

Using the PIC12LF1840T48A Microcontroller with Integrated Sub-GHz Transmitter

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INTRODUCTION

The PIC12LF1840T48A is a Microchip microcontroller that has an on-board transmitter. The transmitter is suitable for operation in the 418, 434 and 868 MHz license-free ISM bands. The modulation is On/Off Keying (OOK) or Frequency-Shift Keying (FSK). This document describes the complete implementation of a radio transmitter using the PIC12LF1840T48A.

KEY REQUIREMENTS

The RF transmitter integrated into the PIC12LF1840T48A has two main functioning modes.

One operation mode, called Preset mode, allows the user to choose from two predefined modes of operation. The setting is done by either pulling the CTRL line low or high. One connection to the DATA line is required to send modulation data to the transmitter.

TABLE 1: AVAILABLE PREDEFINED CONFIGURATIONS

CTRL = 1	433 MHz OOK modulation 10 dB output power
CTRL = 0	868.3 MHz FSK modulation Fdev = 20 kHz 10 dB output power

If one of the pre-defined configurations (see [Figure 1](#)) is used, then there is no need to use an extra I/O pin to control the CTRL line of the transmitter. This pin must be either pulled high (using a resistor > 20 KOhm, but less than 1 MOhm), or pulled low.

Another operation mode is called Advanced mode. This mode is useful when the user needs a custom configuration that cannot be satisfied using one of the two preset modes. This custom configuration can include custom settings, such as different transmitting frequency, RF output power, transmit power-off timer, fine tuning of the transmitting center frequency, different modulation format, and frequency deviation (if FSK mode is used).

If the Advanced mode is used, the user must implement the two-wire interface required to write data to the Configuration register. Please refer to [Table 1](#) for the full description of the Configuration register.

In this case, an extra I/O pin is needed to control the CTRL pin, acting as a clock line. The DATA line of the transmitter must be connected to an I/O pin of the microcontroller section. This is used to carry both data transmitter over-the-air, and Configuration data (when used in conjunction with the CTRL line). The current reference design has the DATA line connected to the CCP1 line of the microcontroller. This is because the KEELOQ® security IC encoder implementation takes advantage of the internal ECCP peripheral to send KEELOQ security IC data packets.

CONFIGURATION REGISTER WRITE

The transmitter can be software-configured to use different transmitting frequencies, different modulation and different frequency deviations (in FSK mode). All these settings are done by using a serial interface (using the CTRL line as clock line, and DATA as data line). A total of 16 are clocked, consisting of a Start bit (logic zero), a read/write bit, and the 12-bit Configuration register (see [Figure 1](#)).

CONFIGURATION REGISTER READ

It is also possible to read back the information stored into the Configuration register. Reading operation is done in a similar way to writing data. The read/write bit is logic '1' in this case. Please note that, when reading back data from the Configuration register, a total of 64 clock cycles are required (see [Figure 2](#)). Reading only the 13-bit Configuration bits is not allowed. Please notice that the DATA line from the transmitter section becomes an output pin after the 8th falling edge of the CTRL line. Care must be taken to change the microcontroller port connected to the DATA line from output to input. After reading all the data, the port must be put back into Output mode. Reading back information from the Configuration register is not required. This can be helpful during the software development phase. This feature is not used in normal operation mode.

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TABLE 2: CONFIGURATION REGISTER

Bit	Name	State	Setting	Default		Notes
				CTRL = 0	CTRL = 1	
D12	Tx Mode	0	Automatic Wake-up	0	0	When set to '1', the transmitter will continuously transmit. When set to '0', the transmitter will go to Sleep mode after a 2 ms inactivity on the data line.
		1	Forced Transmit			
D(11:9)	Frequency	000	418.00 MHz	100	010	RF Operating center frequency.
		001	433.42 MHz			
		010	433.92 MHz			
		011	864.00 MHz			
		100	868.30 MHz			
		101	868.65 MHz			
		110	868.95 MHz			
		111	869.85 MHz			
D8	Modulation	0	FSK	0	1	Modulation format.
		1	OOK			
D(7:5)	Freq. Deviation	000	10 kHz	010	010	FSK Frequency deviation (not used in OOK mode).
		001	12.5 kHz			
		010	20 kHz			
		011	25 kHz			
		100	40 kHz			
		101	50 kHz			
		110	80 kHz			
		111	100 kHz			
D4	RF Power	0	0 dBm	1	1	Programmed RF output power.
		1	1 dBm			
D3	TX Timer	0	2 ms	0	1	Transmit power-off timer.
		1	20 ms			
D(2:0)	Fine Tuning	011	fc + 6 * PLL Step	000	000	Fine tuning from programmed center frequency.
		010	fc + 4 * PLL Step			
		001	fc + 2 * PLL Step			
		000	fc + 0 * PLL Step			
		111	fc - 2 * PLL Step			
		110	fc - 4 * PLL Step			
		101	fc - 6 * PLL Step			
		100	fc - 8 * PLL Step			

FIGURE 1: CONFIGURATION REGISTER WRITE

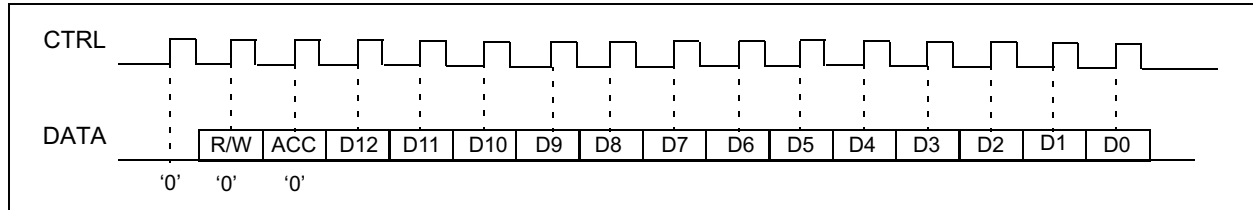
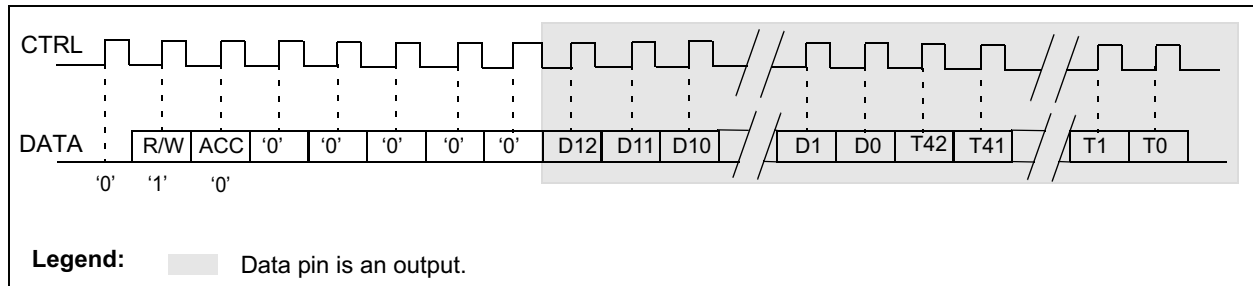


FIGURE 2: CONFIGURATION REGISTER READ



POWERING-ON THE TRANSMITTER

When the transmitter is not active (no RF emission), the entire transmitter section is in Sleep mode.

When using the Advanced mode, the transmitter can be placed in Transmit mode in two ways. This is dependent of the bit D12 in the Configuration Word (Tx mode).

1. When Tx Mode = 0: a rising edge on the DATA line activates the start-up process. The DATA pin must be held high for a period longer than the transmitter start-up time (2 ms). After this start-up pulse, the transmitter is ready to send data over-the-air. The transition back to Sleep mode is done automatically after an inactivity period, in which the DATA line is held low. This power-off time is programmable using the D3 bit in the Configuration register. The available settings are 2 ms and 20 ms. If the transmitter implements KEELOQ[®], we recommend using a power-off time of 20 ms. This is because a typical KEELOQ pocket includes a 2 ms header, which could be interpreted by the transmitter as a time-out period and the transmitter will shut down.
2. When Tx Mode = 1: When setting the D12 bit to logic 1 (by writing to the Configuration register), the transmitter will be placed directly into Transmit mode. After setting the bit, a transmitter start-up time (2 ms) is required. After this start-up period the transmitter is ready to send data over-the-air. The transmitter will remain in Transmit mode until bit D12 is set back in logic zero. The above (when D12 = 0) power-off time is applied (2 or 20 ms).

When using the Preset mode, only the automatic start-up mode is available. The DATA pin must be held high for a period longer than the transmitter start-up time (2 ms). After this start-up pulse, the transmitter is ready to send data over-the-air. The transition back to Sleep mode is done automatically after a period of 2 ms (when using the preset mode for 433 MHz OOK), or 20 ms (when using the preset mode for 868 MHz FSK).

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TRANSMITTER CONFIGURATION

The transmitter can be configured by writing to the Configuration register. The following codes show a transmitter configuration example.

The following definitions (Example 1) can be found in the *12LF1840T48ASettings.h* file:

EXAMPLE 1:

```
#define T48_AUTO_WAKE_UP 0b00000000000000
#define T48_FORCED_TX 0b1000000000000000
#define T48_FREQ_41800 0b0000000000000000
#define T48_FREQ_43342 0b0000100000000000
#define T48_FREQ_43392 0b0010000000000000
#define T48_FREQ_86400 0b0011000000000000
#define T48_FREQ_86830 0b0100000000000000
#define T48_FREQ_86865 0b0101000000000000
#define T48_FREQ_86895 0b0110000000000000
#define T48_FREQ_86985 0b0111000000000000
#define T48_MOD_FSK 0b0000000000000000
#define T48_MOD_OOK 0b0000010000000000
#define T48_DEV_10K 0b0000000000000000
#define T48_DEV_12K 0b0000000010000000
#define T48_DEV_20K 0b0000000100000000
#define T48_DEV_25K 0b0000000110000000
#define T48_DEV_40K 0b0000001000000000
#define T48_DEV_50K 0b0000001010000000
#define T48_DEV_80K 0b0000001100000000
#define T48_DEV_100K 0b0000001110000000
#define T48_TX_0dB 0b0000000000000000
#define T48_TX_10dB 0b0000000001000000
#define T48_TX_2mS 0b0000000000000000
#define T48_TX_20mS 0b0000000000010000
#define T48_TUNE_6PLL 0b000000000000011
#define T48_TUNE_4PLL 0b000000000000010
#define T48_TUNE_2PLL 0b000000000000001
#define T48_TUNE_0PLL 0b000000000000000
#define T48_TUNE_-2PLL 0b0000000000000111
#define T48_TUNE_4PLL 0b0000000000000110
#define T48_TUNE_6PLL 0b0000000000000101
#define T48_TUNE_8PLL 0b0000000000000100
```

The following functions (Example 2) can be found in the *12LF1840T48ACommands.c* file:

EXAMPLE 2:

```
void sendTxCommand (int cmd)
{
    sendByteTxCommand((cmd & 0xFF00) >> 8);
    sendByteTxCommand((cmd & 0x00FF));
}

void sendByteTxCommand(unsigned char cmd)
{
    char i;
    for (i=0; i<8; i++)
    {
        if (cmd & 0x80)
            RA2 = 1;
        else
            RA2 = 0;

        CTRL = 1;
        NOP();
        NOP();
        CTRL = 0;
        cmd = cmd << 1;
    }
}
```

Configuring the transmitter is done by calling the `sendTxCommand` function. This command takes as parameter a bitwise OR with the selected configuration (Example 3).

EXAMPLE 3:

```
sendTxCommand
(
    T48_AUTO_WAKE_UP |
    T48_FREQ_43392 |
    T48_MOD_OOK |
    T48_DEV_20K |
    T48_TX_10dB |
    T48_TX_20mS |
    T48_TUNE_0PLL
);
```

FIGURE 3: ANTENNA DESIGN. OVERALL BOARD DIMENSIONS

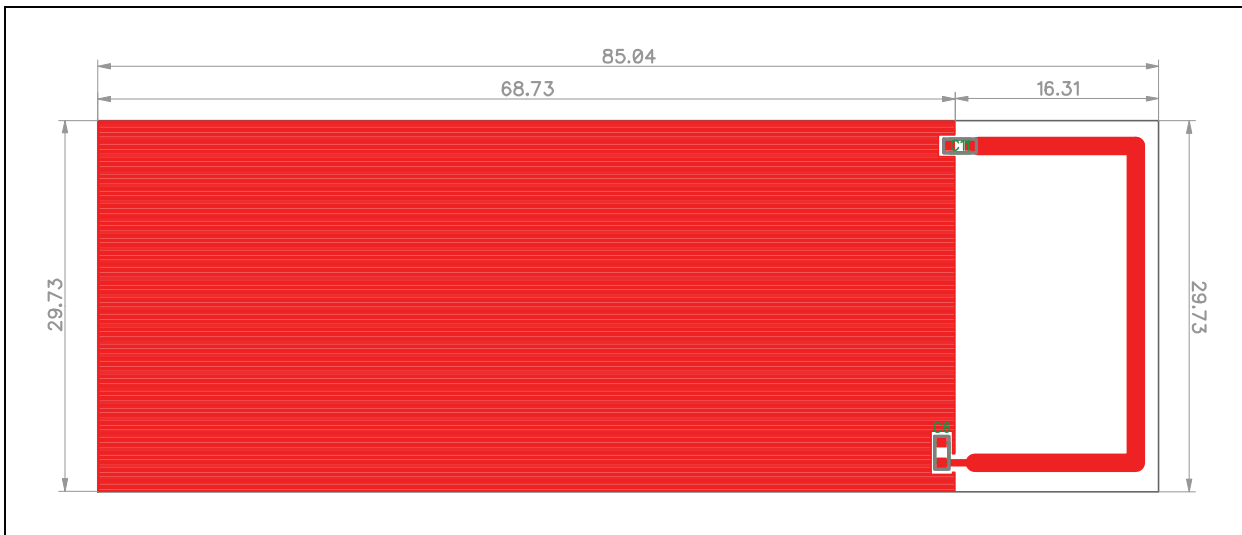
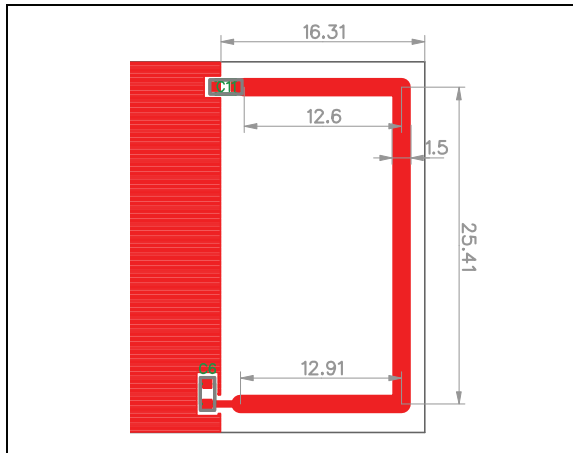


FIGURE 4: ANTENNA DESIGN. LOOP ANTENNA DIMENSIONS



CONCLUSION

The PIC12LF1840T48A is a Microchip microcontroller with an integrated RF transmitter. This document helps the user design a transmitter using this device. A high level of integration combined with a large variety of RF configurations and an overall low cost make this design an ideal solution for a radio transmitter. This device is fully compatible with the existing KEELOQ security solutions.

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APPENDIX A: REVISION HISTORY

Revision A (9/2011)

Initial Release.

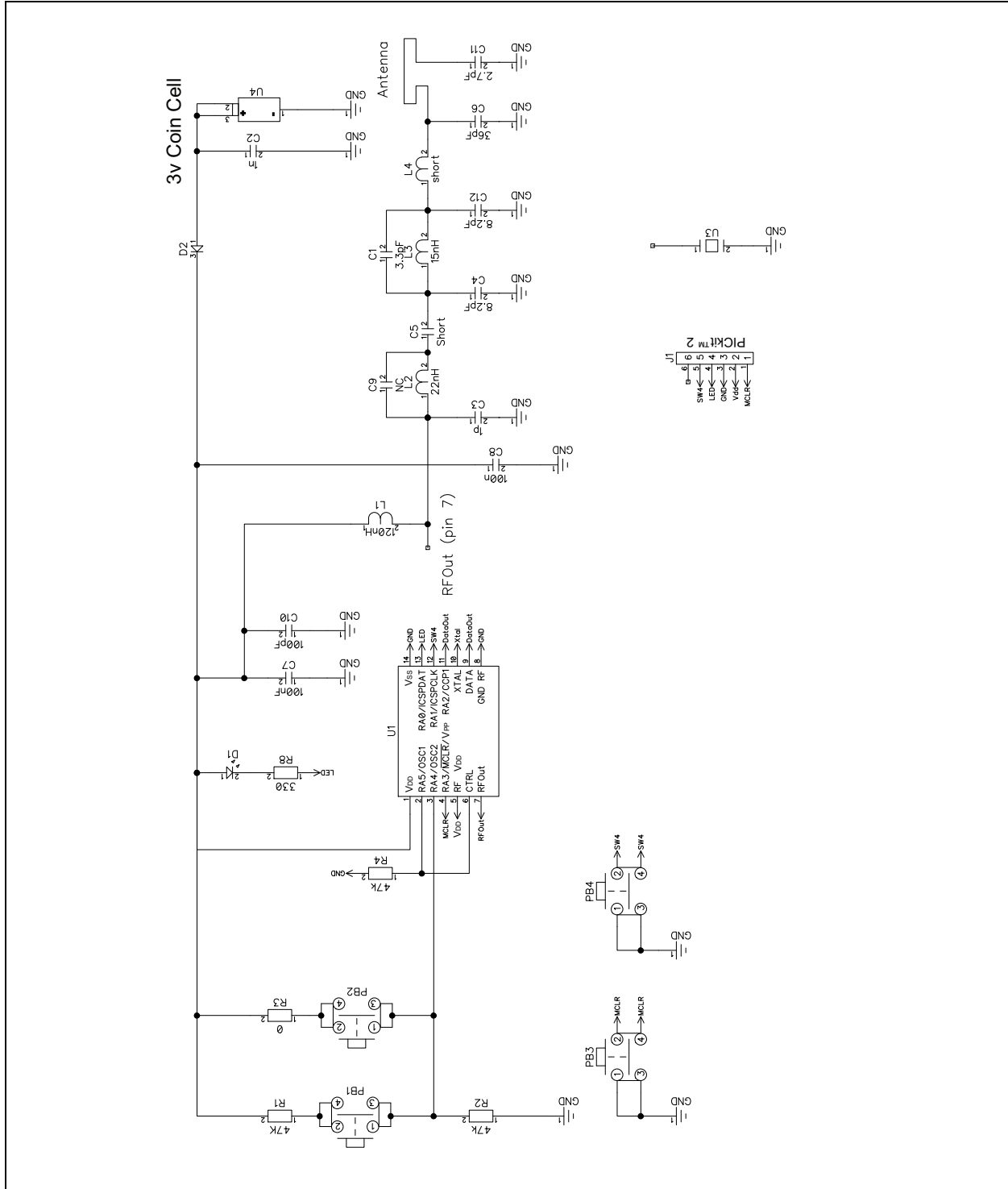
Revision B (11/2011)

Revised Title; Revised Figure 5.

ANNEX – TRANSMITTER SCHEMATICS

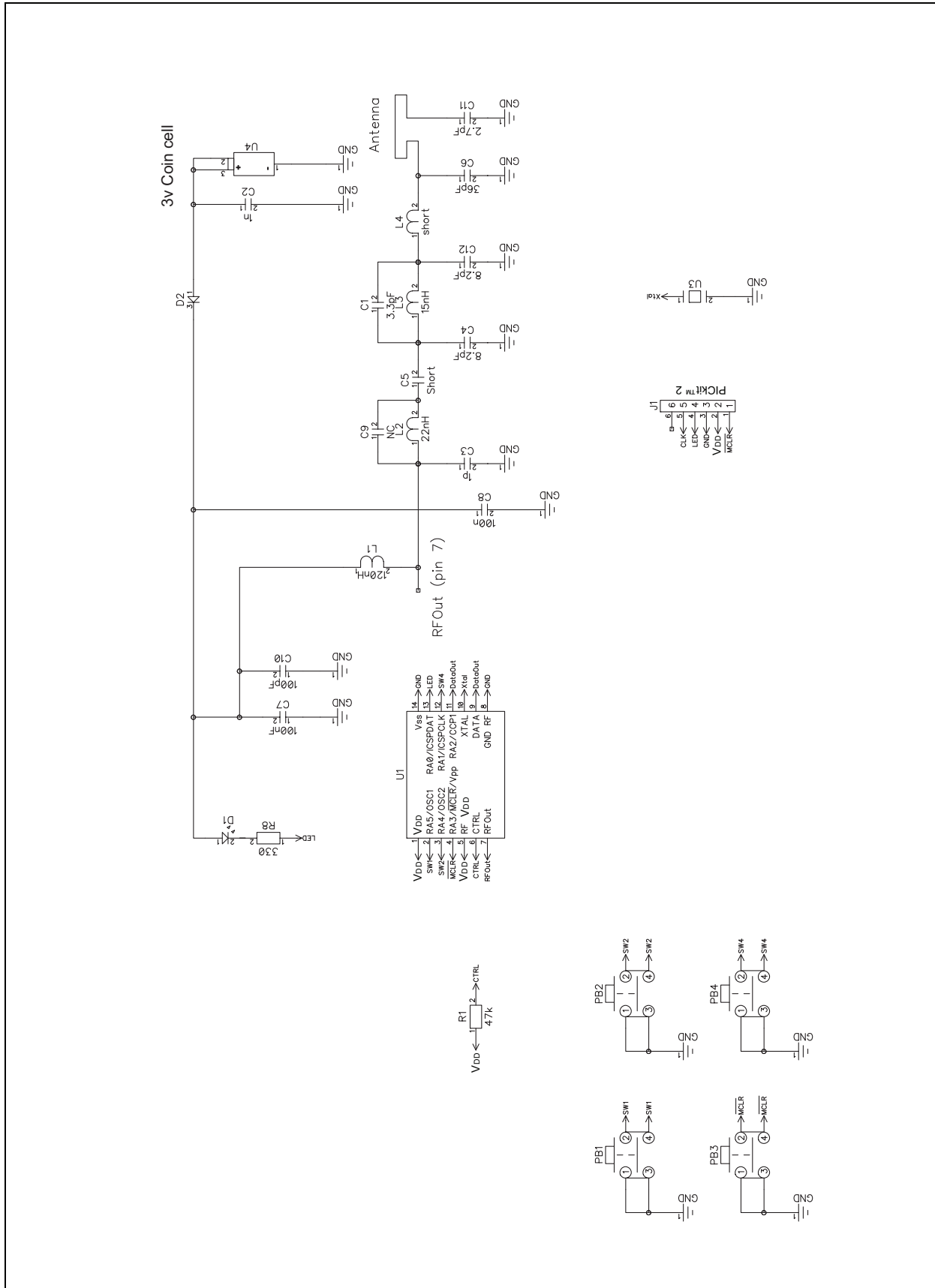
A reference schematic diagram with an RF filter and matching network is provided. The component values are given for 433.92 MHz. The crystal is a low-cost 26 MHz HC-49.

FIGURE 5: REFERENCE DESIGN TRANSMITTER SCHEMATIC – USING THE CTRL LINE



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FIGURE 6: REFERENCE DESIGN TRANSMITTER SCHEMATIC – USING THE PRESET MODE



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