ASK Reader Reference Design

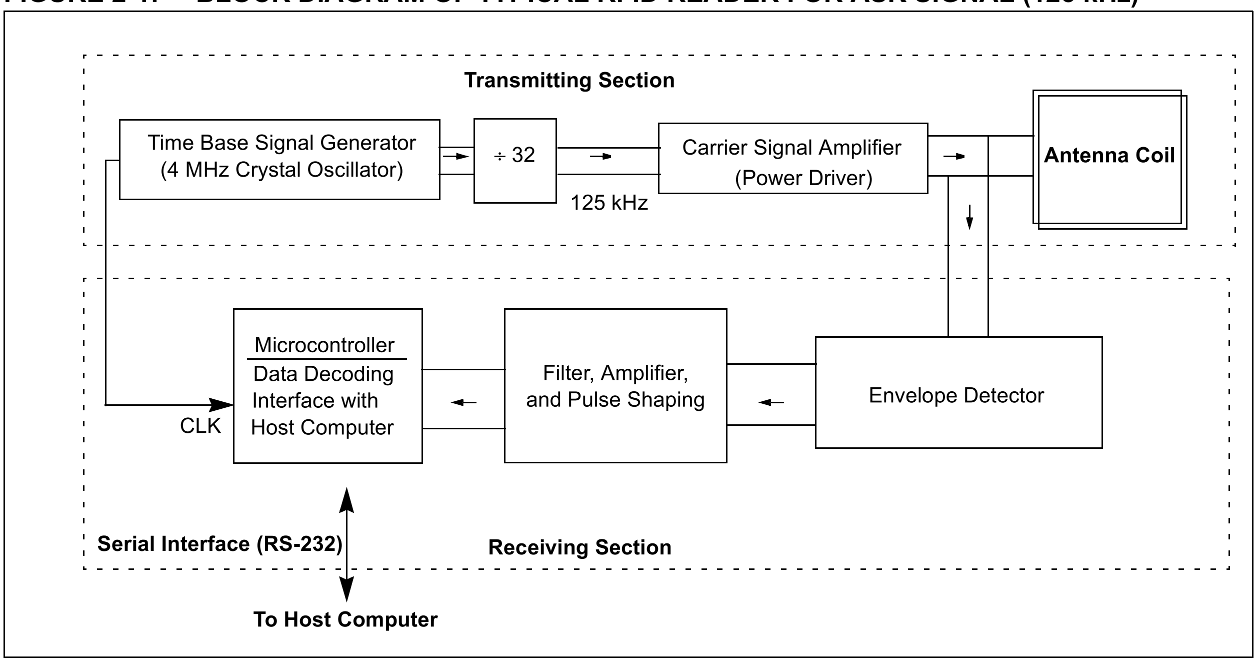
1.0 INTRODUCTION

This application note is written as a reference guide for ASK reader designers. Microchip Technology Inc. provides basic reader electronics circuitry for the MCRF200 customers as a part of this design guide. The circuit is designed for a read range of 3 ~ 5 inches with an access control card. The microID ASK Reader (demo unit), which is built based on the ASK reference design, is available in the microID Designers Kit (DV103001). The circuit can be modified for longer read range or other applications with the MCRF200. An electronic copy of the ASK microID PICmicro® source code is available upon request.

2.0 READER CIRCUITS

The RFID reader consists of transmitting and receiving sections. It transmits a carrier signal, receives the backscattering signal, and performs data processing. The reader also communicates with an external host computer. A basic block diagram of the typical ASK RFID reader is shown in Figure 2-1.

FIGURE 2-1: BLOCK DIAGRAM OF TYPICAL RFID READER FOR ASK SIGNAL (125 kHz)



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2.1 Transmitting Section

The transmitting section contains circuitry for a carrier signal (125 kHz), power amplifiers, and a tuned antenna coil.

The 125 kHz carrier signal is typically generated by dividing a 4 MHz (4 MHz/32 = 125 kHz) crystal oscillator signal. The signal is amplified before it is fed into the antenna tuning circuit. A complementary power amplifier circuit is typically used to boost the ransmitting signal level.

An antenna impedance tuning circuit consisting of capacitors is used to maximize the signal level at the carrier frequency. The tuning compensates the variations in the component values and the perturbation of coil inductance due to environment effect. A design guide for the antenna coil is given in *AN710, Antenna Circuit Design for RFID Applications* (DS00710).

2.1.1 LIMITS ON TRANSMITTING SIGNAL LEVEL (FCC PART 15) IN THE USA

Each country limits the signal strength of the RF wave that is intentionally radiated by a device. In the USA, the signal strength of the carrier signal (125 kHz) radiating from the antenna coil must comply with the FCC (Federal Communications Commission) part 15 regulation. The signal level is specified by the 47 CFR Part 15.209a of the federal regulation. For a 125 kHz signal, the FCC limits the signal level to 19.2 μv per meter, or 25.66 dBμV (i.e., 20 log(19.2) = 25.66 dBμV), at 300 meters away from the antenna. For a close distance measurement, an extrapolation rule (40 dB per decade) is applied (Part 15.31.f.2). For example, the signal level at 30 meters away from the device must not exceed:

$$25.66 \text{ dB}\mu\text{V} + 40 \text{ dB}\mu\text{V} = 65.66 \text{ dB}\mu\text{V}$$

2.2 Receiving Section

The receiving section consists of an antenna coil, demodulator, filters, amplifiers, and microcontroller. In applications for close proximity read range, a single coil is often used for both transmitting and receiving. For long read-range applications, however, separated antennas may be used. More details on the antenna coil are given in *AN710, Antenna Circuit Design for RFID Applications* (DS00710).

In the ASK communication protocol, a ‘0’ and a ‘1’ are represented by an amplitude status of receiving signal. Various data coding waveforms that are available by MCRF200 are shown in Figure 1 in *AN680, Passive RFID Basics* (DS00680).

The demodulation of the ASK signal is accomplished by detecting the envelope of the carrier signal. A half-wave capacitor-filtered rectifier circuit is used for the demodulation process. The peak voltage of the back-scattering signal is detected by a diode, and this voltage is then fed into an RC charging/discharging circuit. The RC time constant must be small enough to allow the voltage across C to fall fast enough to keep in step with the envelope. However, the time constant must not be so small as to introduce excessive ripple. The charging capacitor and load R has the following relationship for a full recovery of the data signal.

$$\frac{1}{\omega_o C} > R > \frac{1}{\omega_o C}$$

where ω_s and ω_o are the angular frequencies of the modulation (data) and carrier (125 kHz), respectively. R is the load (discharging) resistor.

The demodulated signal must then pass through a filter and signal shaping circuit before it is fed to the microcontroller. The microcontroller performs data decoding and communicates with the host computer through an RS-232 or other serial interface protocols.

3.0 microID ASK READER

The electronic circuitry for an ASK reader is shown in Section 4.0. The reader needs +9 VDC power supply. The 125 kHz carrier signal is generated by dividing the 4 MHz time base signal that is generated by a crystal oscillator. A 16-stage binary ripple counter (74HC4060) is used for this purpose. The 74HC4060 also provides a clock signal for the PIC16C84 microcontroller. The 125 kHz signal is passed to an RF choke (L1) and filter before it is fed into a power amplifier that is formed by a pair of complementary bipolar transistors (Q2 and Q3).

For long read-range applications, this power amplifier circuit can be modified. Power MOSFETs may be used instead of the bipolar transistors (2N2222). These power MOSFETs can be driven by +24 VDC power supply. A push-pull predriver can be added at the front of the complementary circuit. This modification will enhance the signal level of the carrier signal and the read range of the ASK Reader.

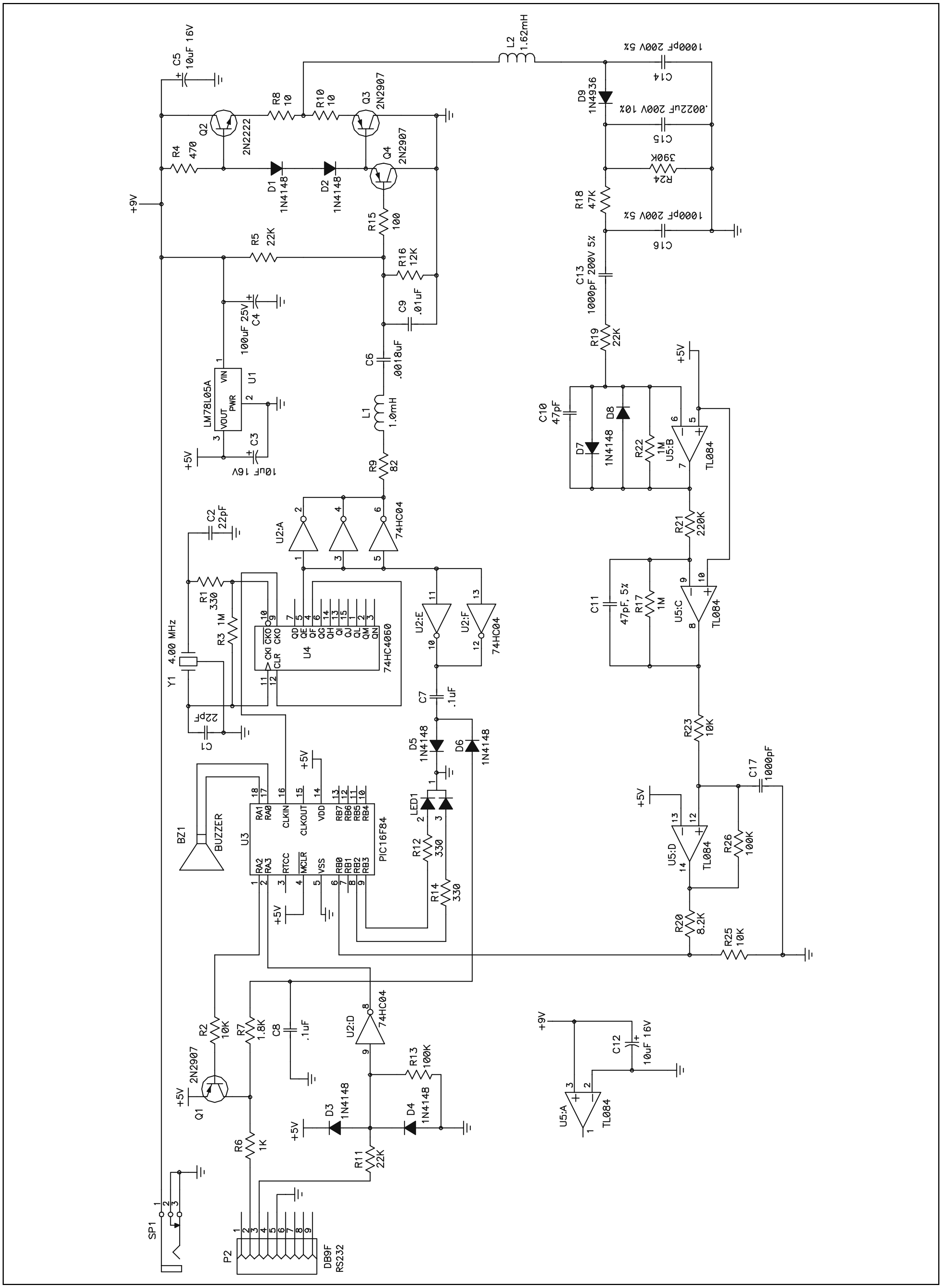
The reader circuit uses a single coil for both transmitting and receiving signals. An antenna coil (L2: 1.62 mH) and a resonant capacitor (C14: 1000 pF) forms a series resonant circuit for a 125 kHz resonance frequency. Since the C14 is grounded, the carrier signal (125 kHz) is filtered out to ground after passing the antenna coil. The circuit provides a minimum impedance at the resonance frequency. This results in maximizing the antenna current, and therefore, the magnetic field strength is maximized.

L2, C14, D7, C15, R24, and the other components in the bottom part of the circuit form a signal receiving section. D9 is a demodulator which detects the envelope of the backscattering signal.

D9 and C15 form a half-wave capacitor-filtered rectifier. The detected envelope signal is charged into C15. R24 provides a discharge path for the voltage charged in C15. This voltage passes active filters (U5:B and C) and the pulse shaping circuitry (U5:A) before it is fed into the PIC16C84 for data processing.

The PIC16C84 microcontroller performs data decoding and communicates with the host computer via an RS-232 serial interface.

4.0 ASK READER SCHEMATIC



5.0 ASK READER BILL OF MATERIALS

Quantity:	Part Number	Part Description	Reference Design
1	02-01518-D	PCB ASSEMBLY DWG, microID ASK READER	
1	03-01518	SCHEMATIC, microID ASK READER	
1	04-01518	PCB FAB, microID ASK READER	
1	08-00161	LABEL, microID ASK READER,U3,CHKS:C1AAh, v1.0, ASK1.HEX	@U3
1	110-93-318-41-001	SOCKET, 18P OPEN FRAME COLLET (0.300)	xU3
1	DE9S-FRS	CONN, D-SUB 9P RECPT RT ANGLE	P2
1	DJ005B	JACK, POWER, 2.5 mm DC	PC MOUNT SP1
1	PKM22EPP-4001	BUZZER, PIEZO, 4 kHz, 3-20V	BZ1
2	D470J25COGHAAAC CAP, 47PF 100V CERAMIC DISC C0G C10,C11 2	D220J20COGHAAAC CAP, 22 pF CER DISK RAD COG 100V	C1, C2
1	ECU-S1H221JCA	CAP, 220pF, CER MONO, RAD, 50V, 5%	C15
1	ECQ-P1102JZ	CAP, 0.001uF POLYPROPYLENE 100V	C17
3	ECQ-P6102JU	CAP, 0.001uF POLYPROPYLENE 630V	C13, C14, C16
1	ECU-S2A182JCB	CAP, 1800pF MONOLITH CERM, 5%, RAD, 100V	C6
1	ECQ-V1103JM	CAP, 0.01uF 100V STACK METAL FILM	C9
2	ECQ-E1104KF	CAP, 0.1UF 100VDC 10% RAD METAL POLY CAP	C7, C8
3	ECE-A16Z10	CAP, 10uF, ELECTRO, RAD, 16V, 20%	C3, C5, C12
1	ECE-A25Z100	CAP, 100uF, ELECTRO, RAD, 25V, 20%	C4
8	1N4148	DIODE, GENERAL PURPOSE, 1N4148 (DO-35)	D1-D8
1	1N4936	DIODE, 1A 400V FAST-RECOVERY RECTIFIER	D9
1	-SPARE- -SPARE- LOCATION DO NOT INSTALL LED1,		
1	78F102J INDUCTOR, 1000uH, COATED		L1
1	MCT0003-001	INDUCTOR, 1.62 µH,	L2
3	2N2907A-TO18	TRANSISTOR, 2N2907A PNP, GEN PURPOUS TO-18	Q1, Q3, Q4
1	2N2222A-TO18	TRANSISTOR, 2N2222A NPN, GEN PURPOUS TO-18	Q2
2	5043CX10R0J	RES, CF 10 OHM 1/4W 5%	R10,R8
1	82E CR-1/4W-B 5%	RES, CF 82 OHM 1/4W 5%	R9
1	5043CX100R0J	RES, CF 100 OHM 1/4W 5%	R15
1	5043CX1K000J	RES, CF 1K 1/4W 5%	R6
3	5043CX330R0J	RES, CF 330 OHM 1/4W 5%	R1, R12, R14
1	5043CX470R0J	RES, CF 470 OHM 5% 1/4W	R4
1	1K8 CR-1/4W-B 5%	RES, CF 1.8K OHM 1/4W 5%	R7
1	390K CR-1/4W-T 5%	RES, CF 390K-OHM,5%,1/4W	R24
1	220K CR-1/4W-T 5%	RES, CF 220K OHM 1/4W 5%	R21
1	8K2 CR-1/4W-T 5%	RES, 8.2K OHM 1/4W 5% CF	R20

Quantity:	Part Number	Part Description	Reference Design
3	10K CR-1/4W-B 5%	RES, CF 10K OHM 1/4W 5%	R2, R23, R25
1	5043CX47K00J	RES, CF 47K 5% 1/4W	R18
1	12K CR-1/4W-B 5%	RES, CF 12K OHM 1/4W 5%	R16
3	22K CR-1/4W-B 5%	RES, CF 22K OHM 1/4W 5%	R5, R11, R19
2	5043CX100K0J	RES, CF 100K 5% 1/4W	R13,R26
3	1M0 CR-1/4W-B 5%	RES, CF 1.0M OHM 1/4W 5%	R3, R17, R22
1	LM78L05ACZ	IC, REG, +5V 0.1A TO-92	U1
1	MM74HC04N	IC, HEX INVERTER 14P DIP	U2
1	PIC16F84-10/P	IC, PIC16F84 PLASTIC, 18P DIP	U3
1	MM74HC4060N	IC, 14 STAGE BINARY COUNTER, 16P DIP	U4
1	TL084CN IC, QUAD OP AMP, 14P DIP		U5
1	EFO-EC4004A4	RESONATOR, 4.00MHZ CERAMIC W/CAP	Y1
2	JS-01	SCREW, JACKSCREW, #4-40x0.416"	P2