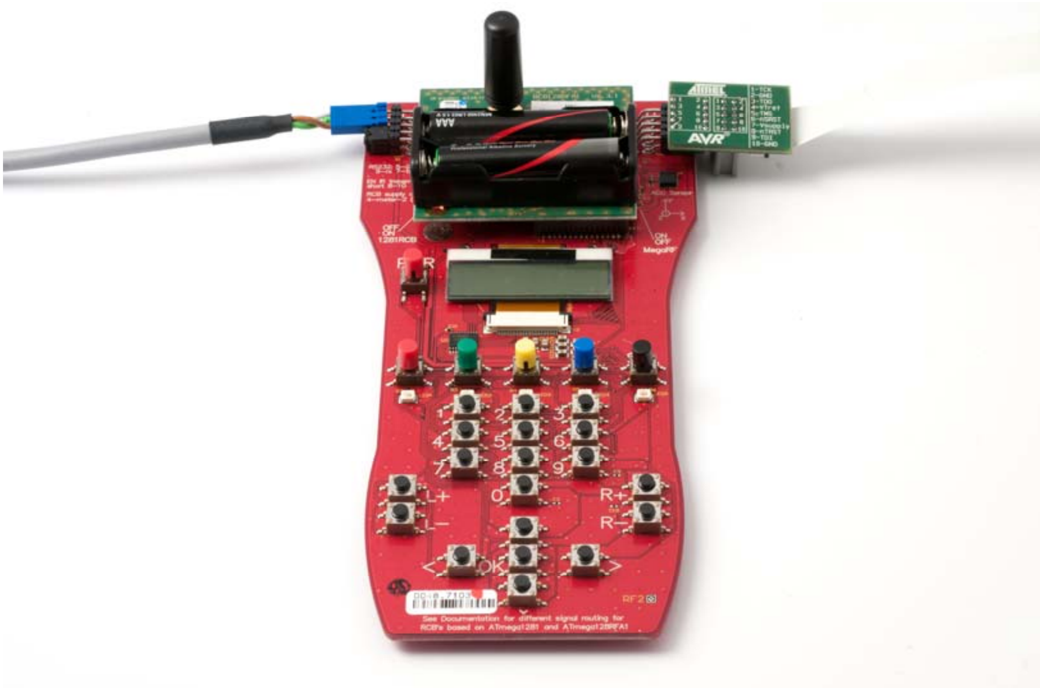
The KeyRemote is a hardware platform used to demonstrate Atmel hardware and software solutions for remote control applications. In combination with one of the various RCBs, the KeyRemote contains all the functional blocks that might be used in state-of-the-art remote controls. Programming and debugging interfaces are provided to support application development.

While the KeyRemote primarily provides the user interface hardware, an appropriate RCB (see Table 3-1) must be included to provide the microcontroller and radio transceiver functionality:

Table 3-1. RCB configurations.

RCB name	Frequency	Comment
RCB128FA1	2.4GHz	Atmel ATmega128RFA1 single-chip solution [1]
RCB231	2.4GHz	Atmel AT86RF231 [2] with Atmel ATmega1281V [4]
RCB212SMA	868/915MHz	Atmel AT86RF212 [3] with Atmel ATmega1281V [4]

Figure 3-1. KeyRemote with RCB128RFA1, Atmel® AVR® JTAGICE mkII, and serial adaptor cable.



4 Peripheral blocks

The following sections describe the different peripheral blocks of the KeyRemote, and how to configure and use each peripheral accordingly.

4.1 RCB interface

In order to operate the KeyRemote, an appropriate RCB must be selected and mounted on the KeyRemote board. The differences between the RCBs are related to port allocations: the single-chip Atmel ATmega128RFA1 solution does not provide access to ports A and C, and the Atmel ATmega1281V-based dual-chip solutions already use port B to control the radio transceiver. Single-chip and dual-chip boards have a different port signal routing, which is already supported in the software provided. Table 4-1 describes these RCB differences.

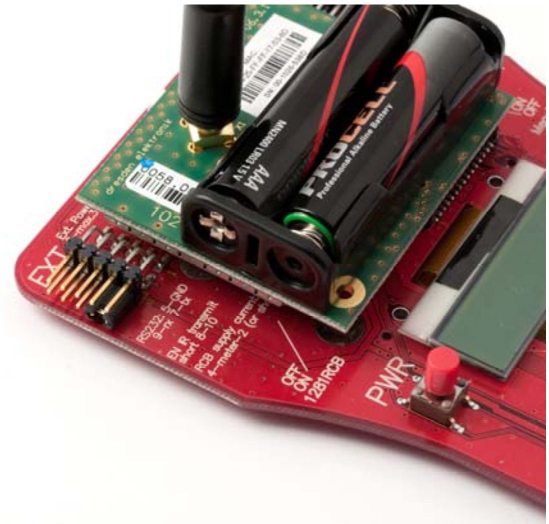
Table 4-1. Signaling with different RCBs.

KeyRemote signal	RCB with ATmega1281V	RCB with ATmega128RFA1	Comment
DATA0..7	PORTA0..7	PORTB0..7	Data bus used for the display, the U3 extension port, and the key matrix
LEDP_SEL	PG1	PE5	U3 works transparently when high. and keeps data information after being switched to low level
LCD_#CS1	PG0	PE4	Low to enable the LCD
IR transmitter	PB7 direct from ATmega1281V: R15 has to be assembled (default when delivered)	PB7 through U3: Remove R15 and assemble the same part at R16	Same pin PORTB7, but R15 and R16 have to be assembled in the correct way

4.2 Power supply

The KeyRemote and RCB hardware are both powered by the batteries on the RCB. The power supply switch on the RCB is used to connect or disconnect the battery power supply voltage. In order to use the battery supply, a jumper bridge must be connected at X1 between pin 2 and pin 4, as shown in Figure 4-1.

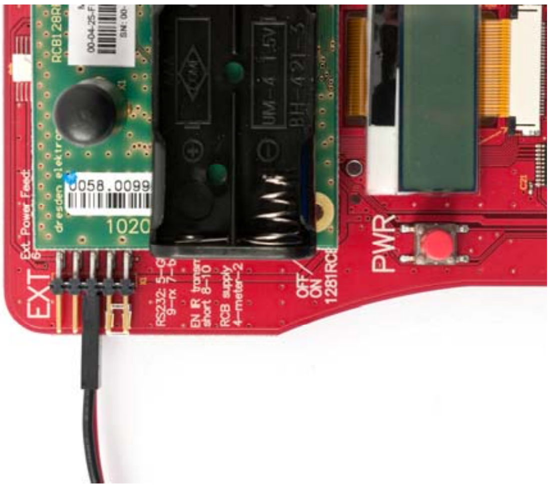
Figure 4-1. X1 battery jumper.



If battery operation is not desired during software development and debug sessions, for example, the setup can also be powered from a lab supply or a regulated DC wall plug transformer. Before an external power supply is used, however, the batteries on the RCB should be removed or the power switch must be placed in the off position. Be sure the external power supply never exceeds 3.6V (see the absolute maximum ratings in Table 5-1).

Figure 4-2 shows an external power supply connected to X1 on pin 6 (+) and pin 5 (-).

Figure 4-2. X1 external power connection.



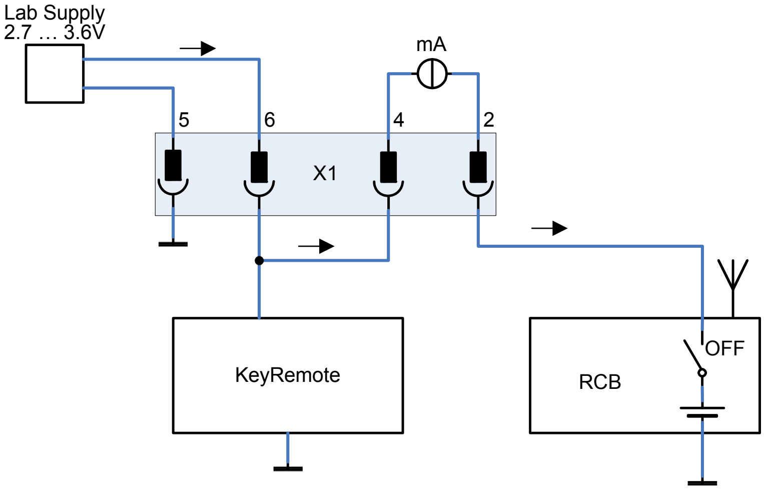
4.2.1 Supply current measurement

The supply current of the RCB and KeyRemote can be measured independently of each other.

The current consumption of the RCB is measured by removing the jumper bridge at X1 pin2/4 and connecting a DC current meter in its place. Also, the batteries should be removed, and the power switch on the RCB needs to be switched off.

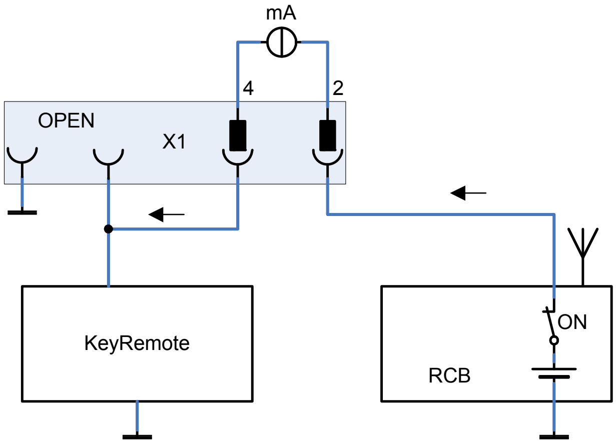
An external power source needs to be connected to pin 6 (+) and pin 5 (-). This can be a lab power supply, a regulated DC wall plug supply, or an external battery (see the recommended operating range in Table 5-2).

Figure 4-3. RCB supply current measurement.



The current consumption of the KeyRemote peripherals can be measured by removing the jumper bridge at X1 pin2/4 and connecting a DC current meter in its place. In this measurement, the batteries from the RCB will supply the KeyRemote with power.

Figure 4-4. KeyRemote supply current measurement.



4.3 Interfaces

4.3.1 Programming interface

To enable software development and flash programming, an AVR JTAGICE mkII can be connected directly to X2. Although the mechanical construction makes it difficult to connect the ICE incorrectly, be sure to locate the pin 1 marking to avoid any hardware damage.

Programming and debugging requires a KeyRemote with an appropriate supply voltage, either from the RCB battery or directly via X1 (see Section 4.2, page 3).

The AVR JTAGICE mkII interface is provided to program the microcontroller located on the RCB, as the KeyRemote does not provide its own microcontroller.

Figure 4-5. KeyRemote with AVR JTAGICE mkII connected.

4.3.2 LEDs

The five LEDs are controlled by data latch U3, and are controlled simultaneously. The state of each LED has to be applied to its corresponding data line, DATA0...DATA4. A short high pulse (minimum 3.2ns) applied by the microcontroller on signal LEDP_SEL stores the new state in the latch. Start this process by applying a new state to data lines DATA0...DATA4 first, and then pull the LEDP_SEL signal high and low. This signaling cycle avoids spikes on the other lines.

The U3 register state can't be read directly by the microcontroller. Instead, the software must maintain a variable that mirrors the state of U3.

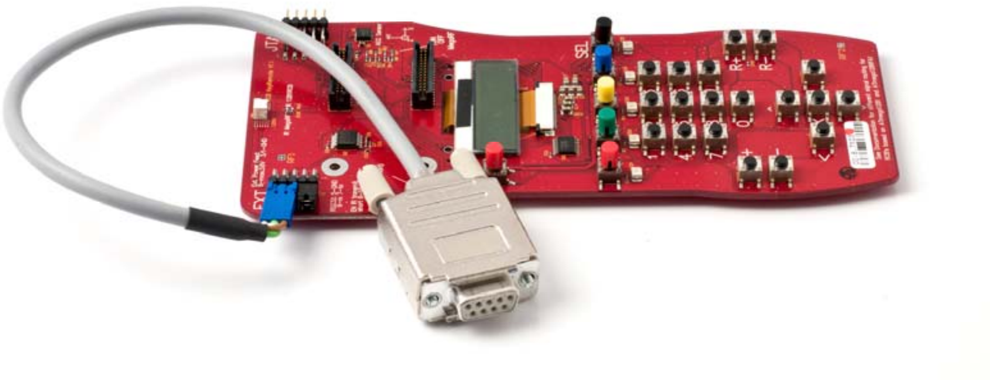
When one LED state is updated, it may be necessary to ensure the signals for the other four LEDs are not changed.

4.3.3 RS232 interface

During software development, the RS232 interface can be a valuable "back door" the developer may use to transmit status and debug messages, as well as to influence the system. A Maxim MAX3221ECAE is used to shift the low-level logic signals to the high signal levels needed to interface properly to a PC.

To enable the RS232 interface, DATA6 needs to be properly configured so the U3 latch device can set bit7 (#EN_232) to logic low. See Table 4-1 and the KeyRemote schematic for detailed information. If the interface is not required, it is recommended to disable the line driver to reduce power consumption.

Figure 4-6. KeyRemote with RS232 cable connected.

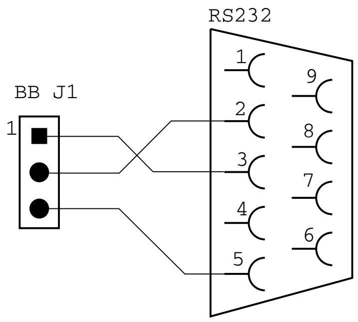


Automated power consumption is achieved using the line driver auto-shutoff. This function enables the driver only when a valid RS232 level is detected. As long as the board is not connected to a host, the line driver is automatically disabled. For further information on the Maxim MAX3221ECAE, refer to the datasheet [6].

The connection to a PC COM port with DB9 connector can be done as documented in the Figure 4-7.

Figure 4-7. RS232 cable.

KeyRemote X1 (DTE)		RS232 SUB-D9 (DTE)
9 (RxD) Input		2 (RxD) Input
7 (TxD) Output		3 (TxD) Output
5 (GND) (brown wire)		5 (GND)



4.3.4 128 x 32 graphic display

The onboard display is a COG type with built-in controller and display memory. It accessed only when it is necessary to change the content of the display.

The controller has a high-performance parallel interconnect to the microcontroller on the RCB. Table 4-2 shows the port assignment between display and microcontroller for different types of RCBs.

Table 4-2. Display signaling with different RCBs.

Display signal	RCB with ATmega1281V	RCB with ATmega128RFA1	Comment
DATA0..7	PORTA0..7	PORTB0..7	Data bus
LCD_#CS1	PORTG0	PORTE4	SELECT
LCD_#RES	PORTE2	PORTE2	RESET
LCD_A0	PORTE3	PORTE3	Data / control
LCD_R/W	PORTE6	PORTE6	/WR signal
LCD_E	PORTE7	PORTE7	/RD signal

For further information, refer to the example source code and the manufacturer data sheets for the display [7] and the display internal controller [8].

For best quality display operation, it is required to arbitrate the hardware operation in between the display access and the key input. When more than one key is pressed at the same time, bus contention may occur. The software has to make sure that information is written to the display only when the keys are up or when only one key is pressed. To achieve this, the key interrupt should be enabled during display access.

4.4 Key matrix

The board features 25 keys, configured as a 3-row, 9-column matrix. The three rows are connected to RCBPORTD1/2/3. These lines have full wake up capabilities for the controller.

The columns make use of data lines DATA0 ... DATA6 and PORTD5/7. These signals have an alternate function to control additional hardware on the KeyRemote board (see sections 4.3.2 and 4.3.4).

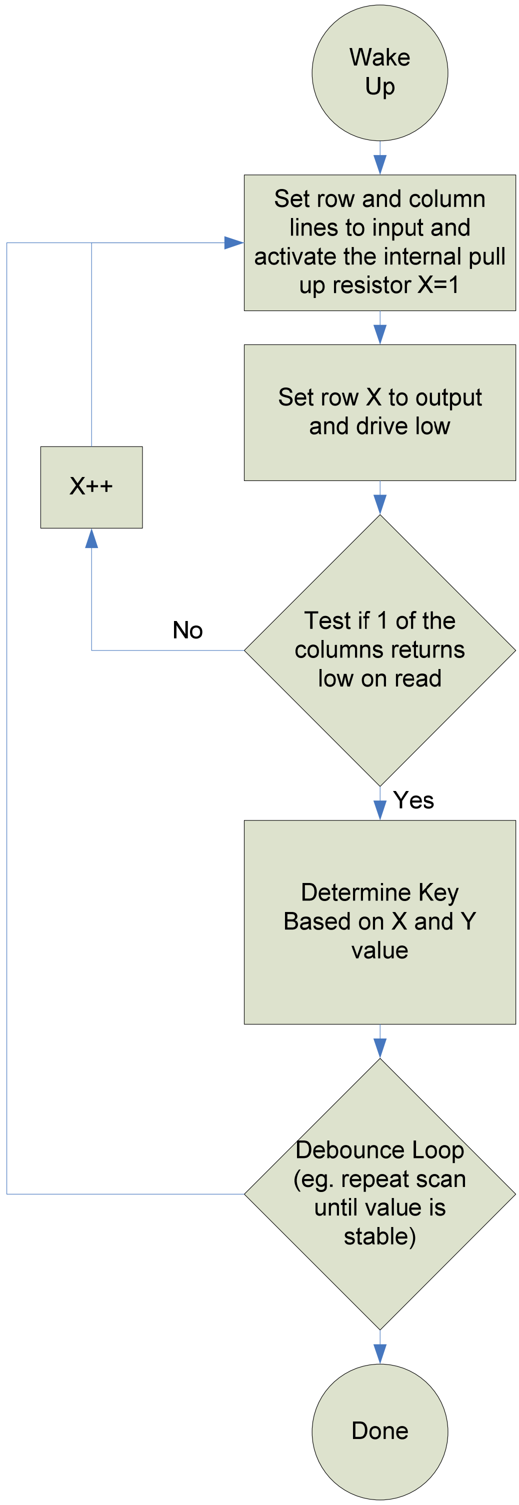
It is recommended to have the KeyRemote in SLEEP mode to reduce power consumption as long as no activity is required. However, key activity recognition has to be ensured to wake up the KeyRemote, if needed.

To prepare the system for SLEEP and to ensure key recognition, follow the steps below:

1. Disable hardware not required (RS232, acceleration sensor, display, etc.) to reduce power consumption during SLEEP mode
2. Set LEDP_SEL to low (DATA lines are now used for key recognition)
3. Set DDRD1/2/3 to input
4. Set PORTD1/2/3 high to activate the internal pull-up resistors. (The pull-up resistors will keep the signal level at these pins high until a key is pressed)
5. Configure lines DATA0 ... DATA6 and PORTD5/7 as outputs, and set each to low level. (The low on the column lines will pull the row line down as soon as a key is pressed)
6. Enable the low level interrupt for PORTD1/2/3
7. Enter sleep mode

After doing this, and once a key is pressed later on, the system will wake up. The software performs a scan routine, as shown in Figure 4-8, to process the key entry.

Figure 4-8. Key scan algorithm.

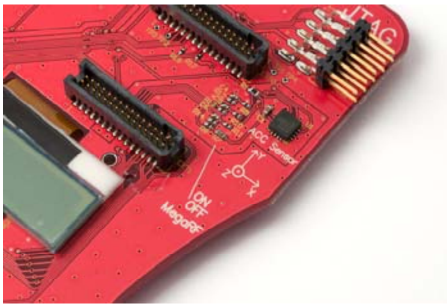


4.5 Acceleration sensor

In addition to the interfaces described above, the KeyRemote integrates an analog acceleration sensor, U1 [9]. This type of sensor can be used for pointing at menu driven screens, or to recognize gestures. Due to gravitational acceleration, the system can easily determine how a user holds or moves the device.

The orientation of the three axes is illustrated on the PCB (see Figure 4-9).

Figure 4-9. Three-axis acceleration sensor.



The analog outputs are connected to the analog-to-digital converter (ADC) of the RCB microcontroller. X_{out} is connected to PF0-ADC0. Y_{out} is connected to PF1-ADC1. Z_{out} is connected to PF2-ADC2.

For zero G, the sensor output equals half the supply voltage. A resistor network divides the voltages within the RCB controller measurement range. Since the sensor output values depend on the supply voltage, a fourth channel is implemented to measure the sensor supply to correct for supply voltage variations. The voltage divider implements a 25% decrease, and is connected to PF3-ADC3 of the microcontroller.

The resistor network also implements capacitors to set the acceleration sensor bandwidth. Depending on the application scenario, the sensor bandwidth can be adjusted by setting the capacitor values.

To enable low-power applications, the sensor can be powered down with the controlling signal, ACC_PWR. It corresponds to bit 6 (DATA5) of latch U3. Please refer to Section 4.3 for details on how to set these control lines.

4.6 IR transmitter

The KeyRemote features a 950nm infrared transmitter (IR LED) on top of the PCB, LED6. This is the standard operating infrared wavelength used in remote controls for electronic devices or appliances. To enable the IR LED, a jumper has to be placed at connector X1 to short pins 8 and 10.

The IR LED is connected to controller port PB7. This port has to be used because it is the output compare modulator output. Please refer to the AVR datasheet for more information.

If using the KeyRemote assembled with the RCB128RFA1 [5] featuring the single-chip ATmega128RFA1, latch U3 has to be configured for transparent mode by setting LEDP_SEL to high level.

For operation with ATmega1281V-based RCBs, the resistor assembled on R15 must be removed and mounted as R16. By doing this, the IR LED is driven directly from the ATmega1281V pin.

5 Electrical characteristics

5.1 Absolute maximum ratings

Stresses beyond those listed under absolute maximum ratings (see Table 5-1) may cause permanent damage to the board. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this manual are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. For more details about these parameters, refer to individual datasheets of the components used.

Table 5-1. Absolute maximum ratings.

No.	Parameter	Condition	Minimum	Typical	Maximum	Units
5.1.1	Storage temperature range		-40		+85	°C
5.1.2	Humidity	Non-condensing			90	%
5.1.3	Supply voltage		-0.3		+3.6	V
5.1.4	Maximum input supply current	Sum over all power pins			0.5	A

5.2 Recommended operating range

Table 5-2. Recommended operating range.

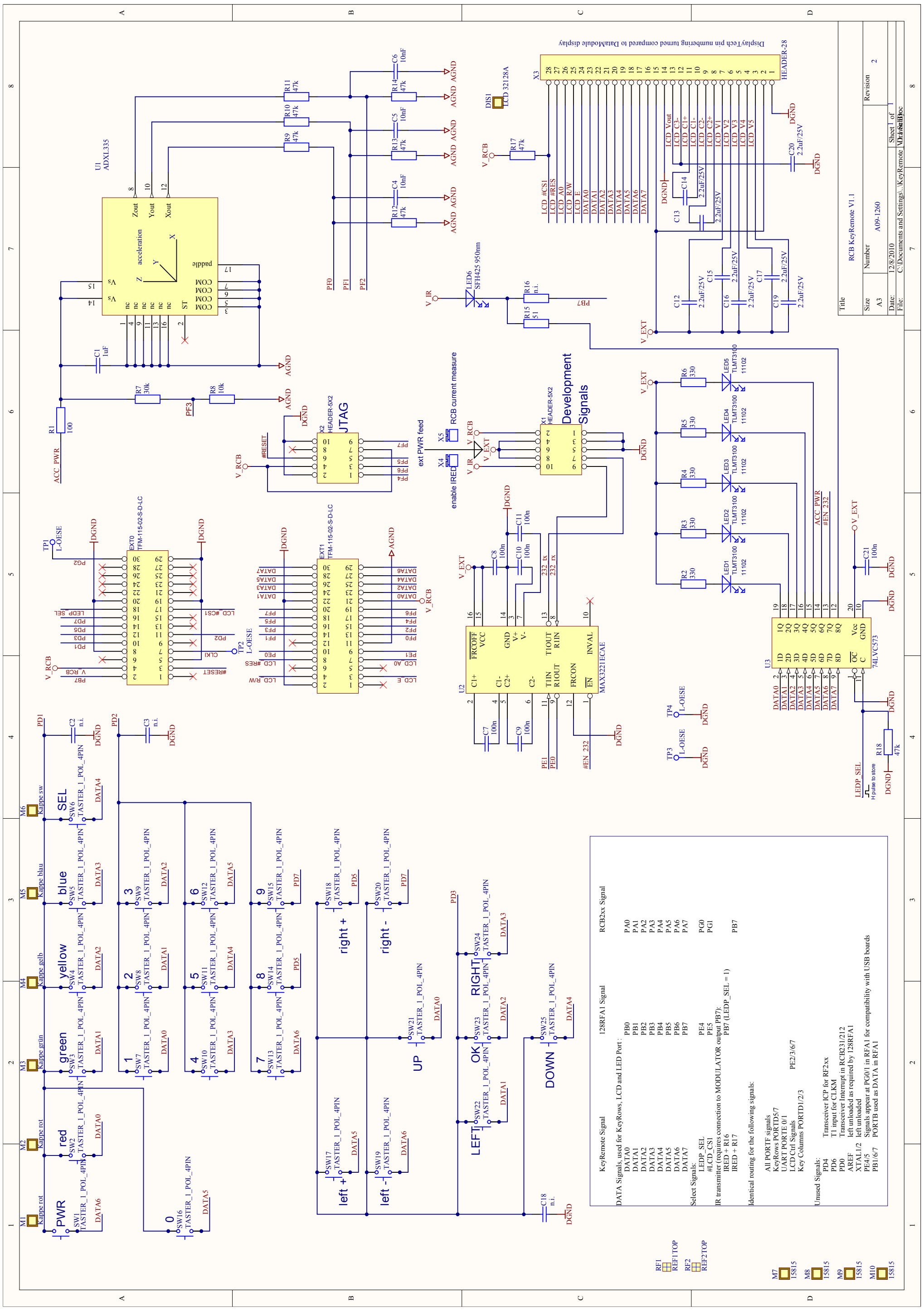
No.	Parameter	Condition	Minimum	Typical	Maximum	Units
5.2.1	Temperature range		-10		+60	°C
5.2.2	Supply voltage		1.8	3.0	3.6	V

6 Abbreviations

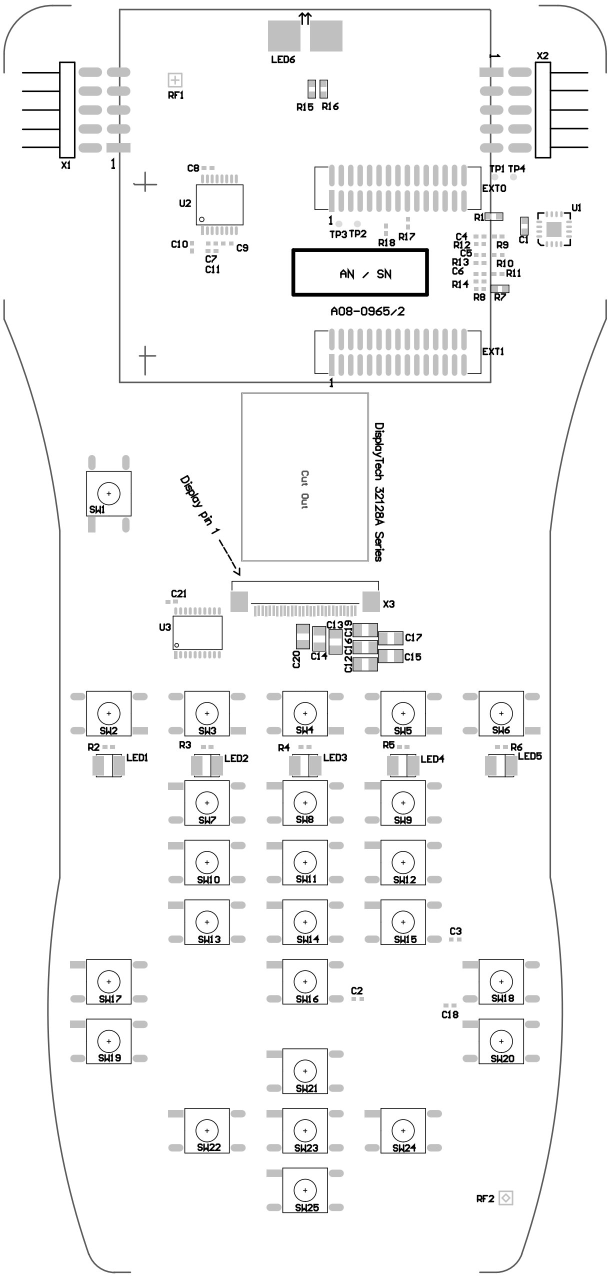
ADC	-	Analog to digital converter
COG	-	Chip on glass
IR	-	Infra Red
LED	-	Light Emitting Diode
PCB	-	Printed Circuit Board
RCB	-	Radio Controller Board

Appendix A - PCB design data

A.1 Schematic



A.2 Assembly drawing



A.3 Bill of materials

Table A-1. Bill of materials.

Qty.	Designator	Description	Footprint	Manufacturer#	Manufacturer	Comment
1	C1	Capacitor	0603H0.8			1µF
3	C2, C3, C18	Capacitor	0402A			n.i.
3	C4, C5, C6	Capacitor	0402A			10nF
6	C7, C8, C9, C10, C11, C21	Capacitor	0402A			100nF
8	C12, C13, C14, C15, C16, C17, C19, C20	Capacitor	0805			2.2µF/25V
1	DIS1	Key head, round, black		32128A-FA-BW	DisplayTech	LCD 32128A
2	EXT0, EXT1	Header, 15x2-pol.	TFM-115-02	TFM-115-02-S-D-LC	Samtec	TFM-115-02-S-D-LC
5	LED1, LED2, LED3, LED4, LED5	LED red	LED_PLCC-2	TLMT3100	Vishay	TLMT3100
1	LED6	LED IR	SFH425			SFH425 950nm
2	M1, M2	Key head, round, red			APEM	Cap red
1	M3	Key head, round, green			APEM	Cap green
1	M4	Key head, round, yellow			APEM	Cap yellow
1	M5	Key head, round, blue			APEM	Cap blue
1	M6	Key head, round, black			APEM	Cap black
4	M7, M8, M9, M10	Rubber feet, 10x3.5mm, clear				Rubber feet
1	R1	Resistor	0603H0.4			100Ω
5	R2, R3, R4, R5, R6	Resistor	0402A			330Ω
1	R7	Resistor	0603H0.4			30kΩ
1	R8	Resistor	0402A			10kΩ
8	R9, R10, R11, R12, R13, R14, R17, R18	Resistor	0402A			47kΩ
1	R15	Resistor	0603H0.4			51Ω
1	R16	Resistor	0603H0.4			n.i.
2	RF1, RF2		REF1TOP, REF2TOP			REF1TOP, REF2TOP
6	SW1, SW2, SW3, SW4, SW5, SW6	Switch	SW_Farnell177-807	DTSM644R	APEM	SWITCH_1_POL_4PIN

Qty.	Designator	Description	Footprint	Manufacturer#	Manufacturer	Comment
19	SW7, SW8, SW9, SW10, SW11, SW12, SW13, SW14, SW15, SW16, SW17, SW18, SW19, SW20, SW21, SW22, SW23, SW24, SW25	Switch	SW_Farnell177-807	4-1437565-1	Tyco	SWITCH_1_POL_4PIN
4	TP1, TP2, TP3, TP4	Solder/test point	TP_05			L-OESE
1	U1		LFCSP-16	ADXL335BCPZ	Analog Devices	ADXL335
1	U2	RS-232 receiver, auto-shutdown	SSOP-16/0.65			MAX3221ECAE
1	U3	OCTAL D-TYPE TRANSPARENT LCH 3SO	TSSOP-20	74LVC573APW	Philips	74LVC573
2	X1, X2	Header, 5x2-pol.	TSM105_2x5pin_ang	TSM105-01-L-DH	Samtec	HEADER-5X2
1	X3	Header, 28-pol.	HD_FFC_FPC0,50_28pol	52435-2872	Molex	HEADER-28
2	X4, X5	Shorts two contacts				Jumper, 100mil

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References

[1] Atmel ATmega128RFA1; 8-bit Microcontroller with Low Power 2.4GHz Transceiver for ZigBee and IEEE 802.15.4; Datasheet, Rev A; 12/09; Atmel Corporation
[2] Atmel AT86RF231; Low Power 2.4 GHz Transceiver for ZigBee, IEEE 802.15.4, 6LoWPAN, RF4CE, SP100, WirelessHART, and ISM Applications, Datasheet; Rev C; 09/09; Atmel Corporation
[3] Atmel AT86RF212; Low Power 2.4 GHz Transceiver for ZigBee, IEEE 802.15.4, 6LoWPAN, RF4CE, SP100, WirelessHART, and ISM Applications; Datasheet; Rev C; 02/10; Atmel Corporation
[4] Atmel ATmega1281V; 8-bit Microcontroller with 64K/128K/256K Bytes In-System Programmable Flash; Datasheet; Rev M; 09/10; Atmel Corporation
[5] Atmel AVR2044; RCB128RFA1 - Hardware User Manual; Schematic Drawing; Layout Drawing; Atmel Corporation
[6] MAXIM MAX3221ECAE; ±15kV ESD-Protected, 1µA, 3.0V to 5.5V, 250kbps, RS-232 Transceivers with AutoShutdown; Datasheet; Rev 6; 9/05; MAXIM Semiconductor
[7] Displaytech 32128A; LCD module; Datasheet; Rev 1.0; 3/06; Displaytech Ltd.
[8] Sitronix ST7565V; 65 x 132 Dot Matrix LCD Controller/Driver; Datasheet; Ver 1.5b; 2009/09/14
[9] Analog Devices ADXL335; Small, Low Power, 3-Axis ±3G Accelerometer; Datasheet; Rev B; 1/10

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