PIC Microcontroller Based Solar Tracker Using Fuzzy Logic

MUDIT AGARWAL

This is a Solar Tracker Based on Fuzzy Logic. Its function to rotate the sensor in front of light to receive the maximum amount of light. This is very useful at places where solar energy is used to produce electricity.

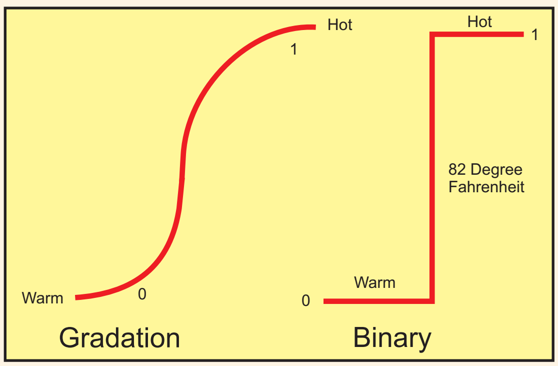

Fig.1. Temperature Changes Graph Gradual and Step

Fuzzy Logic

Let me expalin Fuzzy logic in an easier way. For example how is a warm sunny day determined to be not warm but hot instead, and by whom?. The threshold of when someone considers a warm day hot depends on the person's personal heat threshold and influence of his environment see fig.1. There is no universal thermometer that state that 81.5 degree Fahrenheit is warm and 82 degree Fahrenheit is hot. Further a person living in

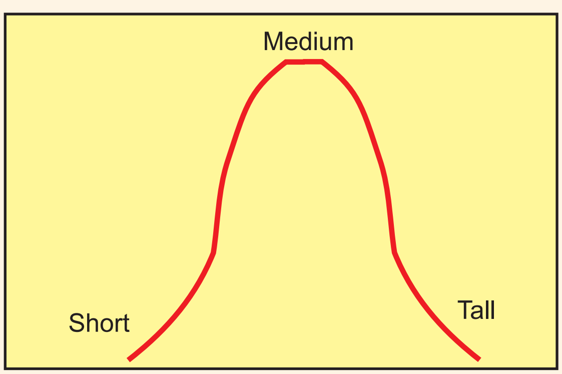

Fig.2. Gaussian Height Graph

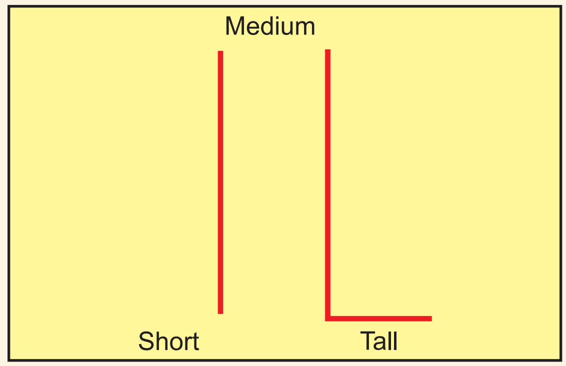

Fig.3. Binary Height Graph

Chennai has a different set of temperature values for hot days from a person living in Simla and both

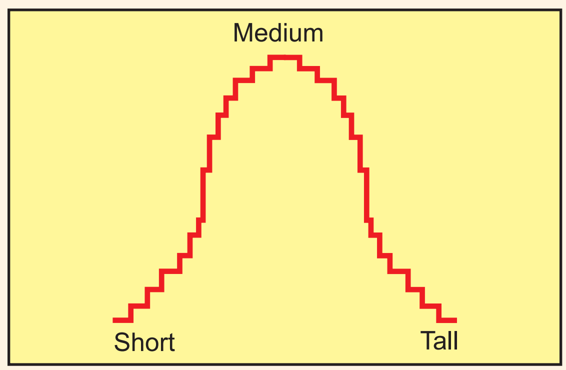

Fig.4. Digitized Height Graph

these values will be different from those who are

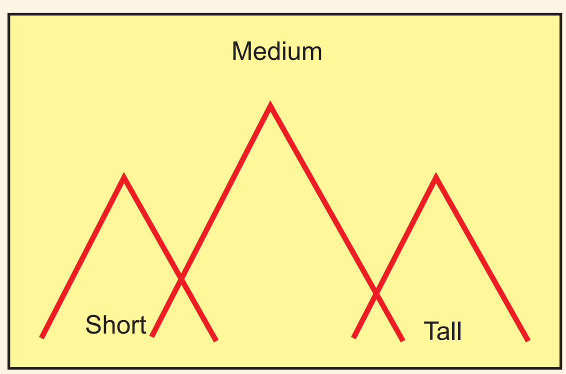

Fig.5. Fuzzy Height Graph

living in Bangalore. a hot day has different temperature scale in winter from that in summer. The same things applies to other things such as navigation, speed, height. eg if we graph the height of 5000 peoples our graph looks like of fig.2. We can use this graph of height to classify shortness, average height and tallness. If we apply a hard rule that everyone under 5'4" is short and everyone taller that 6' is tall then our graph resemble fig.3. In this condition what happens if someone have a height of 5'11" ie the perason's height is closer to the tall group.so instead of hard rules peoples use soft logic or fuzzy logic. Fuzzy logic uses groups and qualifies the membership in each group. So a person who is 5'11" tall is almost out of medium group and well into the tall group see fig. 5. Fuzzy Logic provides alternative to the digitized graph, a high resolution digitized graph is also accurate in classifying height fig. 4. To implement Fuzzy logic in PIC microcontroller we assign a numeric range to a group.
The sensor used for the tracker is cadmium sulphide photocell. Cadmium Sulphide Photocell is a light sensitive resistor. Its resistance varies in proportion to intensity of the light falling on its surface. The project uses two CdS cells. The photocell are mounted over a small piece of wood for each CdS two small holes are drilled for the wire lead to pass through. Longer wires are soldered to these wires and connected to PIC microcontroller.

Motor Driver

An H-bridge is an electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards. The term "H-bridge" is derived from the typical graphical representation of such a circuit refer fig. 6. An H-bridge is built with

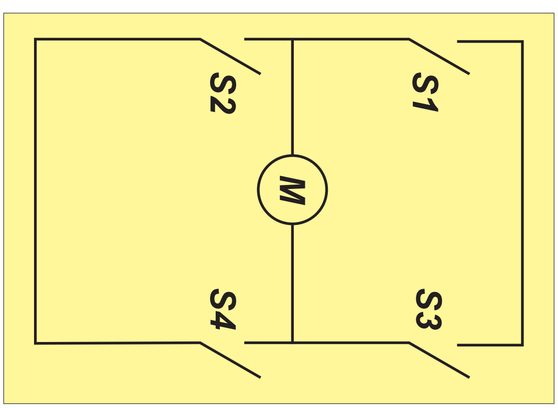

Fig. 6. Block Diagram of H-Bridge.

four switches (solid-state or mechanical). When the switches S1 and S4 (according to the below right figure) are closed (and S2 and S3 are open) a positive voltage will be applied across the motor. By opening S1 and S4 switches and closing S2 and S3 switches, this voltage is reversed, allowing reverse operation of the motor. Using the nomenclature above, the switches S1 and S2 should never be closed at the same time, as this would cause a short circuit on the input voltage source. The same applies to the switches S3 and S4. This condition is known as shoot-through. This H-bridge uses MOSFETs for one main reason - to improve the efficiency of the bridge. When BJT transistors (normal transistors) were used, they had a saturation voltage of approximately 1V across the collector emitter junction when turned on. A power supply of 10V consumes 2V across the two transistor required to control the direction of the motor. 20% of power was eaten up by the transistors. The transistors also would get quite hot. MOSFETs are used here because when they turn on they have an ON resistance called RDS(on). This is the resistance between the Drain and Source when turned on. It is quite easy to buy MOSFETs that have very low RDS(on) ratings of less than 0.1 ohm. Now, when a MOSFET has a low RDS(on) rating, it usually has quite a high current rating typically in the 10s of amps. Low RDS(on) P channel MOSFETs are more difficult to find than N channel. I had to resign myself to a higher rated P channel MOSFET. There are quite a few MOSFET manufacturers: MOTOROLA, International Rectifier, National Semiconductor to name a few. MOSFETs work by applying a voltage to the Gate. They call this transconductance. When a positive voltage greater than the Gate threshold voltage is applied, the MOSFET turns on. Circuit Diagram of Fuzzy Logic Based Solar Tracker is shown in fig. 7. Component Layout of Fuzzy Logic Based Solar Tracker is shown in fig. 8. PCB Layout of Fuzzy Logic Based Solar Tracker is shown in fig. 9.

The Software

```
list p=16f72
#include pic116f72
__CONFIG _MCLRE_OFF & _CPD_OFF
&_CP_OFF & _PWRTE_ON & _WDT_OFF &
_INTRC_OSC_NOCLKOUT & _BODEN_OFF c b l o c k
0x20count1count2count3
count4transo
buffLO_count
HI_count
count3
```

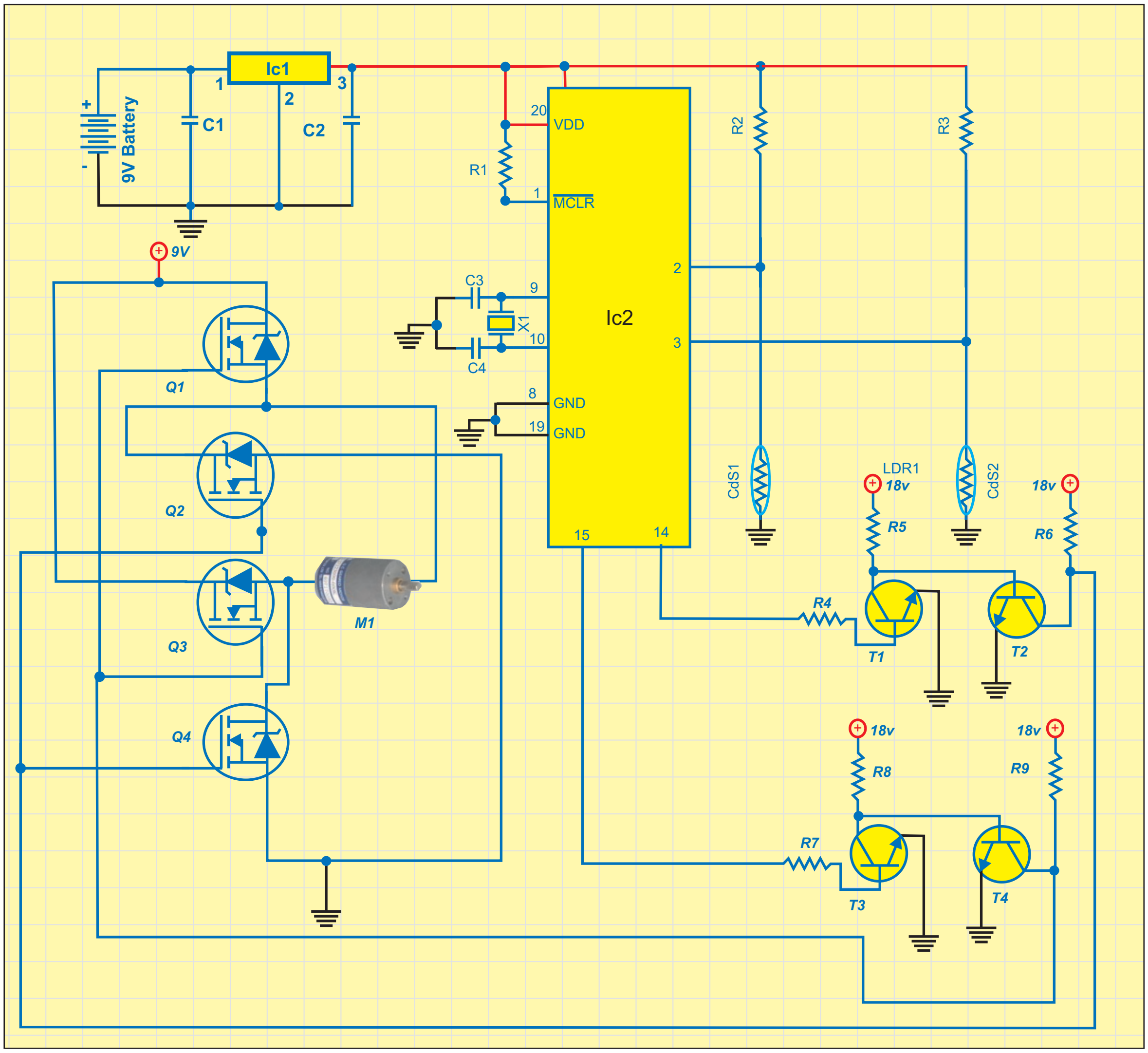

Fig. 7: Circuit Diagram of Fuzzy Logic Based Solar Tracker.

COMPONENT LIST

SEMICONDUCTOR DEVICE

Ic1	7805
Ic2	PIC16F72
T1-T4	Bc548
Q1-Q4	IRF540

CAPACITORS

C1,C2	0.1uf/25V
C3,C4	22pf

RESISTORS

R1,R2,R3	10K
R4, R7	3.3K
R5,R6,R8,R9	12K

MISCELLANEOUS

Two CdS PhotoCell
Two 9V Battery
One 18V Battery
One 9V DC Geared Motors

```
count2
count1
blank
contor
endc
#DEFINE setuPORTB.F2
#DEFINE sclkPORTB.F3
#DEFINE sdtaPORTB.F4
org0x00
goto init
org0x04
initbcfSTATUS,RP0
clrfGPIO
movlw0x07 movwfCMCONbcfINTCON,GIE       b  s  f
STATUS,RP0
call0x3FF
movwfOSCCALmovlw0xF8
movwfTRISIO
bcfSTATUS,RP0
movlw0x01
movwfcontor callled_ini
```

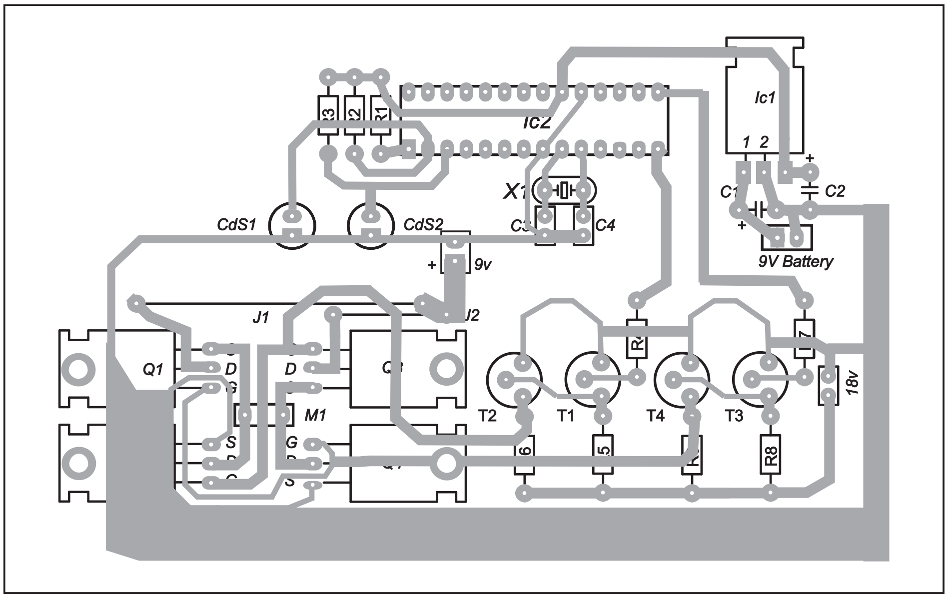

Fig.8 : Component Layout of Fuzzy Logic Based Solar Tracker.

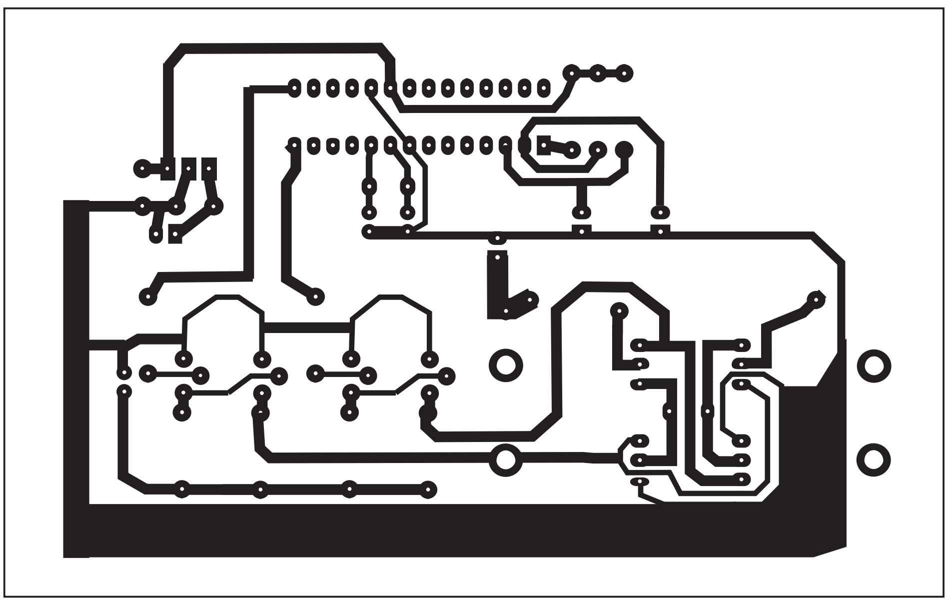

Fig.9 : PCB Layout of Fuzzy Logic Based Solar Tracker.

```
                    loop
calliict
movlw0x74
callact
movlw0x40callact
movlw0xD2
callact
movlw0xD0callact
movlw0xCD
callact
movlw0xBA
callact
calliicp
callpause
```

```
callset_timer
movfcontor,W
callhalta
bcfT1CON,0

conversie
movfTMR1L,W
movwfLO_countm o v f
TMR1H,Wm  o  v  w  f
HI_count
bcfblank,0movlw0x27
movwfcount3m o v l w
0x10 movwfcount2call
convbmovlw0  x  0  3
movwfcount3m o v l w
0xE8movwfcount2c a l l
convb
clrfcount3
movlw0x64m  o  v  w  f
count2callconvb

clrfcount3movlw0 x 0 A
movwfcount2callconvb

clrfcount3movlw0 x 0 1
movwfcount2
bsfblank,0callconvb
callled_home
btfsssetu
calltimp
homagotoloop
convb
clrfcount1conv_high
movfcount3,W
subwfHI_count,W
btfssSTATUS,Cg  o  t  o
conv_endb  t  f  s  s
STATUS,Zg   o   t   o
conv_lowm   o   v   f
count2,Ws  u  b  w  f
LO_count,Wb  t  f  s  s
STATUS,Cg   o   t   o
conv_endc o n v _ l o w
movfcount3,W
subwfHI_count,Fm o v f
count2,W
subwfLO_count,FbtfssSTATUS,CdecfHI_count,Fi  n  c  f
count1,Fbsfblank,0gotoconv_high
conv_end
movlw0xB0
addwfcount1,W
btfssblank,0movlw0xA0movwfbuff
callpush_led
return
led_home
calliict
movlw0x74
callact
movlw0x80
callact
```

```
movlw0x02
callact
calliicp
return
push_led
calliict
movlw0x74
callact
movlw0x40callact
movfbuff,W
callact
calliicp
return
set_timer
clrfT1CON
clrfTMR1L
clrfTMR1H
clrfINTCON
bsfSTATUS,RP0
clrfPIE1
bcfSTATUS,RP0
clrfPIR1
movlw0x03
movwfT1CON
return
led_inicalliictmovlw0x74callactmovlw0x00callact
movlw0x01
callact
movlw0x21
callact
movlw0xA0 callact
movlw0x07 callact
movlw0x24 callact
movlw0x0F
callact
movlw0x06
callact
calliict
movlw0x74
callact
movlw0x80
callact
movlw0x40callact
movlw0x40callact
movlw0x00
callact
movlw0x00  callact
movlw0x00
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callact
movlw0x00
callact
movlw0x00
callact
movlw0x00
callact
movlw0x00
callact
calliicpcalliict
movlw0x74
callact
movlw0x00
callact
movlw0x30
callact
movlw0x01callact
movlw0x0Ccallact
calliicp
return
actmovwftransomovlw0x08
movwf count3
vbitbcfsclk
callpause
btfsc transo,7bsfsdta
btfss transo,7
bcfsdta
callpause
bsfsclk
call pause
bcfsclk
call pause
rlftranso,f
decfsz count3,f
gotovbit
callackp
return
iicpbcfsdtacallpause
bsfsclk
callpause
```

```
bsfsdta
callpause
bcfsclk
callpause
return
iictbsfsdta
bsfsclk
callpause
bcfsdtacallpause
bcfsclk
callpause
return
ackpbsfsclkcallpause
bcfsclk
callpause
return
timpcalliict
movlw0x74
callact
movlw0x40callact
movlw0xC2callact
movlw0xE1
callact
movlw0xFA
callact
movlw0xE1callact
movlw0xBAcallact
movlw0xB0
addwfcontor,Wcallact
movlw0xF3
callact
calliicp
callhaltb
btfscsetu
gototset
tset1movlw0x01
subwfcontor,W
btfssSTATUS,Z
gototset6
movlw0x06
movwfcontor
calliict
movlw0x74
callact
movlw0x80
callact
movlw0x1C
callact
movlw0x1C
callact
calliicp
callpause
calliict
movlw0x74
callact
movlw0x40callact
movlw0xB0
addwfcontor,Wcallact
calliicp
gototset
tset6
movlw0x01
movwfcontor
calliict
movlw0x74
callact
movlw0x80
callact
movlw0x10
callact
calliicp
callpause
calliict
movlw0x74
callact
movlw0x40callact
movlw0xB0
addwfcontor,Wcallact
calliicp
tsetcallhaltb
btfsssetu
gototset1
callhaltb
btfsssetu
gototset1
callhaltb
btfsssetu
gototset1
return
Pause
movlw0x10
movwfcount2
d2decfszcount2,F
goto d2
return
haltbmovlw0xFA
movwfcount1
j1movlw0xFA
movwfcount2
j2nop
decfszcount2,F
goto j2decfszcount1,F
goto j1
return
Halta
movwfcount4
r4movlw0x04
movwfcount3
r3movlw0xFA
movwfcount1
r1movlw0xFA
movwfcount2
r2nop
decfszcount2,Fgoto r2decfszcount1,F
goto r1decfszcount3,F
goto  r3
decfszcount4,F
goto  r4
return
End
```