HARDWARE HACKING BY KEN GLADYSZEWSKI NORTHCOAST 99ERS

ANALOG AND THE TI COMPUTER

When we think of uses for a computer, our thoughts normally turn to word processing, spreadsheets, and data bases. Another equally important use is to monitor and control our surroundings, such as temperature. When trying to use a computer for this purpose, the problem that immediately arises is bringing this type of signal, which is ANALOG, into a computer which is DIGITAL. The method commonly used is to change the analog signal to a digital one, using an analog to digital conversion chip (ADC). Many home computers have a chip like this built into the joystick or game port for use with paddles; unfortunately, the TI does not!

My project got started when I discovered an 8 bit ADC chip made by TI; coincidentally that is both inexpensive (approx.$3.00), and requires few support parts. The TCC 5488 or TLC 549 Chip is unique because it requires only two signals to control it and has serial output. These features make it a natural to be used with the TI joystick port!

The joystick port consists of two outputs, Joy A & B and five inputs: Up, Down, Left, Right, and Fire. When the computer executes a CALL JOYST command, it energizes one of the outputs and examines the directional inputs to see if a switch in the joystick is closed, connecting that output and an input. Using these outputs to control the ADC is complicated by the fact that the Joy A&&B outputs are with respect to the computer console power supply. None of these power supply signals are available in the joystick port, although they appear in various combinations on other connectors, such as video, sound, cassette, grom, and system bus ports.

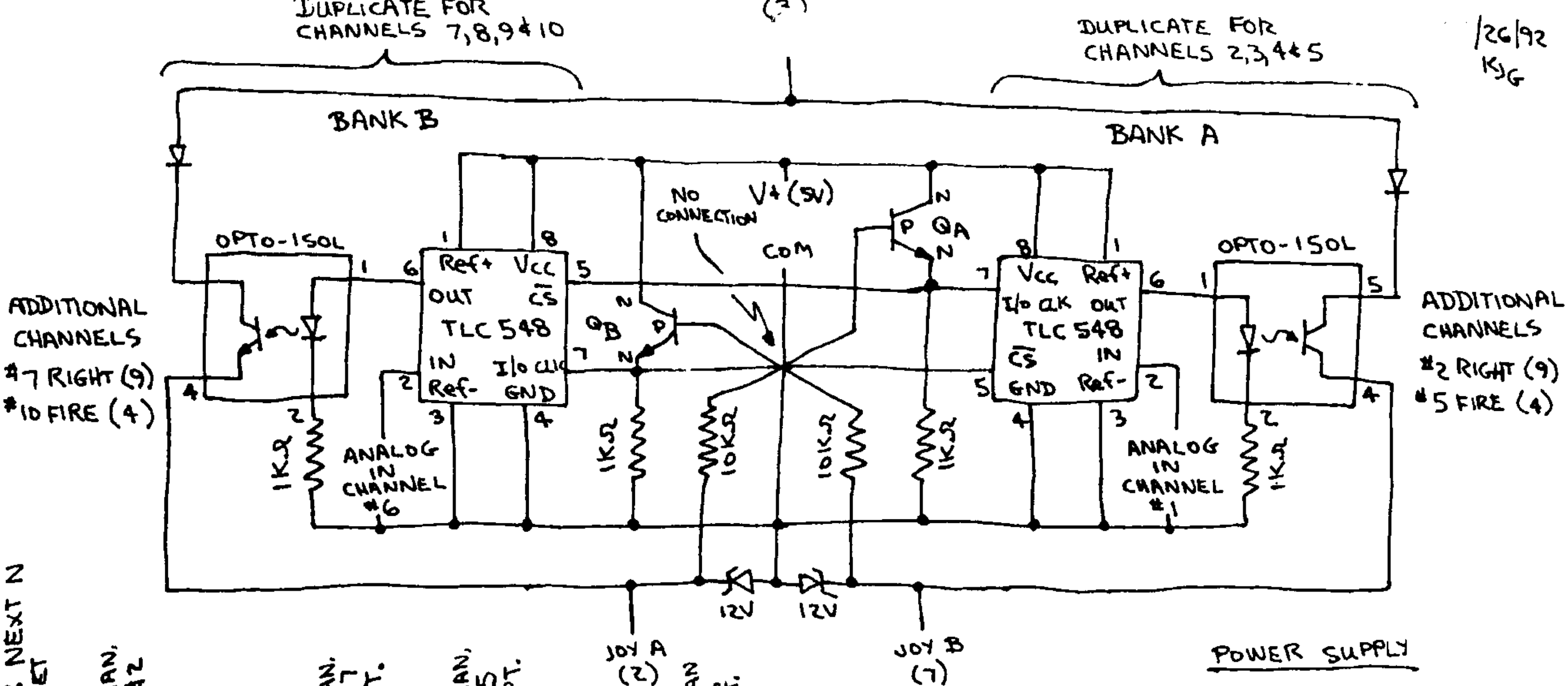
The problem is solved when it is realized that only one output is energized at a time, and the differential between these outputs can be used to generate the two control signals required for the ADC chip. Getting the computer to accept data from the chip is done by lighting an LED in an optocoupler, which causes a photo transister to turn on and act like a switch in a joystick.

The circuit (Fig.1) works as follows: With no joystick commands and hence no output signals on the Joy A & B pins - both transistors Qa and Qb are off causing both the I/O clock and chip select (CS) pins to be held low enabling the chip. When the CALL KEY statement in step 105 is executed, Joy A goes low and Joy B remains high. Transistor Qb is turned on causing the CS pin on the channel 1 chip and others in the same bank to go high resetting these chips.

When the CALL JOYST statement in step 130 is executed Joy B goes low and Joy A remains high. Transister Qa is turned on causing the I/O clock pin on the channel 1 chip and others in the same bank to go high with no effect. The most significant bit (MSB) of data from the previous analog conversion has been available and is now recognized by the computer. The input reflects the bit sense and is returned by the CALL JOYST routine. When this statement finishes, transister Qa turns off and the I/O clock pin goes low causing the next bit to appear on the Data out pin. Step 140 examines the value returned and if on, increments a variable for that channel by a weighted value corresponding to the location of the bit in the ADC Serial output byte.

The circuit shown is for channels 1 & 6, but additional ADC chips may be added easily for up to a total of 6 analog channels with no digital joystick using basic. In basic we are limited to two channels per joystick because the CALL JYST Command will only recognize a legal combination of 2 inputs at a time (up && down or left & right cannot be energized). At the same time this limitation can be overcome and the number of channels per joystick expanded to three by using a decode and an encode chip on each bank. This restriction disappears and speed is increased when assembly language is used allowing up to 10 analog channels with no digital joystick or 5 analog channels with 1 digital joystick with no need for encode and decode chips. A fellow club member is writing the assembly language routine.

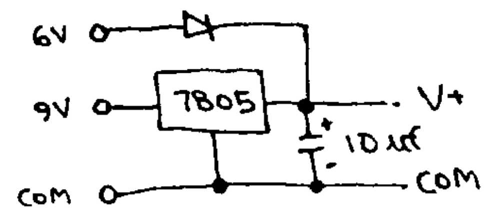
In Basic, Call Joyst examines two analog channels and CALL KEY only examines one. Therefore, to keep channel 1 update time to a minimum when more than one channel is desired, they should be implemented in both HARDWARE and SOFTWARE in the following order: 1,2,(3),6,7,(8),4,9. Channels 3 & 8 need decode and encode chips in Basic.




```
100 FOR N=Φ TO 7 :: P(N)=(2^N) :: NEXT N
105 CALL KEY (1,K,S)   REM RESET
110 A,B,C,D,E,F=Φ
120 FOR M=7 TO Φ STEP -1
130 CALL JOYST (2,W,Z)
140 IF W=4 THEN C=C+(P(M))
150 IF Z=4 THEN D=D+(P(M))
160 NEXT M
170 FOR N=7 TO Φ STEP-1
180 CALL JOYST (1,X,Y)
190 IF X=4 THEN A=A+(P(N))
200 IF Y=4 THEN B=B+(P(N))
210 NEXT N
220 FOR M=7 TO Φ STEP -1
230 CALL KEY (2,K,S)
240 IF K=18 THEN E=E+(P(M))
250 NEXT M
260 FOR N=7 TO Φ STEP-1
270 CALL KEY (1,K,S)
280 IF K=18 THEN F=F+(P(M))
290 NEXT N
300 PRINT A;B;C;D;E;F
310 GOTO 110
```

Lines 120–160: CHAN. 1&2
Lines 170–210: CHAN. 6&7 OPT.
Lines 220–250: CHAN. 5 OPT.
Lines 260–290: CHAN 6 OPT.

POWER SUPPLY



NOTE:

1. IF YOU USE 9 VOLT SUPPLY, YOU ONLY NEED 7805. IF YOU USE A 6 VOLT SUPPLY, YOU ONLY NEED DIODE. YOU DO NOT NEED BOTH.
2. RESISTORS NOT CRITICAL 1/4 WATT 20% RECOMMENDED
   1KΩ RADIO SHACK 271-1321
   10KΩ RADIO SHACK 271-1335
3. TRANSISTORS - GENERAL PURPOSE NPN SWITCHING RADIO SHACK 276-1617
4. ZENER DIODE RADIO SHACK 276-563

... SCHEME USING
DIFFERENT TYPE ADC & SHIFT REGISTER

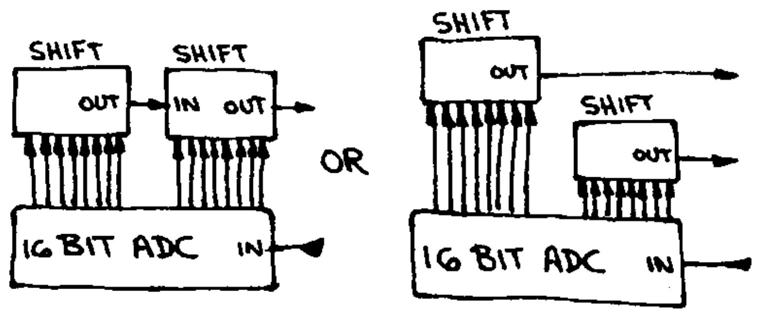
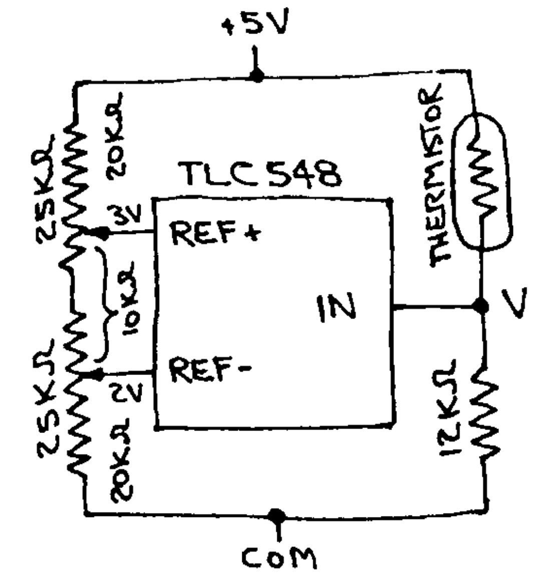


FIG 7 CIRCUIT MODIFICATIONS FOR TEMPERATURE SENSING THERMISTOR



°F	°C	R	V
86	30	8K	3.0
77	25	10K	2.75
68	20	12K	2.5
59	15	14.7K	2.25
50	10	18K	2.0

CALCULATED

$°F = (°C \times 1.8) + 32$

$V = \frac{12}{12+R} \times 5$

THERMISTOR IS RADIO SHACK # 271-110

CHANGE PROGRAM AS FOLLOWS:

```
100  FOR N=0 TO 7 :: P(N)=(2^N)*.141
     :: NEXT N   REM .141 IS CALIB FACTOR
110  A,B,C,D,E,F = 50
     REM 50 IS OFFSET VALUE
```

VALUES IN LINE 300 ARE ACTUAL TEMP

FIG 4 9 BIT RESOLUTION USING (2) 8 BIT ADC'S

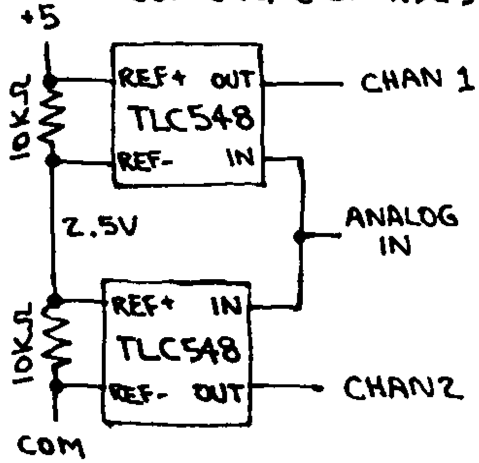


FIG 5 ALTERNATE RESETTING SCHEME

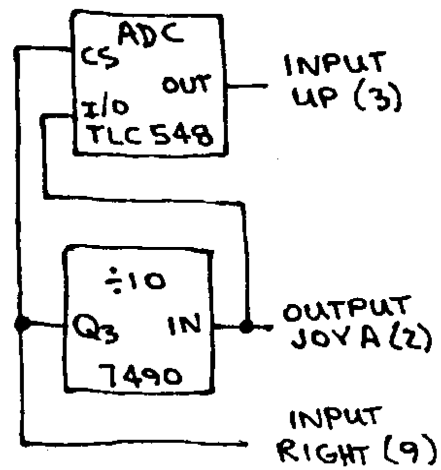
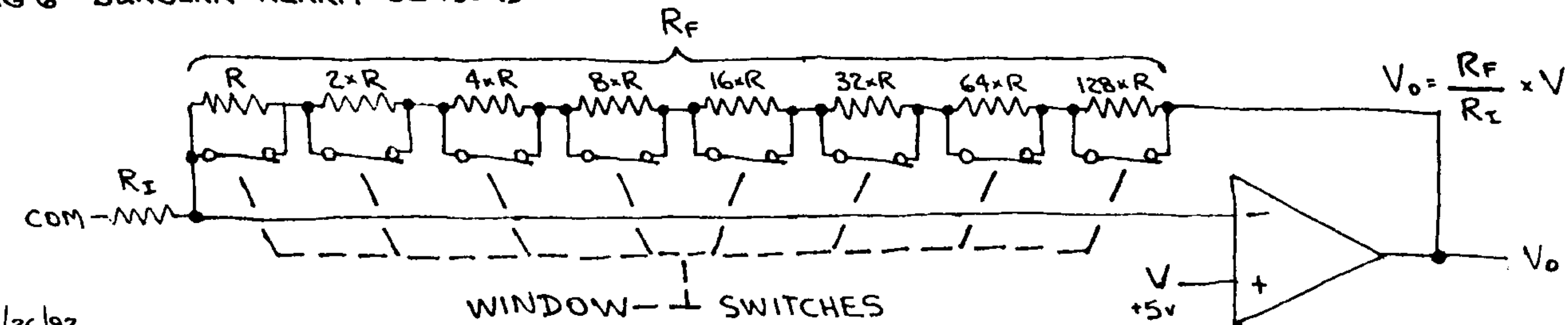


FIG 6 BURGLAR ALARM SENSORS



$V_o = \frac{R_F}{R_I} \times V$

1/26/92
KJG