A “remotely controlled” remote control

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1. The goal

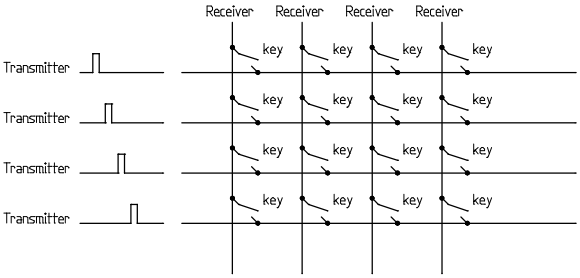
This application note intents to show other interesting aspects for working with the BASIC-Tiger™. What is it about? With the help of a small logic circuit and several DIL relays we will step in the keyboard of external devices and then control it with the BASIC-Tiger™. The advantage of accessing the keyboard is that you don’t have to deal with the complicated controls of the device to operate. For what do you need something like this? The following list is not complete, but should offer some suggestions:

- For almost every device there is a remote control, for some of them it makes sense to control them through the BASIC-Tiger™.
- An alarm system should inform you via handy that there is something wrong in your summer house. Depending on the state of some sensors the BASIC-Tiger™ dials up your cellular phone and you can directly “listen” what is happening.
- Interesting are also interventions in desktop calculators with printer, here the BASIC-Tiger™ can operate the printing element.

So were will build up a universal assembly for the BASIC-Tiger™, which immediately affects almost any device keyboard and with that “remote controls” the concerned device. For this there is always an intervention into that device necessary, so you have to estimate if the intervention makes sense, the keyboard is accessible, hazards are precluded (e.g. high voltages!) etc.

2. How keyboards are assembled

Practically all keyboards of today’s devices are assembled following the same scheme. An electronic chip, sometimes a special circuit, sometimes a microprocessor, outputs pulses time-lagged on several lines, on other it is checked if and when a pulse is received. Both groups are switched together to a matrix, in which e.g. the lines put out the pulses and the columns receive them if a key is pressed (Picture 1). From the assignment of the read columns and the time of the pulse the electronic recognizes which key is pressed.



Pic 1 Scheme of a keyboard matrix

As you can learn from the manual you find this principle in all devices with keyboard, whether now desk calculator, remote control, cellular phone, computer, code lock or Plug & Play Lab of the BASIC-Tiger™. Despite all similarities the operating conditions (what operating voltage, what time scheme, how many lines and columns) are so different, that you can't directly access the electronics without special knowledge. We solve the problem more simple, small DIL relays are switched parallel to the further operational keys. With that you get the same result through the relay as when pressing the corresponding key.
To know where the key we want to bridge per relay is located in the matrix, we either have to look into the keyboard, try out or measure. It is often necessary to combine all three methods.
Having an unknown keyboard matrix, it is first important to separate the "sender lines" from the "receiver lines". The best way to do this is with an oscilloscope, for keys not pressed you can see short pulses on the sending lines, the receiving lines usually are in idle state. Both groups are now arbitrary numbered, e.g. after their position on the cable or connector. If we can take the keyboard apart **(Careful!)**, the lines can be followed and so the scheme of lines and columns can be recognized. If that's not possible, because the lines are not visible or it's arrangement with many feedthroughs is confusing, some trying may help. With a bridge (For security reasons use a resistor of approx. 100Ω) between one sending and one receiving line one (and only one!) function of the device should be released. On a desk calculator e.g. a "5" is randomly entered. By measuring, viewing and trying you finally come to a complete overview of the examined keyboard, at the end there's a table, in which the assignment of sending and receiving lines as well as the corresponding key is listed:

Key	Sender (Line)	Receiver (Column)
"1"	1	3
"2"	1	2
"3"	3	4
Etc.		

Everything further is simple. Choose the keyboard you need for your control task. Our assembly in the chosen variation offers the possibility to control 15 keys. The concerned relay contacts are simply connected to the sending and receiving lines "responsibly" in each case. Keep in mind while working that the device to be controlled might be electrostatic sensitive and only use suitable tools (Soldering iron!). To preserve the device for the "usual" usage,

small patch plug with the needed sending and receiving lines are recommended, which are discreetly attached to the device. With a control cable pluggable to the relays matrix the BASIC-Tiger™ can take over control if needed, because of the potential free relay switches this can be done without problems during operation of both devices (BASIC-Tiger™ and the remote-controlled device)!

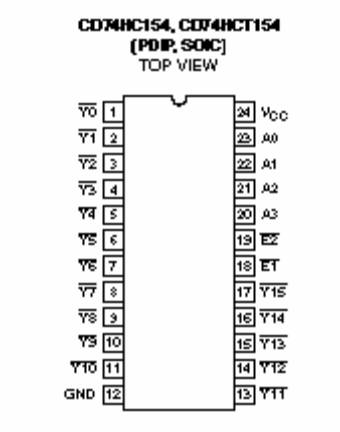
3. The "second" keyboard matrix

The task is to switch one of 15 relays. It has to be impossible to switch two relays simultaneously. In binary logic this means we need a 1-from-16 decoder, which chooses one relay at a time with a 4 bit control word. The control word 1111 (Idle state) should not switch any relay. This task is solved with a standard IC, the 74HCT154 (Picture 2). If you're using DIL relays which require the current of only one TTL load, a protective diode must be connected across the coil of the relay, you don't need any further circuitry. The outputs Y0 to Y14 are directly connected to one leading-out wire, the other one leads to Vcc (Regard polarity of integrated protective diode!).

Datasheet of 74HCT154: http://www.ti.com/sc/docs/products/logic/cd4515b.html

The logic table looks like this:

Bit 3 A3	Bit 2 A2	Bit 1 A1	Bit 0 A0	Output 74HCT154	Relay No.
0	0	0	0	Y0	0
0	0	0	1	Y1	1
0	0	1	0	Y2	2
0	0	1	1	Y3	3
0	1	0	0	Y4	4
0	1	0	1	Y5	5
0	1	1	0	Y6	6
0	1	1	1	Y7	7
1	0	0	0	Y8	8
1	0	0	1	Y9	9
1	0	1	0	Y10	10
1	0	1	1	Y11	11
1	1	0	0	Y12	12
1	1	0	1	Y13	13
1	1	1	0	Y14	14
1	1	1	1	Y15	no relay



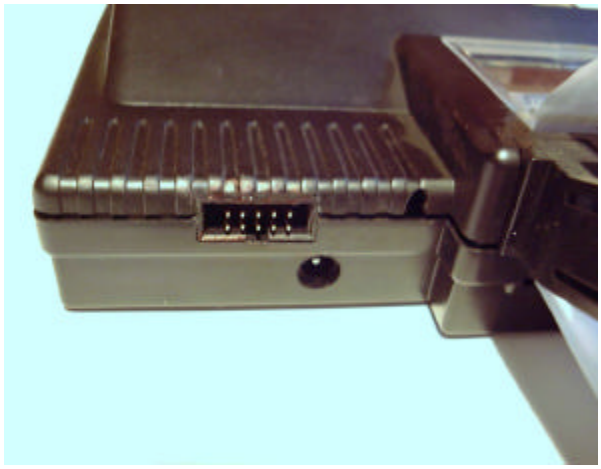
Pic 2 Connection diagram of 74HCT154

With this the hardware is almost complete, only the lines to the keys of the controlled device are still missing. If you there lead out only the needed sending and receiving lines and do the wiring on the relays PCB, you can possibly save lines. You need e.g. 30 lines when using 15 keys, if you however only have to layout 5 sending and 5 receiving lines, the effort is significantly less.

4. An example

It was tempting for the author to connect a protocol printer with minimum effort to the BASIC-Tiger™. The printer was only demanded to print all numbers and the comma, with that date, time and measured values can be put down on a paper strip. The choice was a printing desk calculator for 20 €. The additional circuitry with the 74HCT154 and the relays was connected to the desk calculator through a 10-pin flat ribbon cable. As the desk calculator in normal operation only requires several µA, it can be permanently turned on, supplied by its own batteries. Only when printing up to 300 mA are required. Die following photos show some details of the “device combination”.

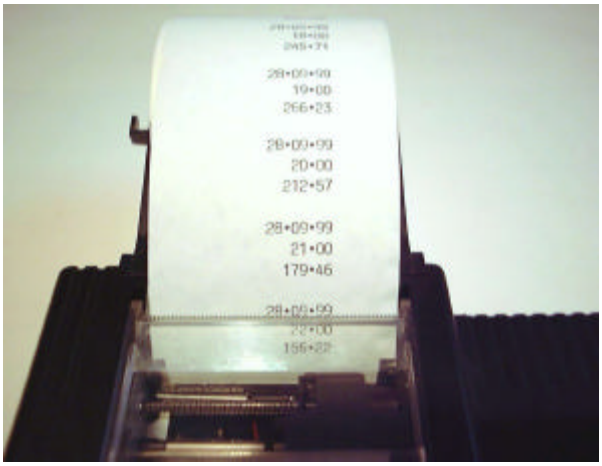
Pic 3 The printer with controller cable



Pic 4 A hidden jack for "remote controlling"

5. Software

For programming of the BASIC-Tiger™ some small details have to be taken into account. 4 free port lines are programmed as output and control the inputs of the 74HCT154. These 4 bits determine the active key. Keep in mind when pressing a key that most keyboards have own debouncing mechanisms, meaning the time a key is pressed shouldn't be too short. Furthermore it is important that between pressing two keys usually a break time is required. Also think about a possible operating fault, so you should be able to access the reset button to restore the default condition of the device to operate. Apart from that the software is only depending on the problem you want to solve, so there can't be a generally usable program.



Pic 5 A "low price printer" for the BASIC-Tiger™