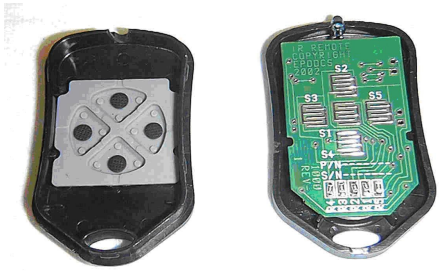
Electronic Product Design & Development Consulting Services

P.O. Box 4739 Cary, NC 27519 919 460 0081 Voice/FAX

IR REMOTE by Murdock Taylor, murdock.taylor@EPDDCS.com

The IR REMOTE is a general-purpose handheld remote control device that utilizes IR Pulse Code Modulation (PCM) to communicate to a customer-designed receiver. IR REMOTE is targeted at any application where remote control of basic commands like ON/OFF, UP, DOWN, MODE, BRIGHTER, DIMMER, FASTER, SLOWER, etc., would improve the product's appeal to the end user. The unique appeal of this design is that it provides a professional looking and affordable remote control unit to those applications whose expected volumes would not allow for a full custom design.

The components comprising this low power design consists of the TI ultra low-power MSP430 microcontroller, Vishay TSOP1833SS3V 33.0 kHz Photo Module for PCM Remote Control Systems, Vishay TSAL4400 Infrared Emitter, 3V Li coin cell battery (CR2032), and the 1 to 5-button key fob style Polycase TB-20 Enclosure. The Polycase TB-20 injection molded enclosures and their elastomer keypads are inexpensive even in small numbers ($2.30/ea qty 1-9). In addition Polycase can provide customization graphics on the enclosures and/or keypads that would address customer requirements for labeling, logos, and color issues. This reference design will allow a professional looking, low-cost, small, battery-powered, and easily customized IR remote control capability to be added to a customer's project.



The software has been designed to allow easy customization by developers to meet their unique requirements. The software is designed to transmit a separate IR PCM code on each button press and each button release. There are five elastomer button keypad targets on the PCB that match all of the possible 1 to 5 button keypad versions of the Polycase TB-20 enclosures. (Note the button numbering scheme on the PCB.) For the situation where the application uses the five-button model, then all 10 separate codes will be transmitted. (The same IR REMOTE PCB is used with all models of the TB-20 enclosures, independent of keypad version.)

In this application, each button press and each button release will transmit a unique 8-bit code. The developer could easily change this to any unique 8-bit, 16-bit, 24-bit, or 32-bit codes, allowing maximum customization. It does allow a developer to provide unique solutions of the same IR REMOTE to different clients, for different product models, even all the way to different end users (if you wanted to go to that much trouble).

The keypad button inputs are: S1 on P2.1, S2 on P2.2, S3 on P2.3, S4 on P2.4, and S5 on P2.5. The only output is P2.0. P2.0 drives an N-channel MOSFET that in turn drives the 3mm Infrared LED (Vishay TSAL4400). The IR LED is driven at 32.768kHz, which is conveniently very close to the center of the IR receiver's 33.0 kHz (+/- 5%) carrier frequency. Since the MSP430 has an external 32.768 kHz low frequency crystal, the IR LED modulation can easily be generated from the 32.768 kHz ACLK. The IR LED will draw just under 15mA when ON (this is a design limitation imposed by the pulsed duty limits of the CR2032 coin cell battery). The IR REMOTE is designed to work with a Vishay TSOP1833SS3V 33.0 kHz PCM 3-pin (power, ground, and output) receiver chip incorporated into the design of the product being controlled. The output of the TSOP1833SS3V is a digital serial signal matching the infrared PCM input, but with the carrier removed (active low logic signal = carrier, high = no carrier). The TSOP1833SS3V is a sophisticated part with considerable IR noise filtering and immunity, resulting in robust and reliable PCM reception. Due to the pulse duty limitation of the 3V Li coin cell battery, the IR REMOTE will only work line of sight and will need to be pointed in the direction of the receiver.

The PCM protocol used is a 32.768 kHz IR burst for 2ms as a start sentinel with a 1.5ms burst as a "1" and a 1ms burst as a "0". There is a 1ms break (with no IR transmission) following each IR burst.

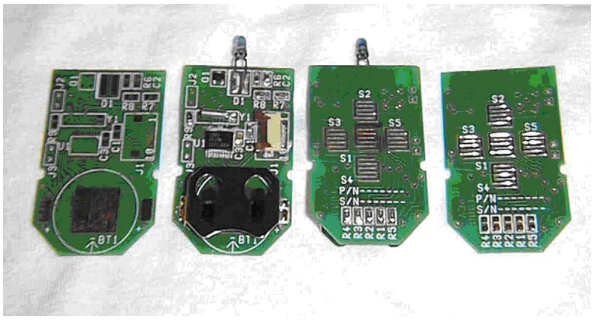
```
_||||___||___|||___||___||___|||___||___|||___|||___
 "S"  "0"  "1"  "0"  "0" "1"  "0"  "1"  "1"
     MSB ----------to---------- LSB
```

"S" = start sentinel, "__" = space,
"||||, |||, ||" = IR burst transmission

The Vishay TSOP1833SS3V PCM receiver chip will output the following digital serial signal in response to the above IR PCM transmission:

```
-____--__--___--__--__--___--__--__--___--___--  "-" = 3V, "_" = 0V
 "S"    "0"  "1"  "0"  "0"   "1"  "0"  "1"  "1"
```

The receiver µC interfacing with the Vishay TSP1833SS3V PCM receiver chip must time the active logic low intervals as well as the logic high space intervals to determine if a valid IR REMOTE command code has been received. If the received signal does not match the PCM protocol or the list of codes in the receiver, the signal should be ignored. The developer can also modify this simple PCM protocol to whatever he or she might like by just changing the IR burst periods or the space period and/or the definitions of each.

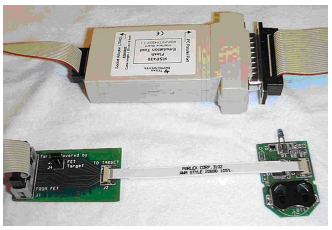


The IR REMOTE board is a small, 2 layer, 1.690" x 1.060", 0.031" thick PCB with SMT components on both sides. The layout of the board and many of the components chosen were dictated by the Polycase FB-20 enclosure. The choice of the PW (0.65 mm pitch spacing) package for the 20-pin MSP430F11x1A and the use of the 10-pin 0.5mm pitch flat flex cable (FFC) connector as the JTAG connector are a direct result of this. The layout was further complicated by fixed locations for certain components – coin cell battery holder, elastomer button keypad targets, and the 3mm T-1 IR LED (a larger T-1¾ IR LED would not fit in the package). The components are oriented (for example the JTAG connector) for routing – no vias could be put in the area where the keypad targets were. For applications requiring high reliability, the keypad targets should be gold plated.

The component cost for the IR REMOTE unit is less than $22 each in quantities of 20.

As far as system response relative to the human interface, the current software can recognize a valid button press (or release) and respond almost 19 times a second (with an 8-bit code). This means pressing and releasing a button with your thumb 9 times in a second. Even with a 32-bit code, the software can recognize a valid button press (or release) and respond 8 times a second (4 separate button presses and releases a second). This technique is more than adequate for this application.

Battery voltage is not monitored. As the 3V Li coin cell battery (CR2032) discharges over time from 3V to 2V, the current available to the IR LED will decrease. This will result in the IR LED getting dimmer and dimmer during its burst transmissions. The net result is that for the receiver to recognize the transmitter, the transmitter will need to get closer and closer to the receiver as the battery becomes discharged. This is the same thing you experience with your TV remote control as its batteries die out, and the end user will recognize this problem for what it is. The IR REMOTE is designed to last many, many years on the Li coin cell battery. A conservative estimate of 50 complete button press and release cycles (100 separate IR transmissions) per day with a 32-bit code will result in an average current consumption for the IR REMOTE of < 1.5 uA (< 1.2 uA with an 8-bit code). **This correlates to an expected battery life of greater than 10 years.** In reality, the IR REMOTE represents a negligible load to the battery. Actual battery life is more a function of the ambient temperature and self-discharge than this load.



There is not enough physical space in this application for the standard TI JTAG connector, so the IR REMOTE PCB has a 10-pin 0.5mm pitch FFC connector. An additional PCB was designed to convert from the standard TI 14-pin JTAG connector to a 10-pin 0.5mm pitch flat flex cable (FFC) connector, which along with a short 10-conductor 0.5mm pitch FFC cable allows the TI FET to connect to the IR REMOTE board for Flash programming/debugging. None of the MSP430 JTAG pins on the IR REMOTE design are shared.

The only internal peripheral used in this application is the 16-bit timer, Timer_A. The 32.768 kHz ACLK is the input to Timer_A to time the debounce delay (30ms) as well as the various intervals in the IR transmission -- start sentinel (2ms), "1" (1.5ms), "0" (1ms), and space (1ms). The on chip DCO with the on chip resistor is used as MCLK. **All button presses & releases are interrupt driven – the unit is asleep in LPM3 most of the time.** The watchdog is disabled and not used in this application.