DALLAS SEMICONDUCTOR

Application Note 59
Wireless Applications with the DS1651 and DS1652 Key and Lock Match Memory

INTRODUCTION
The DS1651 Lock and DS1652 Key operate in combination to limit access of any secure system or area to key holders. Both the DS1651 Lock and DS1652 Key contain a 64–bit memory which acts as the security code, controlling access. The code memory within the DS1651 Lock may be programmed with a known 64–bit code, or the DS1651 can generate a 64–bit code from a random number generator within the DS1651. Once set, the code is nonvolatile, and can then be transferred to one or more DS1652 Key(s) under secure conditions.

To gain access to the lock, the key's code must be transmitted to the lock via some user transmission media, such as RF, optical, IR, or other serial media. Upon receiving a transmission of a 64–bit key code, a DS1651 lock will compare the requesting key's 64–bit code to the lock's programmed 64–bit code. If the key code matches the lock code, the lock generates a match signal, which can be used to allow access to the secure system.

This application note looks at both RF and IR applications circuits for accomplishing this transmission and the reception of these signals. The circuits shown here are intended to be a starting point for users of the DS1651 and DS1652, and are by no means the only (or best) methods for building a complete wireless secure system. It is recommended that anyone who wishes to use the DS1651 and DS1652 in an RF or IR system be familiar with RF and I R transmission techniques and circuit design methodologies; embarking on such a project involves considerable time spent in the design of the transmit and receive circuitry.

Refer to the DS1651/DS1652 data sheet for detailed information on the operation and programming of the lock and key devices. The DS1651 recognizes three variations on the 64–bit code, while the DS1653 Lock recognizes four variations of the code. These variations are summarized in Table 1. This ability to use a single key to access up to four different functions make this system a versatile solution for garage door openers, security systems for building or automobile access, and remote identification.

SEND AND MATCH CODES Table 1

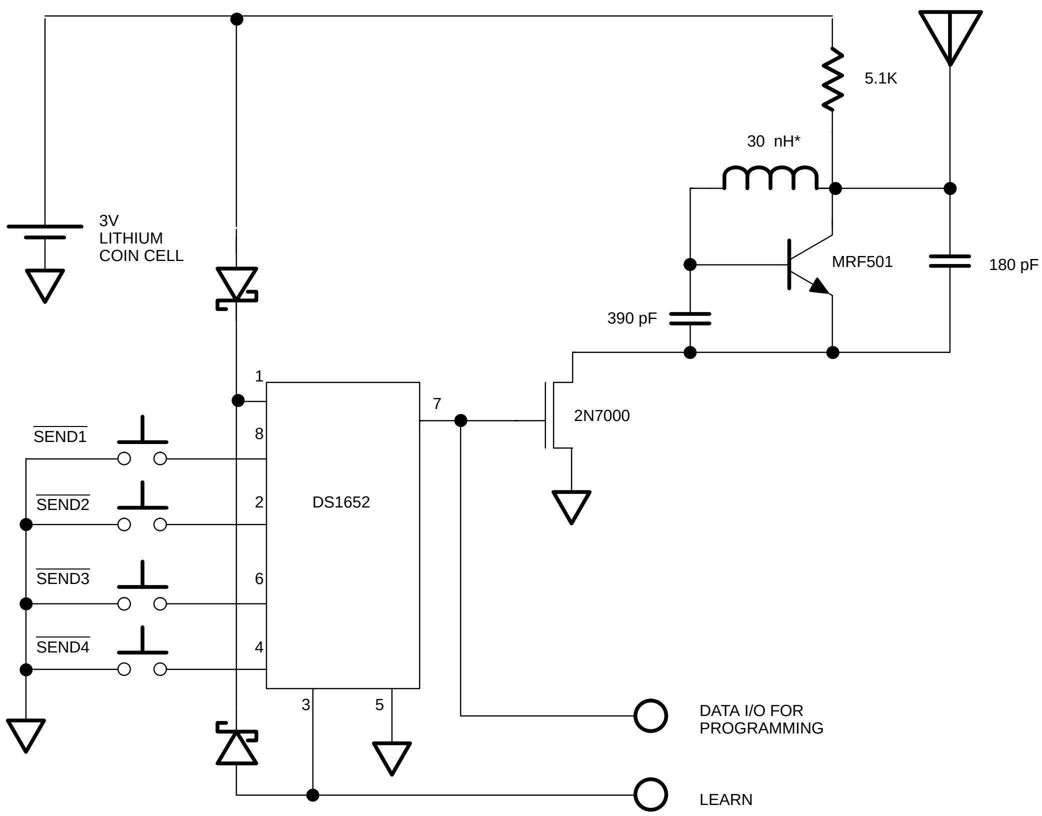
DS1652 INPUT TRIGGERED	64–BIT CODE TRANSMITTED AS									DS1651 MATCH SIGNAL ACTIVE	DS1653 MATCH SIGNAL ACTIVE
$\overline{\text{SEND1}}$	b_0	b_1	b_2	b_3	b_4	–	b_{61}	b_{62}	b_{63}	SEND1MATCH	SEND1MATCH
$\overline{\text{SEND2}}$	$\overline{b_0}$	$\overline{b_1}$	$\overline{b_2}$	$\overline{b_3}$	$\overline{b_4}$	–	$\overline{b_{61}}$	$\overline{b_{62}}$	$\overline{b_{63}}$	SEND2MATCH	SEND2MATCH
$\overline{\text{SEND3}}$	b_0	$\overline{b_1}$	b_2	$\overline{b_3}$	b_4	–	$\overline{b_{61}}$	b_{62}	$\overline{b_{63}}$	SEND3MATCH	SEND3MATCH
$\overline{\text{SEND4}}$	$\overline{b_0}$	b_1	$\overline{b_2}$	b_3	$\overline{b_4}$	–	b_{61}	$\overline{b_{62}}$	b_{63}	N/A	SEND4MATCH

RF TRANSMITTER/RECEIVER SYSTEM
Transmitting the stored 64–bit code from the key to the lock via RF transmission is one way of providing complete, remote control for access to buildings, automobiles, and the like. Many products for security currently operate over RF links, such as garage door openers. Depending upon the country in which your product will be used, and local and federal regulations on the use of the radio spectrum, many different methods for transmitting the codes from a DS1651 to a DS1652 may be considered. Make sure to check with local and federal governments before determining the operating characteristics of your transmitter.

One method of making an RF transmitter is by using one of several surface acoustic wave (SAW) oscillators available on the market. These typically operate at very high (several hundred megahertz) frequencies, and are compact and relatively easy to design with. Unfortunately, the nature of these devices generally prevents their use with the DS1652. The reason for this is that the pulse width of a “zero” for a DS1652 is 20 μs, which does not allow enough time for the SAW to ring up. The result is that logical zeros are shortened in time, and would not therefore be detected by the receiver and DS1651 properly.

The DS1651/DS1652 were designed to used primarily with a low–Q oscillator circuit, such as the Hartley oscillator. A complete key transmitter, built around this circuit, is shown in Figure 1. This example transmitter is designed to be used at 47.7 MHz, a common frequency used in the United States for radio–controlled model airplanes and cars. While this frequency was chosen for the purposes of this application note, other frequencies may easily be used by changing the component values.

RF KEY TRANSMITTER CIRCUIT Figure 1



* Two turns of bus wire wrapped around a pencil.

The frequency of this transmitter is determined by the following equation:

$$f_O = \frac{1}{2\pi\sqrt{LC}}$$

where the C value used is that of the capacitor from the base to the emitter of the MRF501.

The circuit of Figure 1 provides for several desirable features for an RF key. First, the entire transmitter is powered from a single 3V lithium coin cell, which provides significant circuit life without replacing the battery. Two pins are provided for programming the key. Since programming the code into the key must be done under secure conditions, these pins require that the key be physically connected to the DS1651 lock. The data I/O line connects to the lock's data I/O line, while the learn pin is simply tied to +5V when programming, to place the DS1652 is LEARN mode. See the DS1651/DS1652 data sheet for further details on programming modes.

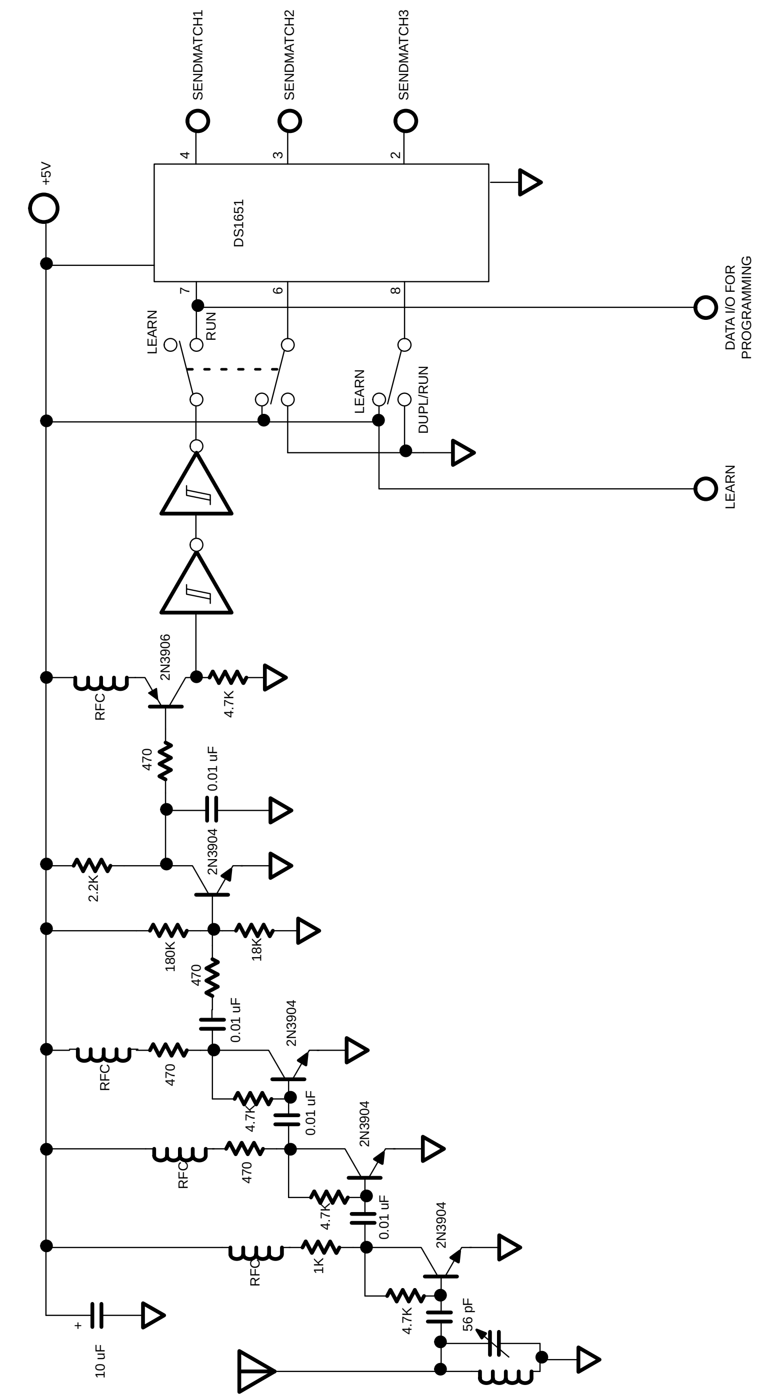
There are four buttons provided on this transmitter, which allows it to be used with a DS1651 or DS1653. These four switches send the appropriate code as shown in Table 1 when engaged. These four switches could be used in an apartment building entry system, for example, to open a parking lot gate with SEND1, open the garage door with SEND2, unlock the door to the apartment with SEND3, and turn on an inside light with SEND4. If all four codes are used, as in the example cited, a DS1653 lock would be needed; if only three codes were needed, a DS1651 would work fine (you just wouldn't turn on the lights inside from the remote control!).

While the transmitter design is relatively straightforward, the receiver design is a bit more tricky, since it involves high gains at high frequencies. The receiver circuit is shown in Figure 2. This circuit consists of a simple tuned circuit on the front end for selectivity, and then several stages of amplification. At the frequency used in our example (47.7 MHz), the 2N3904 is a perfectly adequate transistor; higher frequency applications should substitute an appropriate transistor with adequate f_τ and β.

The first three transistors provide significant gain of the signal received at the antenna. This amplified signal is then sent into the fourth transistor, which is used as a crude detector, stripping off the RF from the signal and providing a pulse output. This is then further shaped by the 2N3906 to provide a relatively clean pulse output, which is shaped further by the use of the Schmitt triggers. Once through all this, the data is accurately recovered and sent to the DS1651 lock.

The lock also provides, through the switches used, for placing the DS1651 in LEARN mode, so that it may generate its own code from an internal random number generator, thereby keeping the code secret even from the user. It may also be placed in DUPLICATE mode to allow for programming DS1652 keys. For this process, the data I/O line and +5V are physically connected to the DS1652's data I/O and LEARN lines, respectively. For more information on the DS1651's modes and operation, refer to the DS1651/DS1652 data sheet.

RF LOCK RECEIVER CIRCUIT Figure 2



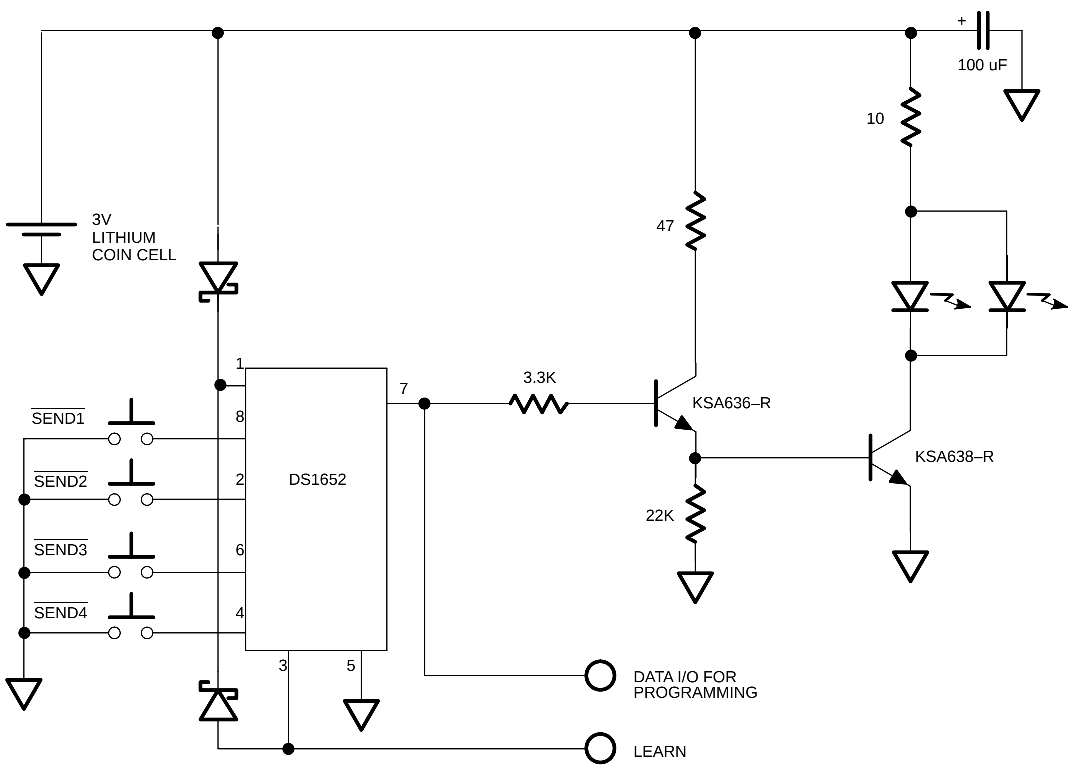
INFRARED TRANSMITTER/RECEIVER

Dealing with the RF spectrum and the associated regulatory requirements can be overwhelming, especially in cases where simple remote signaling is needed. Most of us have TVs, VCRs, and CD players which use a remote control. In most cases, this control is a simple infrared transmitter/receiver system.

Such a system could easily be adapted to applications using the DS1651 and DS1652. An example of an IR transmitter is shown in Figure 3. This simple transmitter uses the data right out of the DS1652 to turn the IR LEDs on and off. This works well enough, but many systems extend the range of the IR transmission by using the data to modulate a high frequency signal (40 KHz, for example) which then modulates the IR LEDs.

The receiver for the circuit shown in Figure 3 is equally simple, and is shown in Figure 4. This circuit taps directly off the IR detector, then conditions the pulse with the two inverters made up of the 2N2222A's. This yields a data output clean enough to run directly into the DS1651. If the modulated system discussed previously were to be used, a simple discriminator/detector circuit would be needed between the receiver front end and the data input to the DS1651.

IR TRANSMITTER Figure 3



IR RECEIVER CIRCUIT Figure 4