Mobile Phone Bank Card Reader Application Report

This solution demonstrates the hardware design and firmware design of mobile phone card reader, and includes an Android application to test and evaluate. The solution features low power and low cost, very few components in the BOM list, and only consumes around 1 µA standby current supplied by a CR2032 battery.

Figure 1. Card Reader Kit

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1 Hardware Block Diagram

This solution decodes track 2 of the magnetic identification card using software. In addition to the magnetic reader, a single-channel OP amp is required for conditioning the signals extracted from the card. Inside the MCU, the analog-to-digital converter (ADC) peripheral is needed to sample the extracted signal. Then, the firmware running on the MCU decodes the information contained in the card. Finally, the MCU notifies the host mobile phone via the microphone port whether the decoding is successful or not.

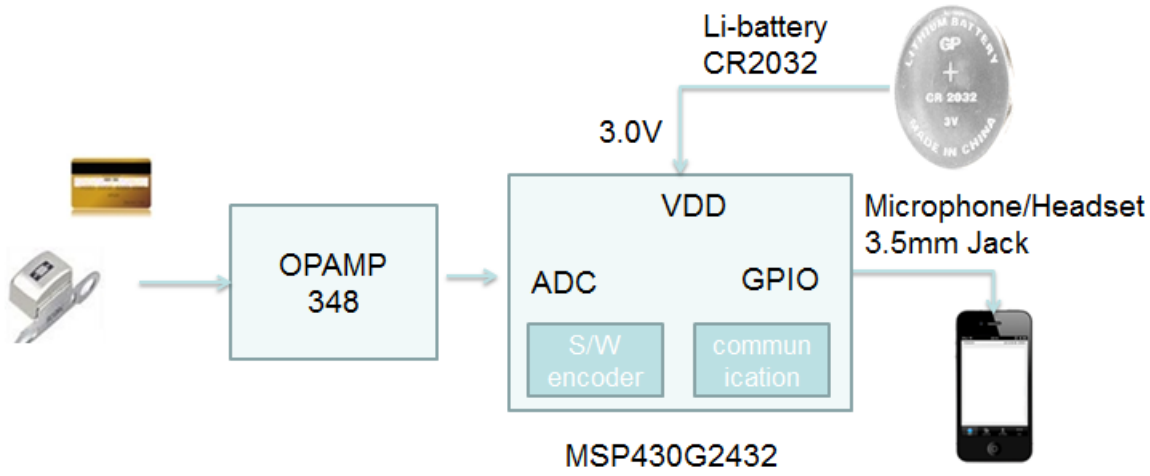

Figure 2. Hardware Block Diagram

2 Schematic

The schematic for the hardware has 11 resistors (two are for testing and should be removed) and four capacitors (see Figure 3).

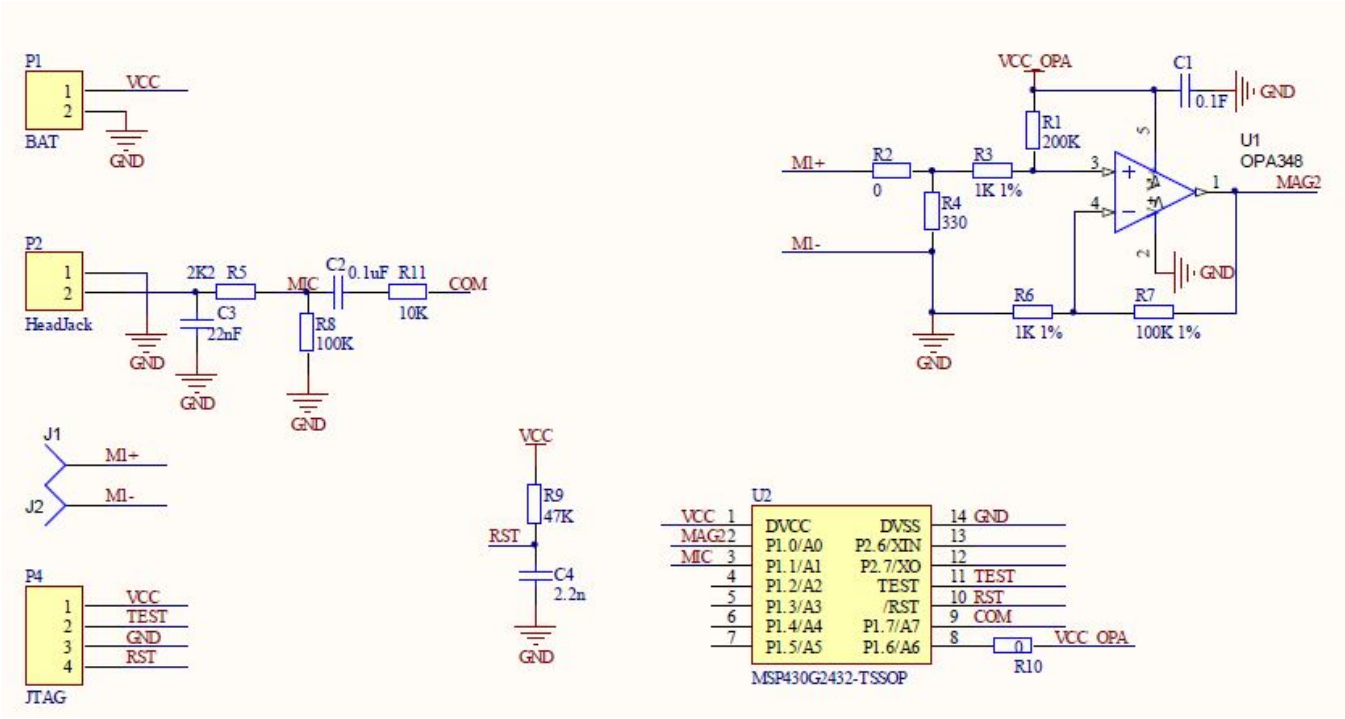

Figure 3. Schematic

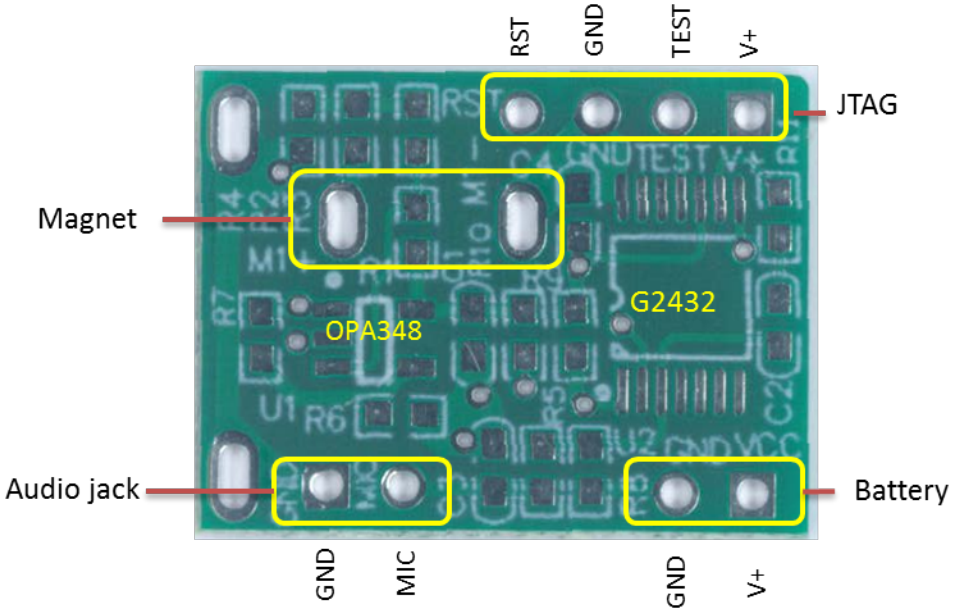

Figure 4. PCB Layout

3 Firmware

The card reader has four states in its life cycle: standby, idle, decode, and locked.

Standby: When the reader is removed from the mobile phone and put into storage, it consumes as little power as possible, around 1 µA on average. During this stage the MCU wakes up every second to see if it is attached to the audio jack. If yes, the reader goes into an idle state.

Idle: When attached to a mobile phone, the reader goes into idle mode and tries to detect a card-swiping activity. During this stage, the reader consumes more power, around several hundred micro amps of current. If the card is swiped in this stage, the reader tries to decode and validate the information that resides in the IC card. The firmware reports the result (fail or success) to the host mobile phone via the microphone port. For low power consideration, or if the reader is idle for around one minute, it shuts down to locked mode and stops responding to user input.

Decode: In this stage, the MCU runs faster to do decoding work. For single track decoding, the reader requires at least 4 MHz of MCLK. In this case, as MSP430G2432 does not have a calibrated 4 MHz DCO on-chip parameter, a 8 MHz DCO was used instead, although this may take more power than the 4 MHz DCO. The decode progress uses an internal timeout of several milliseconds to several seconds, depending on different swiping speeds. After the decode process completes (whether it is successful or not), the reader returns to idle mode and waits for another trigger.

Locked: When the reader is attached to the mobile phone and is not operated for approximately one minute, it reverts to a locked stage to minimize power consumption. The power consumption in this state is the same as with standby mode. In this mode, the reader does not respond to any input. Unplug the reader to exit this mode and return to standby mode.

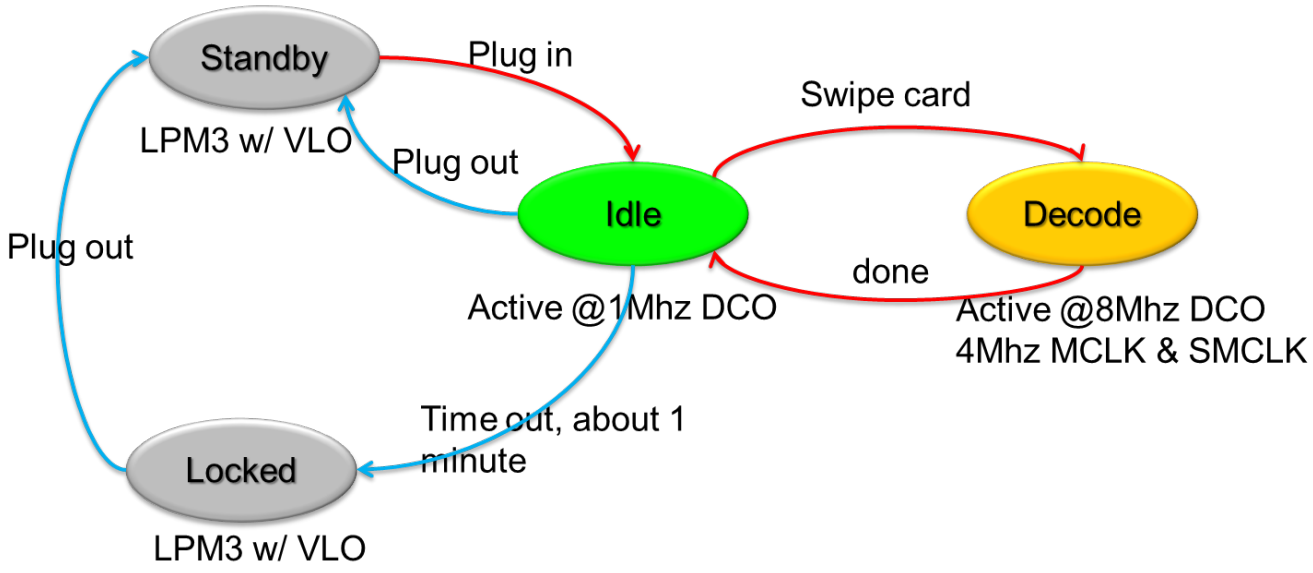

Figure 5. State Machine

4 Android Application

The Android application was developed to test and evaluate the card reader solution. The user can find information on track data and failure rate statistics on this easy-to-use application.

To read out the bank card content, follow these steps:

1. Run the application.
2. Plug in the reader (the user can also do this before step 1).
3. Swipe the card. Touching the bottom edge of the card with the bottom of the slot and moving smoothly will help. If successful, the card information is shown on the screen (see Figure 6). If not, “No data” is shown.

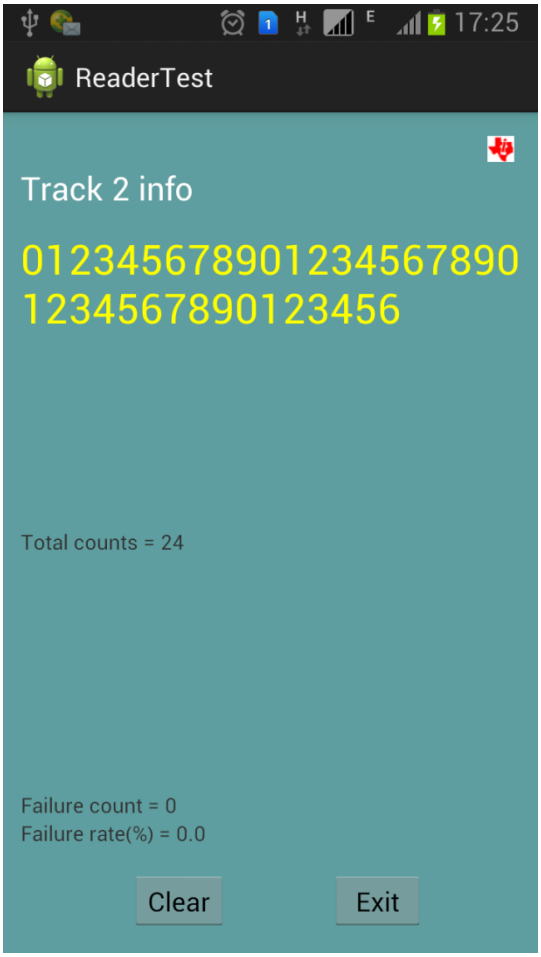

Figure 6. GUI Application for Android

5 System Power Consumption

As stated before, use an 8 MHz calibrated DCO for stable communication with the host mobile phone. In decode stage, the system runs under 4 MHz MCLK and SMCLK, dereived from the DCO divided by two. The current is directly measured from battery output, providing the entire system's power consumption data. Table 1 shows that the peak current consumed is less than 2 mA, which is within the capability of this type of battery (CR2032).

Table 1. Power Consumption

STATE	CLOCKS	AVERAGE CURRENT	PEAK CURRENT	CONDITION
Standby	VLO/DCO at 1 Mhz	1 µA	656 µA	FLUKE-287C, DC, uA / mA
Idle	DCO at 1 Mhz	407 µA	780 µA	
Decode	DCO at 8 Mhz MCLK = 4 Mhz	1.75 mA	1.91 mA	
Locked	VLO/DCO at 1 Mhz	1 µA	666 µA	

6 Bill of Materials

Table 2. Bill of Materials

Item	Quantity	Reference	Value	Part Description	Manufacturer	Part Number	CB Footprint
1	1	C4	2.2 nF	CAP CER 2.2 NF 6V 10% 0603	NC	N/A	0603
2	1	C3	22 nF	CAP CER 22 NF 6V 10% 0603	NC	N/A	0603
3	2	C1, C2	0.1 uF	CAP CER 0.1 UF 6V 10% 0603	NC	N/A	0603
4	2	R2, R10	0	RES 0.0 OHM 1/16 W JUMP 0603 SMD	NC	N/A	0603
5	2	R7, R8	100k	RES 100K OHM 1/16 W 0603 SMD	NC	N/A	0603
6	1	R11	10k	RES 10K OHM 1/16 W 0603 SMD	NC	N/A	0603
7	2	R3, R6	1k	RES 1K OHM 1/16 W 0603 SMD	NC	N/A	0603
8	1	R11	200k	RES 200K OHM 1/16 W 0603 SMD	NC	N/A	0603
9	1	R5	2K2	RES 200K OHM 1/16 W 0603 SMD	NC	N/A	0603
10	1	R4	330	RES 330 OHM 1/16 W 0603 SMD	NC	N/A	0603
11	1	R9	47k	RES 47K OHM 1/16 W 0603 SMD	NC	N/A	0603
12	1	U2	MSP430G2432-TSSOP	MCU TSSOP14-PW	Texas Instruments	MSP430G2432-TSSOP	TSSOP14
13	1	U1	OPA348	Opa amplifier SOT23-5-	Texas Instruments	OPA348	SOT23-5

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