



# Simple Infrared Remote Control Reference Design

AN024003-0208



## Abstract

At present, the consumer electronics industry has no widely accepted standards governing infrared (IR) transmission schemes used by manufacturers of consumer products. Each manufacturer is free to select an existing transmission protocol or create a new, unique transmission methodology.

The proliferation of IR protocols is posing a significant challenge to the manufacturers of Universal IR remote controllers. Zilog is a leading supplier of Universal remote control solutions for many years.

Zilog's Z86L88 microcontroller (MCU), along with the new Crimzon<sup>®</sup> MCU family, have been implemented in over a hundred million Universal remote control devices worldwide. Zilog's patented T8/T16 timer architecture provides for the transmission of various infrared signals.

This application note discusses the implementation of the T8 and T16 timers for generating the infrared signals required for operation of RCA<sup>™</sup>'s Universal remote control devices. The T8 timer is used in modulo N mode (free running) to generate the carrier frequency while the T16 timer is used in normal auto-reloading mode to generate the modulated signals, respectively.

► **Note:** *AN0240-SC01, the source code associated with this application note, is available for download at [www.zilog.com](http://www.zilog.com).*

## Family Overview

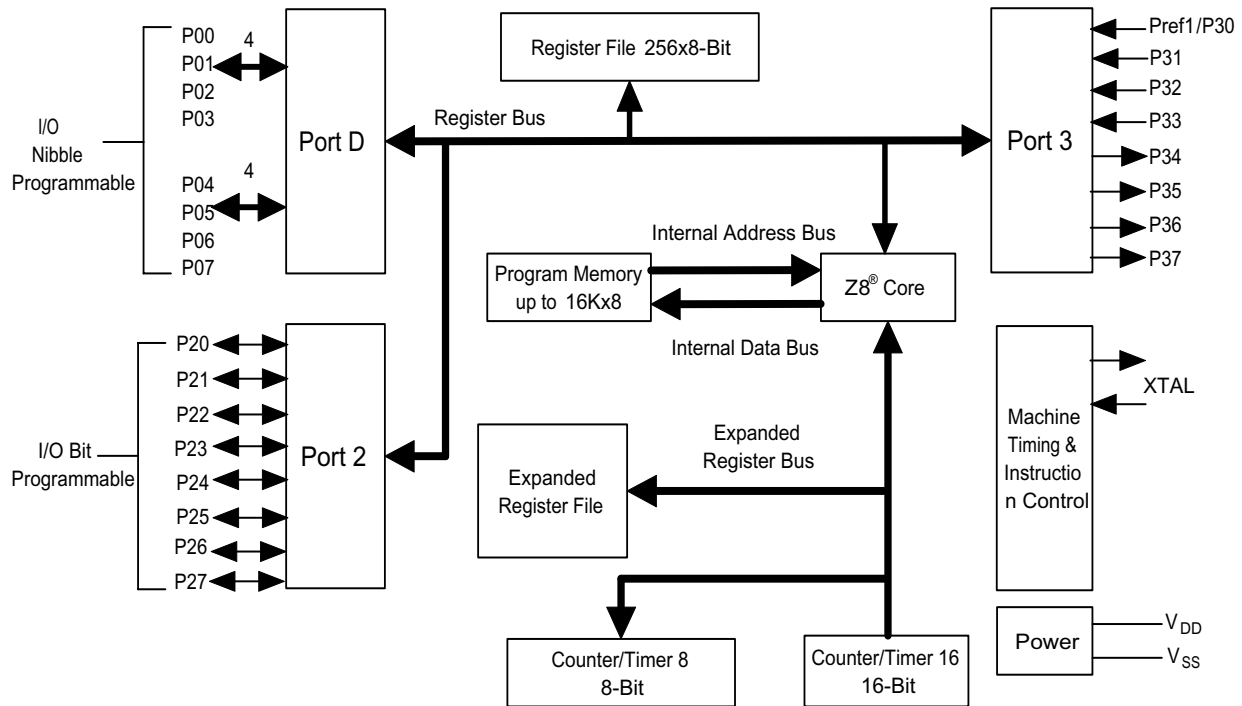
With one of the most comprehensive IR databases in the industry, Zilog's Crimzon low voltage microcontrollers offer the design flexibility required to create a wide variety of optimized Universal remote control solutions.

In addition, the continuously updated infrared database (IrDB) of Infrared remote control codes enables the Universal remote control manufacturers to realize solutions for the latest products in the market. This is complemented by advanced data compression algorithms, in turn allowing for incorporation of more end device data in the microcontroller's ROM space.

Zilog's broad range of cost-effective and low-power IR microcontrollers provide the system designers with a wide range of package footprints: 20-pin, 28-pin, 40-pin, and 48-pin in PDIP, SOIC, and SSOP respectively. Memory sizes range from 4K to 64K in the ROM version, and from 4K to 128K in the OTP version respectively.

## Crimzon MCU Overview

The Crimzon *timers* are used in Zilog MCU families that have the prefixes of: ZLP, ZLR, ZGP, ZGR, Z86D99, and Z86L99. For example, ZLR16300 is a member Crimzon infrared remote control MCU family. The device's architecture incorporates the Crimzon *timers* and peripherals as shown in the [Figure 1](#).



**Figure 1. Block Diagram of ZLR16300 MCU**

## Features

The main features of Crimson Timers and Peripherals are:

- Low power consumption—60 mW (typical)
- Three standby modes:
  - STOP—2 A (typical)
  - HALT—0.8 mA (typical)
  - Low voltage reset
- Special architecture to automate generation and reception of complex pulses or signals:
  - One programmable 8-bit counter/timer with two capture registers and two load registers.
  - One programmable 16-bit counter/timer with one 16-bit capture register pair and one 16-bit load register pair.
  - Programmable input glitch filter for pulse reception.
- Six priority interrupts
  - Three external
  - Two assigned to counter/timers
  - Low-voltage detection interrupt
- Low-voltage detection and high-voltage detection flags
- Programmable watchdog timer/power-on reset (WDT/POR) circuits
- Two independent comparators with programmable interrupt polarity
- Selectable pull-up transistors on ports 0, 2, and 3
- Programmable ROM mask options
  - Port 0: 0–3 pull-ups
  - Port 0: 4–7 pull-ups
  - Port 2: 0–7 pull-ups
  - Port 3: 0–3 pull-ups
  - Watchdog timer at power-on reset



## Discussion

The most common infrared signals have a carrier frequency range of 30-56 kHz. The data is encoded in the *Mark* and *Space* timing sequences. There are various types of encoding schemes available for remote control applications. One of the most popular type is the *Pulse Position* encoding method.

In this method, the *Mark* time duration for ONES and ZEROS are the same, while the *Space* time duration are different. [Figure 2](#) shows an example of constant carrier signal with *Pulse Position*

encoding. A short *Space* represents ONE and a long *Space* represents ZERO.

## RCA™ Signal Format

The RCA™ infrared code has a Header (leading automatic gain control pulses) of 4 ms in the High state and 4 ms in the Low state, followed by 4 bits system, 8 bits data, 4 bits system complement, 8 bits data complement, and a trailing pulse width of 8 ms in the Idle state respectively.

This signal packet repeats each time the Volume Up key is pressed and held (see [Figure 3](#)). In the system or data bit, bit 1 is represented by 500 uS of

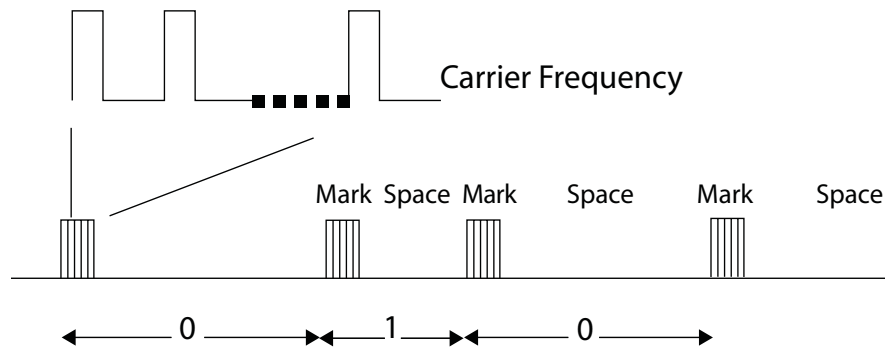


Figure 2. Constant Carrier Infrared Signal

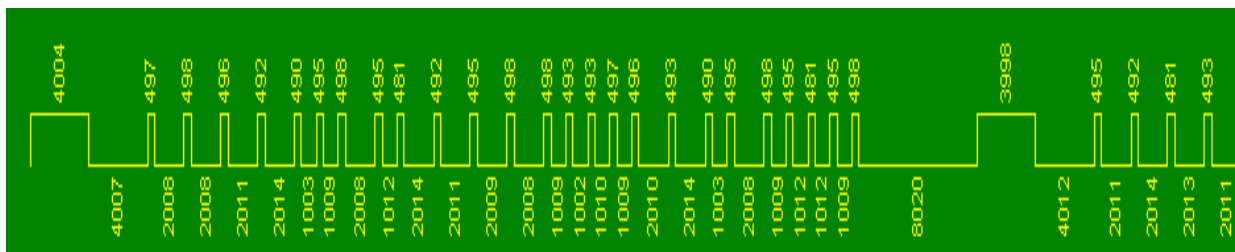


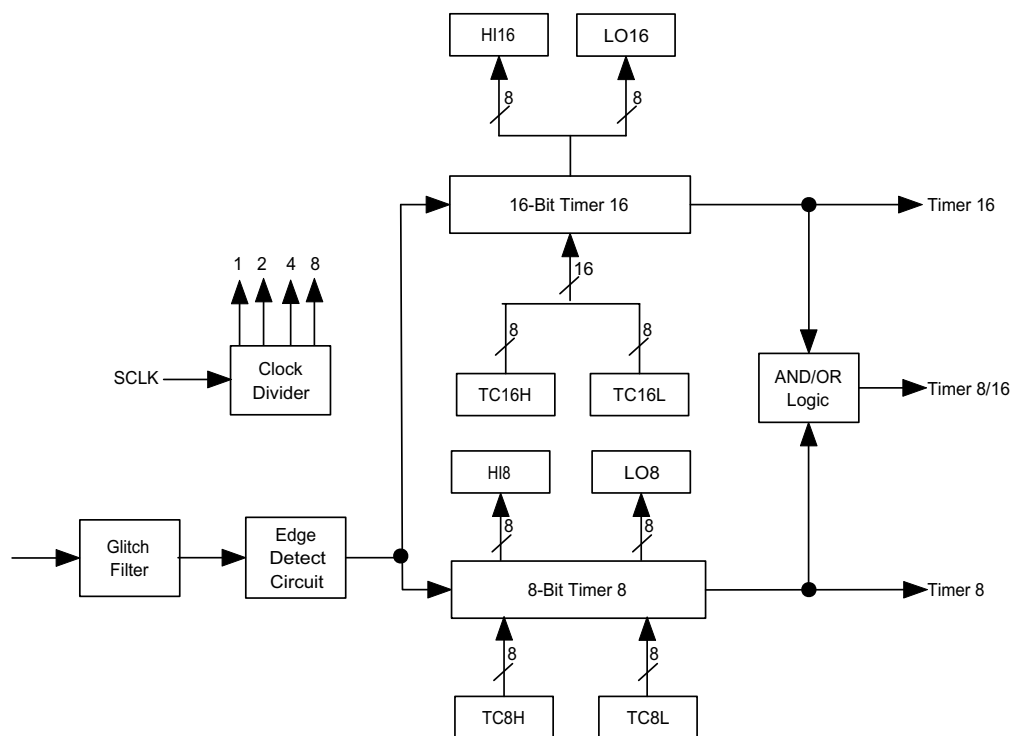
Figure 3. Capture of RCA™ TV Volume Up Signal

► **Note:** Captured signal of a remote control may vary from the actual specification.

## Generation of Infrared Signal

In Crimson timers, the carrier frequency is generated by the T8 timer in the free running mode. The TC8H register holds the Carrier ON time value, while the TC8L register holds the Carrier OFF time value respectively. Timer T16 is used to generate the modulated signal for both *Mark* and *Space* timings.

The T16 timer period is equal to  $TC16H * 256 + TC16L$ . Each timer is linked to its own clock divider module, based off the internal system clock. The two timers are logically *AND-ed* internally. The output at pin P36 is used to drive an Infrared LED via a transistor.

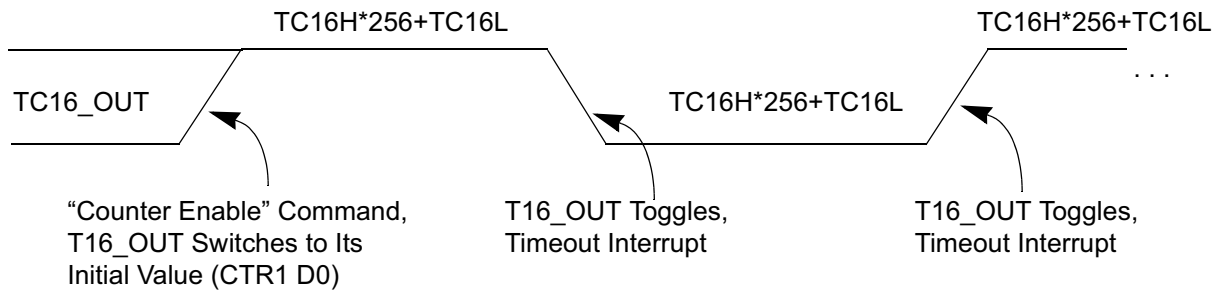


**Figure 4. Crimson T8/T16 Timers Block Diagram**

The modulated signal needs to be reloaded with different timings, as the timer T16 is in Modulo N (free running) mode. The Mark and Space timings are continuously loaded to the TC16H and TC16L registers. Figure 5 shows the T16 operation in the Normal Transmission mode. In this scenario, the timer logic (normal transmission mode, clock dividers, initial values, logic AND operation, and output pins) as well as the T8 carrier value are set up first, followed by the loading of the first Mark (from the Header) timing in the TC16H and TC16L registers, respectively.

It is important that both the T8 and T16 timers are enabled simultaneously. The T16 timer is a free running timer and will load the data into the counter on being enabled. The Header *Space* value can then be loaded into TC16H and TC16L registers.

A new timing value must be loaded into the TC16H and TC16L registers before the *Time-out* occurs. Figure 6 displays the flowchart of the timer operation.



**Figure 5. T16\_OUT in Normal Transmission and Modulo-N Mode**

## Summary

Zilog patented T8 and T16 *timers* can generate and capture many complex infrared remote control signals. Based on a time resolution of 250 nS, these *timers* support nearly all infrared remote control application.

The free running T8 and T16 timers do not require software overhead to reload the value when the T16 timer times out. Moreover, they can be synchronized with CTR3 registers. Hence complex sequences of infrared pulses with a wide range of *Mark* and *Space* timing combinations can be generated.

## References

Details about the Crimzon family of products can be found in the references listed below:

- *ZLP32300 Product Specification* (PS0208)
- *ZLR16300 Product Specification* (PS0214)
- *ZLR32300 Product Specification* (PS0226)
- *ZLP12840 Product Specification* (PS0244)
- *Z86D99x/Z86L99x Product Specification* (PS0038)
- *Z8 LXM CPU Core User Manual* (UM0183)
- *ZDS II—Crimzon and Z8 GP User Manual* (UM0164)
- *ZLP128ICE01ZEM User Manual* (UM0190)
- *ZCRMZNICE01ZEMG Crimzon In-Circuit Emulator User Manual* (UM0217)

You can download the above documents from [www.zilog.com](http://www.zilog.com).

## Appendix A—Glossary

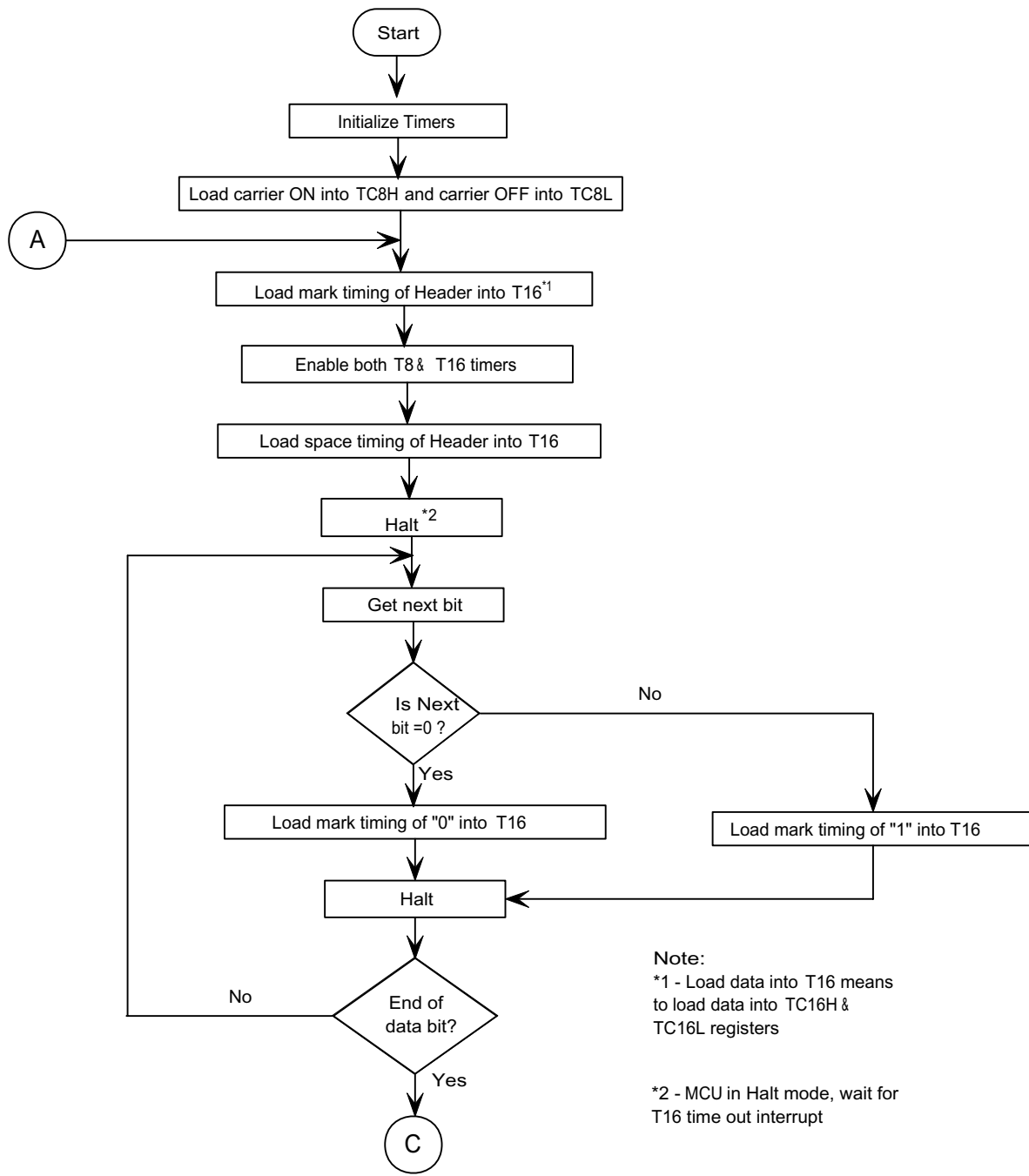
Table 1 lists the abbreviations used in this application note.

**Table 1. Glossary**

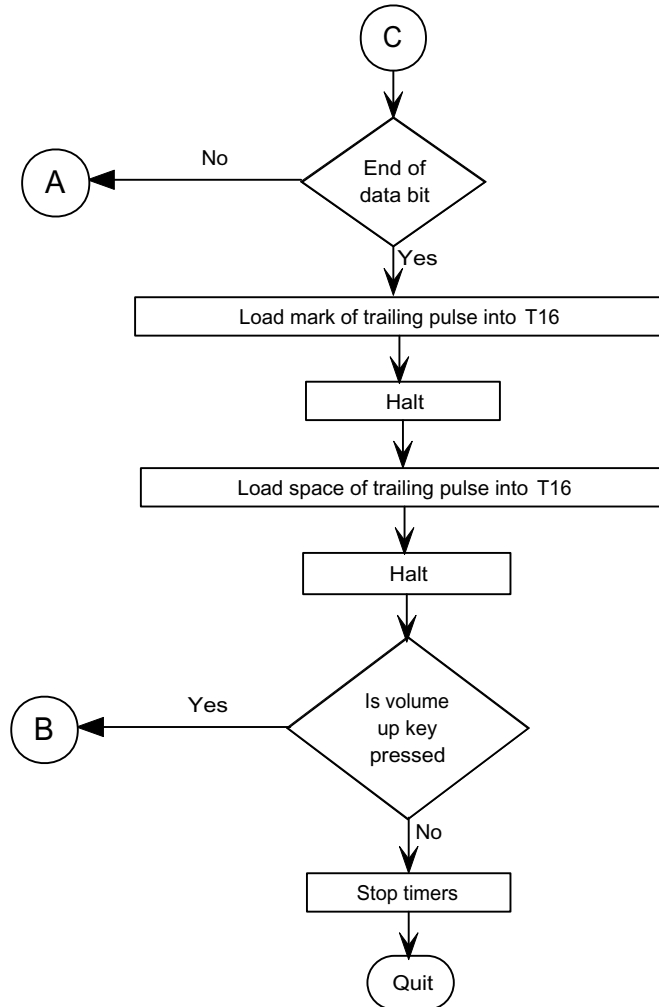
<b>Term/Abbreviation</b>	<b>Definition</b>
UIR	Universal Remote Control
IR	Infrared Remote
MCU	Microcontroller
OTP	One Time Programmable
ROM	Read Only Memory
ICEBOX	In-Circuit-Emulator Box
ZDS	Zilog Developer Studio
IDE	Integrated Development Environment
LED	Light Emitting Diode
PCB	Printed Circuit Board
WDT	Watchdog Timer
FPGA	Field Programmable Gate Array
PDIP	Plastic Dual-In-Line Package
SSOP	Shrink Small Outline Package
SOIC	Small Outline Integrated Circuit

## Appendix B—Flowcharts

The IR signal transmission routine is illustrated in [Figure 6](#).



(Continued)



**Figure 6. Timer Operation Flowchart**

## Appendix C—Schematics

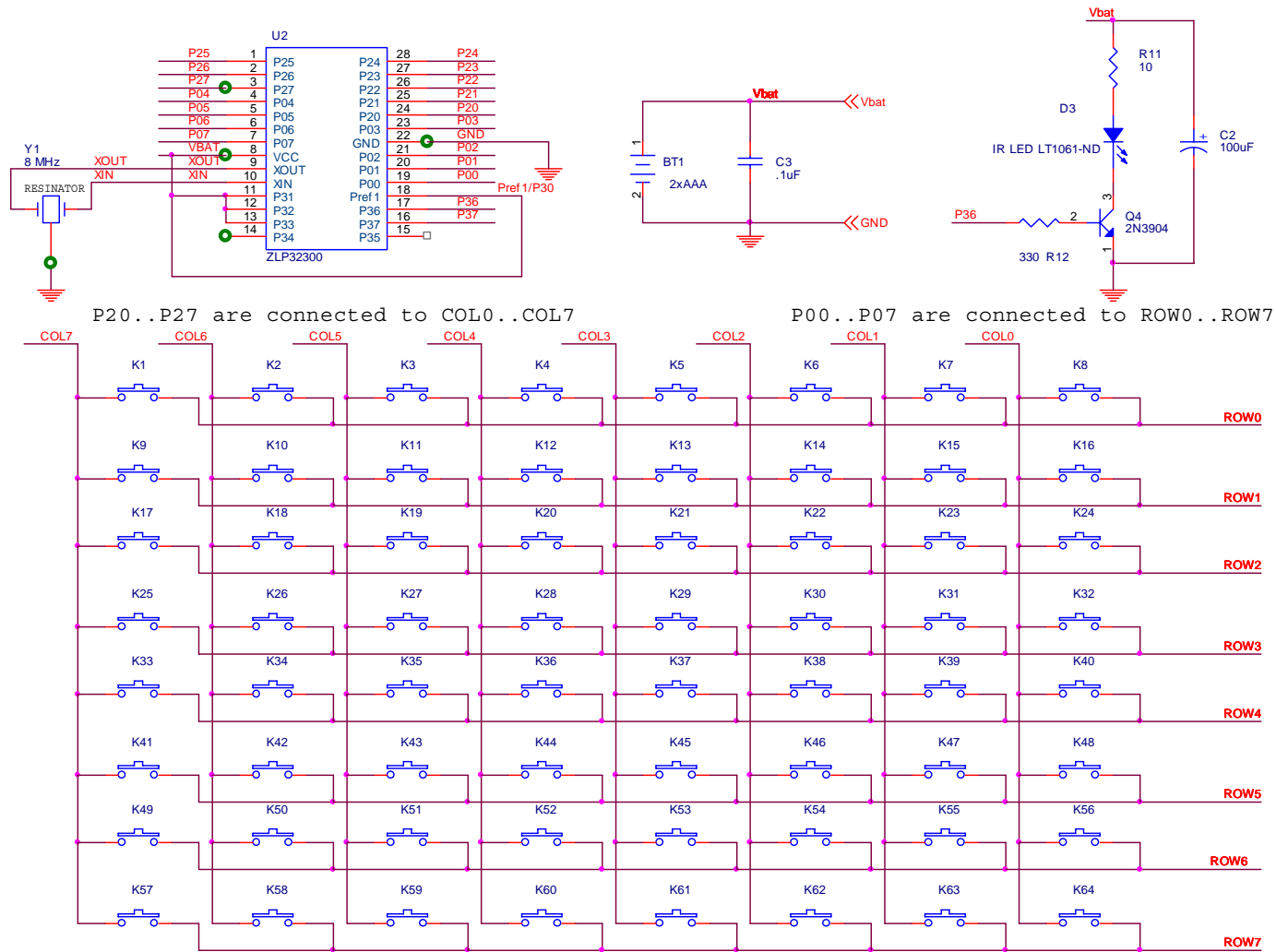


Figure 7. Schematic Diagram of Simple Remote Reference Design



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