TIRIS RFID Reader

Battery-free RFID tags release unique identity codes

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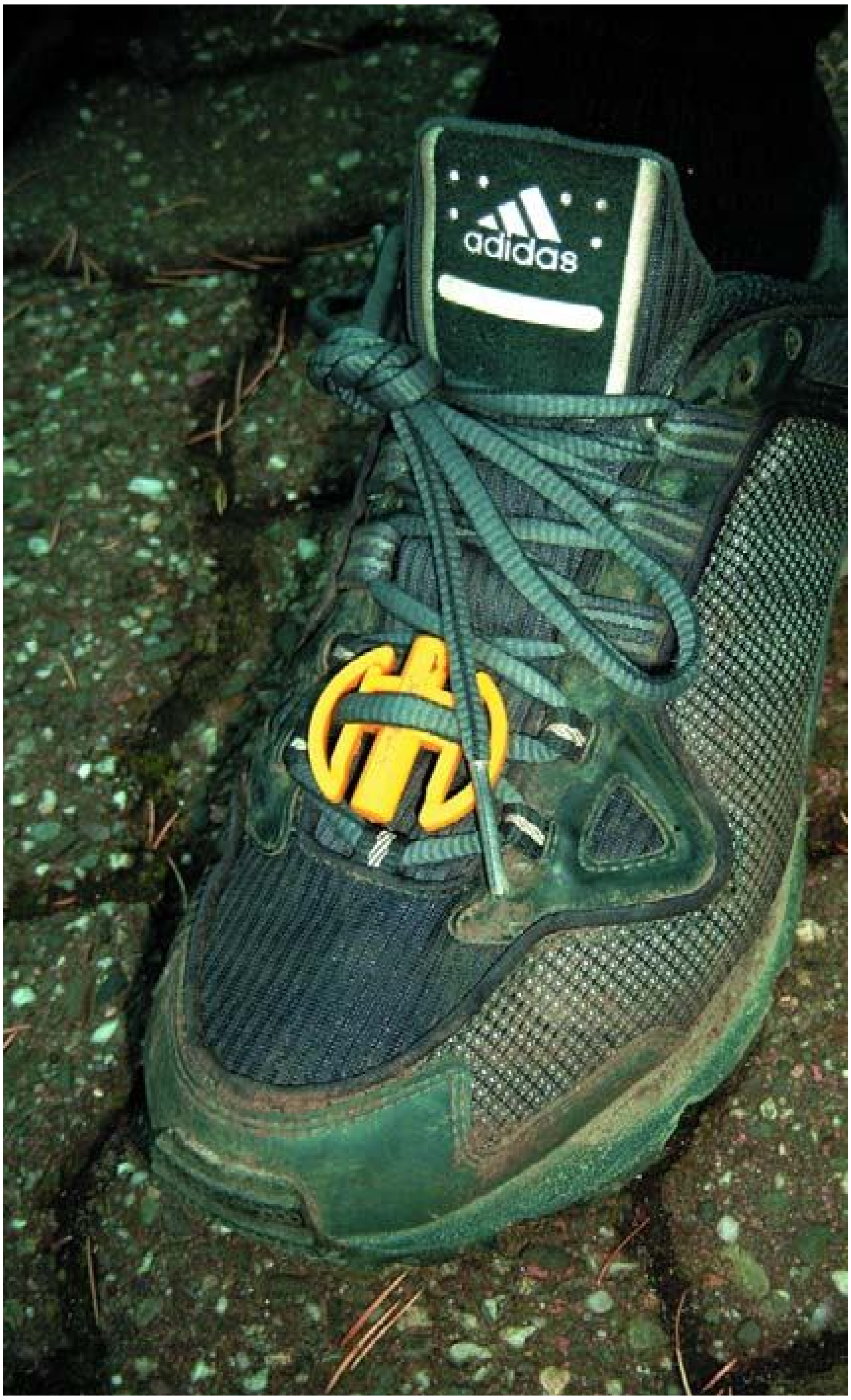

The TIRIS family of RFIDs from Texas Instruments can be found in many consumer applications ranging from vehicle security to logging marathon runner times. The two simple designs described here are able to read these passive RF tags whilst using the absolute minimum of hardware.

There is already an enormous market for contact-less Radio Frequency Identification (RFID) tags. One of the market leaders is the Texas Instruments Registration and Identification System (TIRIS). Each tag is a transponder i.e. a reader unit in close proximity transmits a signal to the tag and it responds by sending back a signal containing its unique identification code. The RFIDs that we have used here are encapsulated passive mini tags available in many different outlines ranging from a chip card to a pet ID implant. A small selection of the devices can be seen in

Figure 1. The author would like to thank Texas Instruments for supplying the components. The purpose of our original investigation was to build a device that could read the low frequency (134.2 kHz) TIRIS family of tags while using the minimum possible hardware outlay (and hence cost). The two circuits described here are the results of this investigation.

Figure 1. TIRIS tags come in many variants.

A circuit for minimalists: A System on a Chip

The first reader circuit shown in **Figure 2** is about as simple as it gets and consists of little more than a microcontroller together with a transmit/receive coil. The coil connections to the microcontroller in **Figure 3** make use of the input/output programmability of the port pins. The reader software initially configures the pins to output mode and then drives the coil at 134.2 kHz to 'charge up' any tags within range. After this charging period the pins are switched to high impedance mode, effectively disconnecting them from the coil. The coil is now in receive mode and picks-up any return signal from a tag in range. The signal passes to an on-board analogue comparator with resistors R2 and R3 providing the DC reference voltage. Capacitor C1 performs low pass filtering.

The trade-off for this minimal hardware approach is that the software has more work to do and is correspondingly more complex. An overview of all the software routines is shown in **Figure 5.**

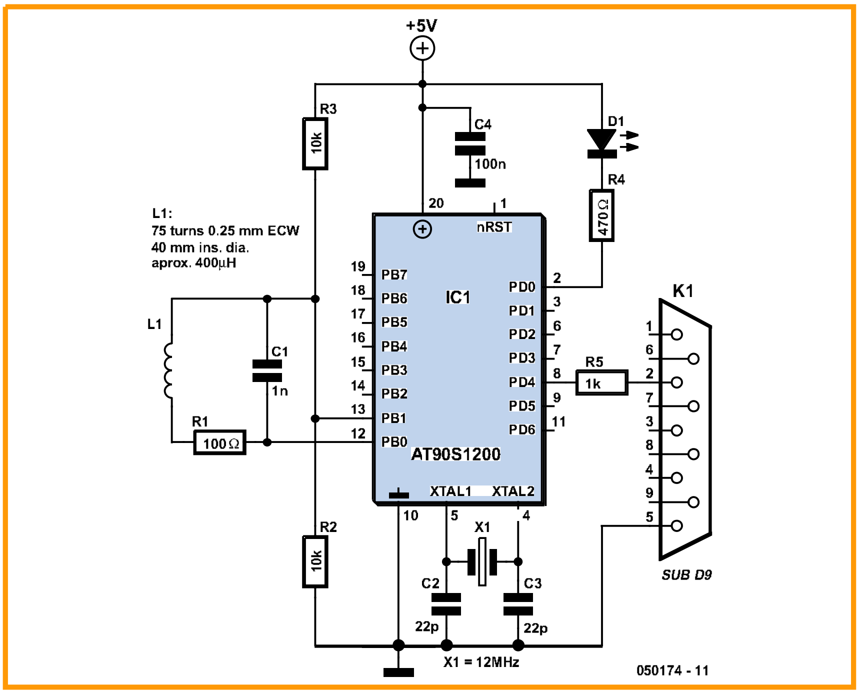

Figure 2. The simplest TIRIS reader.

Transmitting and receiving

The microcontroller uses a 12 MHz crystal oscillator. The charging signal sent to the RFID is a alternating field at a frequency of 134.2 kHz and this cannot be divided down from the 12 MHz microcontroller clock very easily. A 'software oscillator' technique is borrowed from the field of Direct Digital Synthesis (DDS) whereby a clock is produced by counting alternatively 89 and 90 periods of the 12 MHz source so that we arrive at an average division factor of 89.418… The spectral purity of the resultant signal is sufficient to ensure good energy transfer to the tag. When sufficient charge has been stored in the tag reservoir capacitor a stream of data is transmitted containing a identity 'key' unique to the tag. The digital information is sent using frequency modulation where 134.2 kHz represents a '0' and 123.2 kHz a '1'. Each bit length occupies 16 periods of the modulation frequency. The signal is picked up by the reader coil and fed to an internal comparator to generate an interrupt for each period of the signal. An internal counter is then used to measure the time between each interrupt. Measurements from several periods are then averaged to provide some low pass filtering. For the purposes of testing these counter values are also

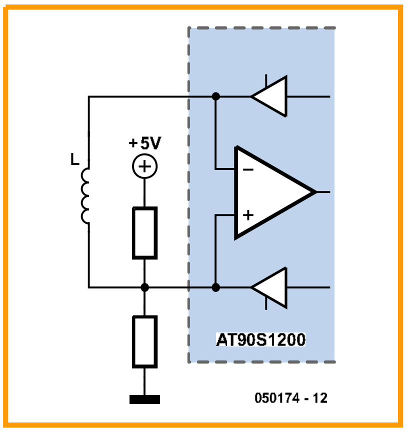

Figure 3. Bi-directional coil to microcomputer connections.

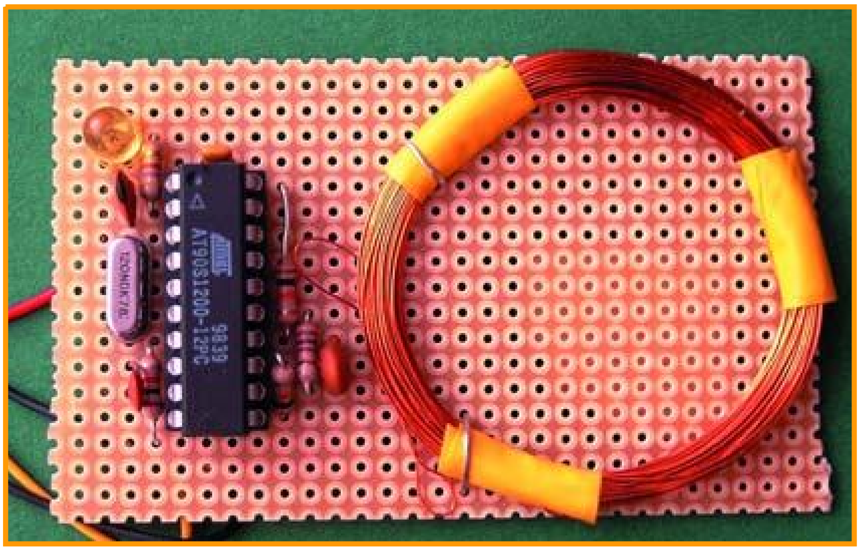

Figure 4. Layout of the minimal version.

output on the highest six bits of port B of the processor. It is a simple job to connect a D/A converter to these pins and display the resulting analogue output signal on an oscilloscope. This provides a convenient and useful indication of the proper function of the receiver as shown in **Figure 6**. The upper trace shows the RF field detected by a test coil placed close to the transponder. The (delayed) trigger point is chosen when the reader stops sending its ‘charging’ signal on the left of the screen after this point we see the modulated tag signal which has a characteristic diminishing amplitude, reducing as the stored energy is used up. The lower trace shows the recovered data from this signal. Each bit read in the interrupt routine after the valid START bits is reassembled into bytes and stored. A TIRIS tag sends eight bytes of data followed by a two-byte checksum or CRC (Cyclic Redundancy Check). The checksum is verified by software along with the terminating STOP byte. If no error is detected the OK LED lights and the receive data is sent out from the RS232 port at a rate of 9600 bits/s. If an error is detected the OK LED remains off and a question mark character is sent out from the RS232 port.

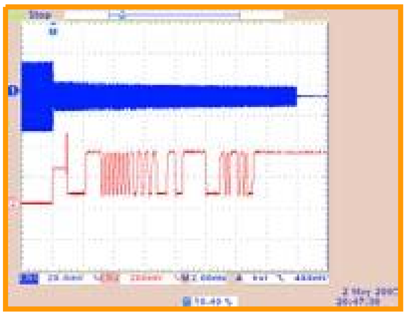

Figure 6. The RF signal and recovered data.

With all the functions built into the software this basic reader circuit is a good starting point for many useful applications but the tag needs to be quite close to the reader to ensure reliable reading. If more range is required then a slightly more sophisticated circuit is necessary.

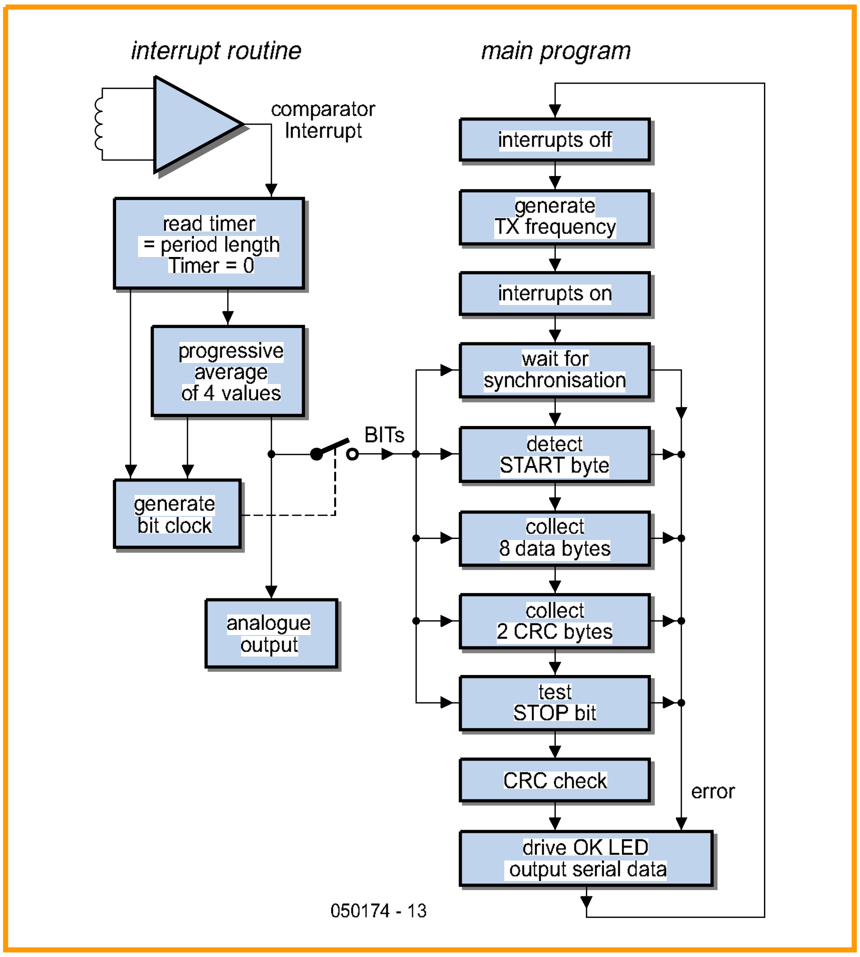

Figure 5. The software structure.

Boosting the range

The minimalist circuit diagram has been expanded slightly (**Figure 7**) to incorporate a better coil driver stage together with a signal amplifier in the receive path. The coil switching configuration is shown in **Figure 8.**

When the reader transmits, transistors T1 and T2 operate in push-pull mode to drive the series resonant circuit formed by C1 and L1. The circuit has a Q (quality) factor of around 10 and is defined largely by the ON impedance of the P-channel BS250

MOSFET. In receive mode T1 conducts and the coil now becomes part of a parallel resonant circuit tuned to the receive frequency. The received signal is amplified through the dual op amp IC2. During transmit with the coil in resonance the signal level can reach 100 V so it is important to add protection (Schottky diodes D2 and D3) to ensure that this signal does not go beyond the op amp supply rails and destroy the input stage.

This circuit easily achieves a range of about 15 cm. It is important to ensure that the capacitors C1a and C1b are chosen so that the circuit is in resonance at 130 kHz. In the prototype a combined capacitance (C1a + C1b) of 1.6 nF was optimal but it depends on the coil properties so you may need to adjust this value to achieve best results. There is a good opportunity here to experiment with different coils to try to improve the range. Coils wound on ferrite rod also produce good results.

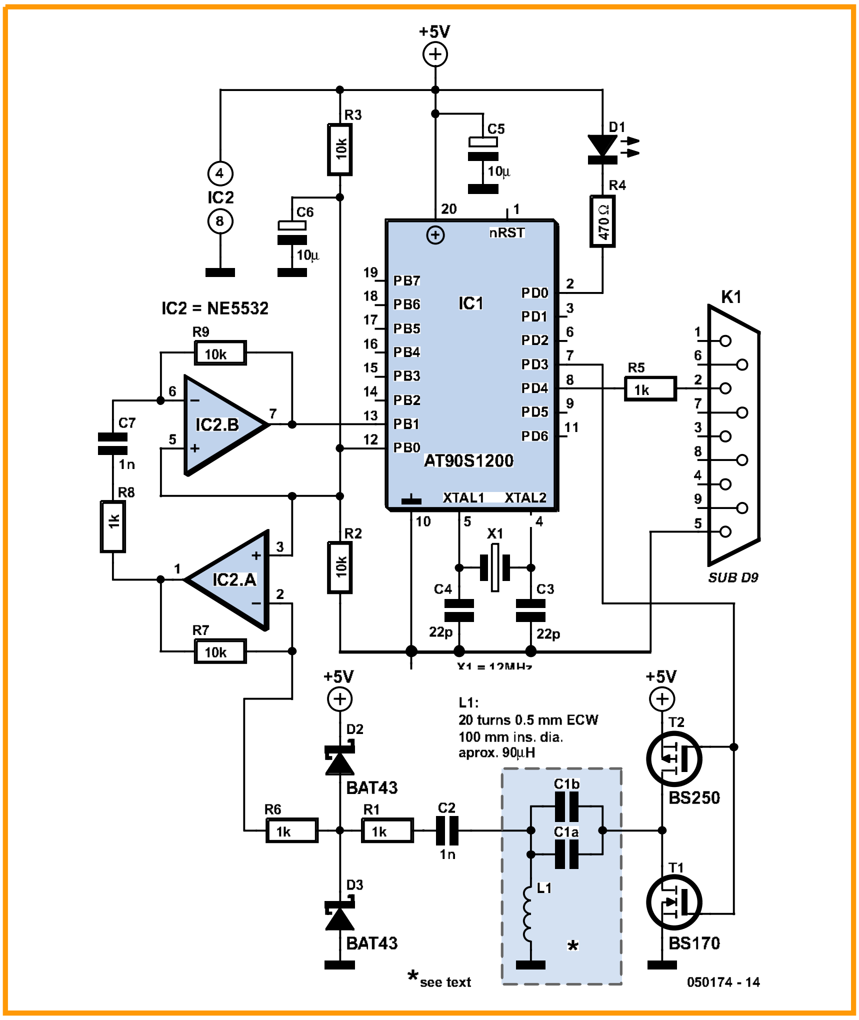

Figure 7. A driver stage and receive amplifier boost the range.

Applications

All the software source code for this project is freely available and can be modified or adapted to suit any application that you have in mind. The files TIRIS1.ASM and TIRIS2.ASM for the ATMEL AVR assembler are available free of charge from the Elektor Electronics website at www.elektor-electronics.co.uk; look for file number **050174-11.zip** under month of publication. A list of distributors of TIRIS components is available from www.ti.com/tiris/docs/customerService/distributors.shtml

Code lock

The reader circuit can be easily adapted to operate as a door entry system. The reader LED indicator can be replaced by a relay (with diode protection across the coil and possibly with an additional transistor driver). The relay can now be used to energise a standard electric strike mechanism to release a door latch. Additional security will be provided if the short-range reader is used and the reader coil is hidden behind a non-conductive panel near the door entrance. It will not be obvious to the uninitiated how the door can be opened or where the electronic reader is situated.

The reader software can be modified so that it will only respond to an individual or group of TIRIS tags. In this case the ID code of each tag will need to be known before hand or alternatively the reader will require a 'Teach-in' mode to record the tag signature during system set-up.

Computer security

Both circuits shown in this article can form the basis of a PC security device to prevent unauthorised access. With the RS232 port connected to a PC or microcontroller serial port, software routines can be written that use the tag identity information to grant or block access to the computer. Additional security measures will be necessary to fully secure both the hardware and software and prevent hacking.

Home security

The simplicity of this design means that several reader units can be built quite cheaply to control entry points around the house with outputs fed back to a central controlling PC or microcontroller where each door latch can be activated and provide access control.

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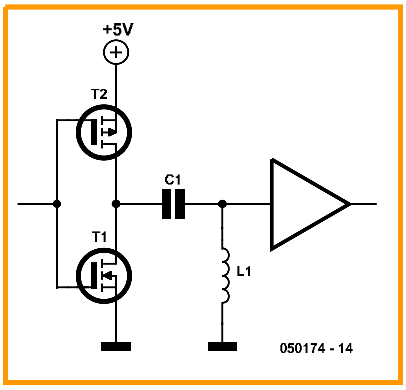

Figure 8. Resonant circuit coil switching.