DIY KIT 86 TELEPHONE SWITCHER

This device connects to the telephone line and can be used to remotely control up to 4 relay outputs using a DTMF (tone dialing) telephone. Security is provided via a user defined 4 digit access code. The switcher is controlled by a Motorola microcontroller, the 68HC705K1. The fully commented source code is provided on floppy disk.

FEATURES

- 4 relay outputs
- user defined 4 digit access code
- auto disconnect after 30 seconds of inactivity
- low power consumption: approx. 15mA when running and 10mA when idle (no relays operating)
- powered by 9-12 volt DC plug pack
- circuit to protect phone connection built-in
- connects to standard single line phone line
- small, compact, double-sided PCB - 8 x 10.5 cm
- commented K1 source code supplied on disk

ASSEMBLY

First check the components supplied in the Kit against the Component listing. Identify all the components. It is generally best to solder the lowest height components first: the resistors, diodes & IC sockets. Make sure to get the diodes the correct way around. Match up the bar on the diodes with the bar on the overlay.

Make sure to get the orientation of the 4 BCD switches around the correct way. There is a white dot on the switch to line up with the dot marked on the overlay. This also applies to the two resistor networks. There is a white dot or bar on one end of the 10 pin (9 resistors, 10 pin) network. This marked end goes into the box marked on the overlay of the component.

Use needle-nosed pliers to bend over the legs of the MJE340. Remember to allow for the screw to go in to secure it to the PCB for heatsinking.

The 4.096 MHz crystal in the tuning fork package should be secured to the PCB by some wire offcut from a resistor. Bend it in a U-shape & solder into the mounting holes provided. You can also quickly solder the wire to the case of the crystal. (Or just leave it unsoldered if you do not want to risk heat damage to the crystal.) Also when you solder the other crystal, Y1, do it quickly. We have found that crystals are easily damaged by soldering.

Check the orientation and name of every IC before you put it into its socket.

CIRCUIT DESCRIPTION

We will not review the operation of how telephone lines work (see References below) or the operation of the K1 microcontroller here (see earlier DIY microcontroller kits for this.)

The brains of the switcher is the Motorola 68HC705K1 microcontroller, IC4. Incoming rings are detected via C4, R7 and the opto-coupler IC2 and fed to the interrupt input of the microcontroller. The incoming call is answered by connecting the circuit based around Q1 and Q2 (an electronic holding coil) to the line via IC1, a bi-directional opto-isolator. This circuit has a low DC resistance but a high AC impedance which is required by telephone circuits when the line is looped. The RC network consisting of R4, R5 and C3 is used to provide impedance matching to the telephone line. The metal oxide varistor
protects the switcher from telephone line transients. The configuration and values used here are optimized for the Australian telephone system but they should work in all other phone systems. They may be changed to suit other telephone systems if it is desired to get official approval of this device.

DTMF detection and decoding is provided by IC3.

The output relays, RL1-4, are controlled via the addressable latch IC5 and relay driver IC6. One output from the latch (Q6) is used to output a 800Hz software generated tone into the telephone line via the impedance matching network. This tone is used to signal the user when commands have been completed or of any command errors. BCD rotary switches, SW1-4, allow the user to set up a 4 digit access code. These switches are read by the microcontroller via the 8-bit shift registers IC7 and IC8. The switch settings are latched into the shift registers and read out serially.

OPERATION

For testing try to arrange two phone lines physically next to each other. Connect a 9-12 volt, centre positive DC plug pack to jack X6. Connect the switcher to the telephone line via the telephone jack. The two middle pins of a standard RJ-11 jack are used. The outer two pins are not used. (This is important: do not think you can unplug your fax or modem & attach the line to the switcher. Check the plug wires for a single line, 2 middle pin connection.) The switches SW1-4 set the 4-digit user access code. The overlay indicates the digit which each switch controls. SW1 is the first digit; SW4 is the fourth digit.

Turn on the power. All relays should be released. The device is now ready to accept incoming calls. For testing purposes you may want to attach LED's to the 4 relay outputs to give visual indication of the relays state. Solder temporary connections to the input power jack and a current limiting resistors to the LED's.

Logging On. Incoming calls are automatically answered after 4 rings. Four short beeps are sent back to the user to indicate that the call has been answered.The user then enters the 4-digit access code, followed by "#". If a mistake is made press "*" to abort. The unit will respond

with 2 short beeps and the access code may be re-entered. If the entered code is incorrect the device will respond with 1 long beep. The user is allowed 3 attempts at entering the correct access code before the switcher automatically disconnects. If the correct access code is entered the switcher responds with 4 short beeps and is then ready to receive commands from the user. If no keys are pressed for 30 seconds the unit will sound 3 long beeps and disconnect.

Relay Commands. Commands consist of 3 character sequences. Each command sequence must begin and end with "*" or "#". Ending with a "#" will execute the command. Ending with a "*" will abort the command. The middle character in the command sequence are the numbers "1,2,3,4 or 0".

There are only 4 commands:

1. Turn a relay on	*<1-4>#
2. Turn a relay off	#<1-4>#
3. Turn all relays off	#0#
4. Forced disconnect	*0#

A series of beeps are used to indicate various conditions to the user:

4 short beeps	Command executed OK.
2 short beeps	Command aborted
1 long beep	Invalid character entered

A "forced disconnect" command will cause 3 long beeps to be sent back to the user before the switcher hangs up. As with entering the access code, if no key is pressed for 30 seconds the unit will sound 3 long beeps and disconnect.

Additional Notes

1. The 4 bursts of ring must be received within a 30 second time period.

2. If less than 4 rings are received then the switcher will "hang" and not restart until the 30 second time period has elapsed.

3. The software defines a valid ring as having an "off" time of more than 1 second between each burst of ring. So the American single ring, and the European double ring are both seen as a single ring by the K1.

4. The number of rings to answer is set in software. Changing this value from the default 4 rings requires editing the software, re-assembling and programming another microcontroller. The "Rings to Answer" variable is set with an equate statement at the start of the code.

5. The software on the disk is provided for your information only to see how the code works. No programming of the kit is required. That has been already done.

WHAT TO DO IF IT DOES NOT WORK

1. Check that all components are in their correct place and the correct way around. Check the soldering.

2. Is the phone lineinput just using the middle two wires in a standard, single line telephone connection.

3. Is the power supply 9 - 12V DC center positive. Use a voltmeter to check the output of the 78L05.

4. Is the switcher answering the incoming phone call.

REFERENCES

On the web there are some telephone circuits at

www.cpcug.org/user/pmartin

For alot of miscellaneous telephone/modem etc info see

ftp://mirror.lcs.mit.edu/telecom-archives

The newsgroup **sci.electronics.basics** frequently discussed telephone questions.

See the following books & articles:

Understanding Telephone Electronics, by J. Fike & G. Friend, published by Sams.

DTMF Decoder, in Silicon Chip, 5/91, p30.

DTMF Decoder, in Electronics Now, 11/93, p53.

Build a DTMF Decoder/Logger, in Popular Electronics, 9/95, p37.

For information about all DIY Kits see our web page at

http://kitsrus.com

Send us email at

peter@kitsruus.com

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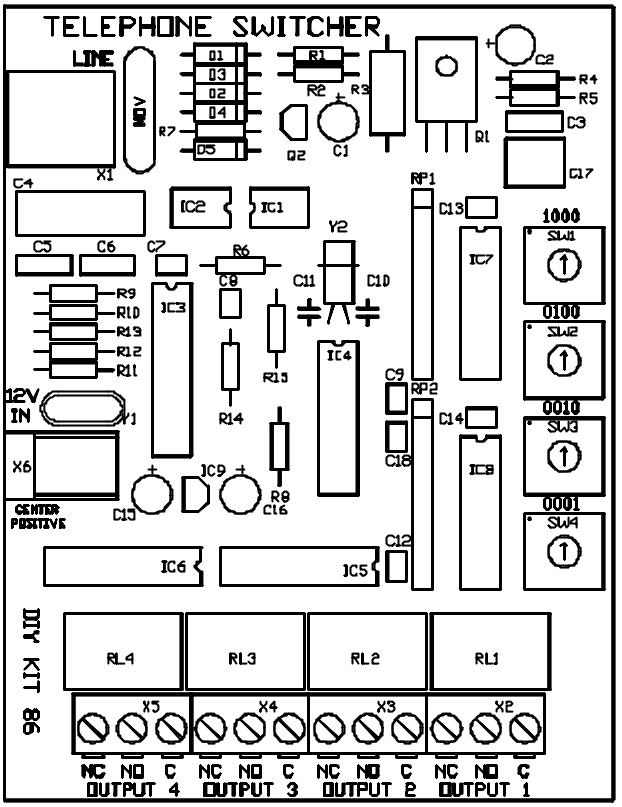
COMPONENTS

Resistors, 5%, 1/4W carbon film:		
100R	R4 brown black brown	1
820R	R5 grey red brown	1
2K2	R6 red red red	1
10K	R8 R15 brown black orange	2
22K	R7 red red orange	1
47K	R1 R2 yellow violet orange	2
56K	R11 green blue orange	1
68K	R12 blue grey orange	1
220K	R9 R10 R13 red red yellow	3
270K	R14 red violet yellow	1
Resistors, 5%, 1W carbon film:		
56R	R3 green blue black	1
Electrolytic capacitors:		
1uF 50V	C1 C16	2
4.7uF 50V	C2	1
10uF 25V	C15	1
Monobloc 100n	C7 8 9 12 13 14 18	7
Ceramic capacitors:		
27pF	C10 C11	2
Box capacitors:		
1uF 63V, 1J63	C17	1
100nF 63V. .1J63	C3	1
10nF 63V, .01J63	C5 C6	2
Dipped polyester:		
330nF 250V, .33K	C4	1
1N4004 diode	5	
10K network	RP1 RP2 2	
MJE340	Q1	1
MPSA42	Q2	1
LCA110	IC1	1
4N25	IC2	1
MT8870CE Mitel	IC3	1
68HC705K1P	IC4 1	
74HC259	IC5	1
ULN-2003A	IC6	1
74HC166	IC7, IC8	2
78L05	IC9	1
3.5795MHz crystal	Y1	1
4.096MHz crystal	Y2	1
Metal Oxide Varistor		1
BCD rotary switch		4
AZ-SH-112L mini relay		4
Rubber feet		4
3 pole terminal block		4
6 pin IC socket		2
16 pin IC socket		5
18 pin IC socket		1
Phone jack	X1	1
Power jack	X6	1
Nut & bolt set		1
Floppy disk set		1
K86 PCB		1



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