“Montreal Doppler I” - by Jacques, VE2EMM

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- **The pictures and diagrams referenced by some of the embedded links in this document may be found at the end of this document.**
- **ONLY THE TEXTof the user's comments were found in the archive and NOT the pictures.** *(Note that the W1EMT and IK4CIE comments consisted only of pictures and are not included – sorry.)*

The Montreal Doppler

FEATURES :

- PIC16C72 controlled
- 32 LEDs display
- Reduced component count, only 4 ICs
- On demand, the antenna switching can be made to +5 volt or to 0 volt
- It will drive the KA4IIA Antenna Switcher, K0OV new wide band Antenna Switcher or the original ROANOKE switcher with resistors added.
- Fine filtering. Bandpass is less than 2Hz
- The display is automatically slow flash to the last good LED when the radio receiver goes squelched
- Overload indication by the processor, the 180 degree lamp fast flash on overload. Modulation does not blink the lamp
- Rock solid software, and it works fine...
- Antenna plan at http://members.aol.com/homingin/newdopant.html on the Homingin web site

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  This version uses the ROANOKE digital filter, a MAX294CPA as a very sharp low pass and a band pass filter. Buy the MAX 294CPA or the MAX293CPA and the MAX 494CPD directly from the Maxim web site.
  All the digital functions are taken care by the PIC, it also does some averaging of the returned signal.

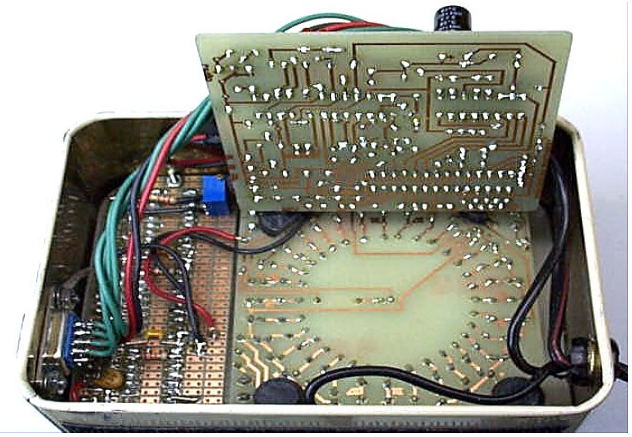
  Users comments and suggestions.
  From Ian, G8PWE
  From Mike, K5ATM
  From Jay, W1EMT Pictures
  From Victor ik4cie Picture

  Download the source program and the Hex file here for ham operators only .

  Instruction text for the construction and operation of VE2EMM 32 LED DOPPLER.
  Schematic diagram V3.07.
  Parts list.
  A note from MAXIM tech support about the MAX294. My experience with the MAX294 indicates that about 1 in 10 is defective.

  Component location
  Components location and PCB

  PCB in gif format 2X
  PRINTED CIRCUIT board drawing in PROTEL EASYTRAX for DOS format.
  A set of PCBs is available from FAR CIRCUITS.



Fine print:
All material on this page is distributed on a WYSIWYG basis and as such I can't take any responsibility for the use of this design and its results. However in saying this it must also be mentioned that every effort has been taken to ensure that it as error free as possible.

BACK TO HOME PAGE INDEX
Many thanks to Al Waller K3TKJ for graciously hosting my web pages on QSL.NET.

July 16th, 1999

Documentation for VE2EMM 32 LED MONTREAL DOPPLER

1- OPERATING INSTRUCTIONS

While receiving an unmodulated signal, turn up the volume until the 180 degree lamp flashes,then reduce the volume until the 180 degree lamp goes off. The volume is now set. The display will then indicate the direction of the fox.

When the radio receiver goes squelched, the display will slow flash the LED of the last good direction indication.

Calibrate the direction to a known fox by turning the CAL pot, then pressing the reset button will load the new calibration and change the displayed direction.

2- CIRCUIT DESCRIPTION

The signal from the RX goes through a HighPass filter composed of a .01uF cap and a 51k~ resistor, the 10R pot can be replaced by a 10R fixed resistor and the internal speaker can be connected across it through a switch. The signal is then amplified 20 times by the free amp of the MAX294. Output pin 3 from the free amp of the MAX294 goes to amp "A" of the MAX494 rail to rail amplifiers, configured as a 500 Hz bandpass filter. The 1500~ resistor below the BandPass can be adjusted to change the BP frequency. The signal from pin 1 of the MAX494 goes to the input of the MAX294 filter, its knee frequency is determined by the capacitors on pin 1.

The output of the MAX294 goes through a 1M0 damping resistor to the switch filter a 74HC4051, do not substitute this chip as it is better than the ordinary 4051. An additional 1M0 resistor could be switched in parallel to the damping resistor for faster response.

The MAX494 amp "B" is just a buffer with a high impedance input. It is followed by a LowPass filter "C" to restore a nice sine wave. Amp "D" is a comparator used to generate a square wave of the signal, the comparison point is the middle voltage of the signal generated by the 62k~ resistor ant the .47 uF cap at pin 13 of amp "D".

The whole analogue circuit operation is centred around 2.5 volts generated by the voltage divider of the two 2.2k~ resistors, 47 uF and .1uF caps.

A DC voltage proportional to the peak of the filtered input signal is generated by a 1N4148 diode and associated filters, this signal is called SIGLVL. This signal is maximum when there is no modulation.

The PIC16C72 inputs two analogue signals, a calibration voltage at pin 2 (install a second 10k pot and a SPDT switch to provide the doppler with the calibration for two radios), and the input signal level at pin 3. It also generates the capacitors filter switching signals pins 4, 5 and 6, the antennas switching signals at pins 11, 12, 13 and 14, the + commons for the display at pins 15, 16, 17 and 18 and the 0 volt to the cathodes of the LEDs at pins 21 to 28.

3- SOFTWARE DESCRIPTION

The software first check the CAL pot to set the proper direction, then measure the amplitude of the input signal to set flags signalling overload and squelched conditions.

Prescaler and counter TMR0 generate an interrupt at a rate of 16 kHz. 500 turn per second times 32 counts = 16000 Hz.

The interrupt loop switches the signals to the 500 Hz digital filter, changes the antennas, detect the phase of the incoming signal, averages the last 2 returns, set in the calibration, activates the display and advances the 32 count counter.

4- ANTENNAS

The switching signals are from +5 volt to 0 volt. Request modified software for opposite signals.

It will drive directly the Jim Sorenson KA4IIA switcher with MAR-4 preamps. I changed the coupling capacitors to a value of 100 pF, 2 of them are used in parallel at each coupling point. I also changed the chokes to 5 turns around 2 ferrite beads for VHF-UHF use.

It will also drive Joe Moell K0OV new wide band switcher, do not forget that the ground plane must be at +3.7 volt instead of 0 volt.

And It will drive the original ROANOKE antenna switcher with 680R resistors added in series with the switching lines.

5- CONSTRUCTION HINTS AND SUGGESTIONS

To eleminate Microprocessor noise, mount the doppler in a metal box.

Make the 180 degree light a different color to indicate signal overload.

On the display board, with insulated jumper wire, connect the 4 "D1" points together with the "D1" input wire. Do the same with "D2", "D3" etc.

Use a One Time Programming 20mHz PIC device for reduced cost. (no upgrade then possible)

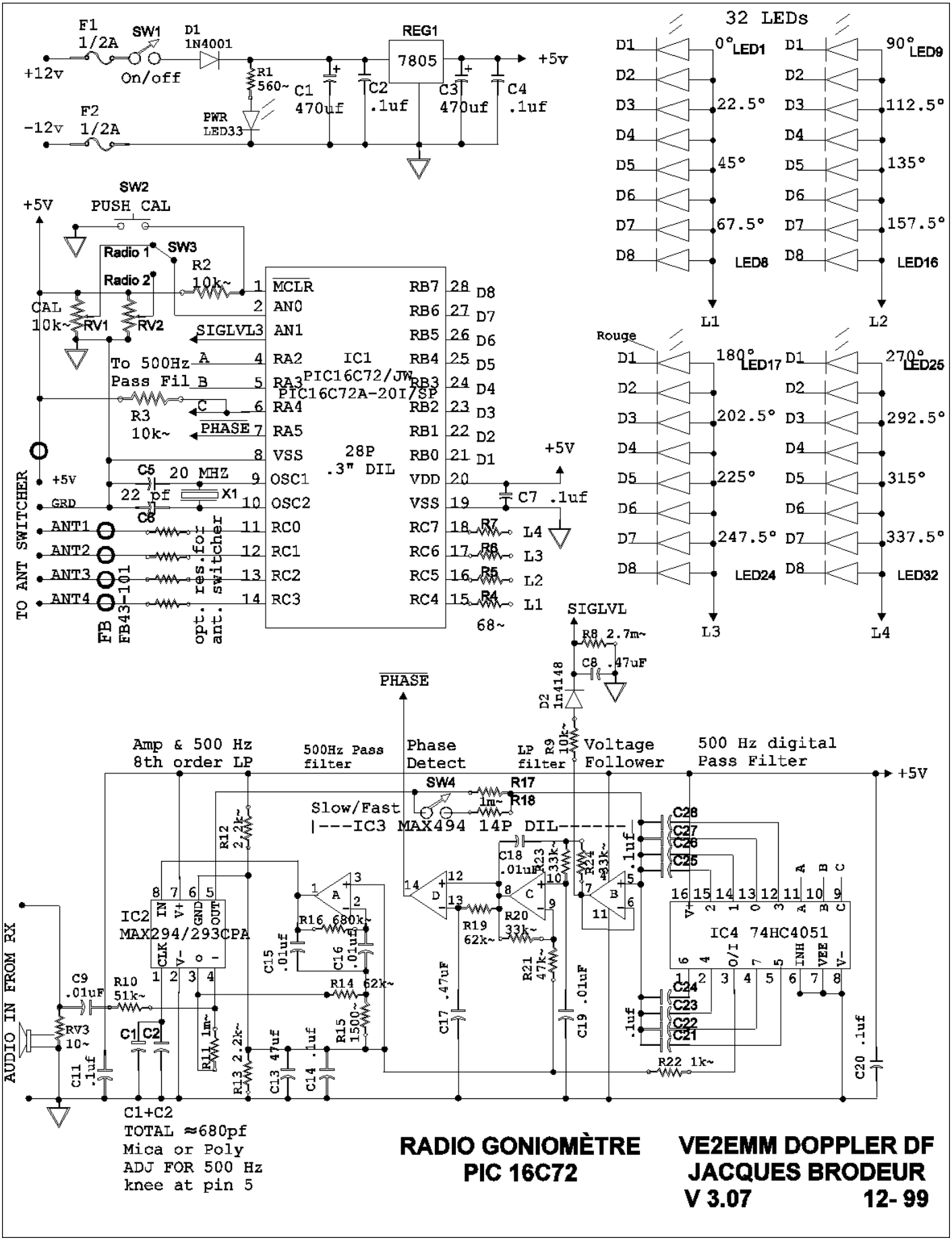
On the WEB, ask for free samples from MAXIM for the MAX devices.

Use the brigthest possible diffused red LEDs for maximum visibility and viewing angle.

Please put my call Letters on the front panel, its my only reward.

GOOD LUCK, Let me know how you are doing and if you like its performance by sending me a QSL card with your comments.

Jacques Brodeur VE2EMM
5034 Joseph-A-Rodier
Montreal, Qc
Canada H1K 5E1


F1
1/2A
SW1
D1
1N4001
+12v
On/off
R1
560~
C1
470uf
REG1
7805
C2
.1uf
C3
470uf
C4
.1uf
+5v
F2
-12v
1/2A
PWR
LED33
32 LEDs
D1
D2
D3
D4
D5
D6
D7
D8
0°
LED1
22.5°
45°
67.5°
LED8
90°
LED9
112.5°
135°
157.5°
LED16
L1
L2
SW2
PUSH CAL
+5V
Radio 1
SW3
Radio 2
R2
10k~
CAL
10k~
RV1
RV2
SIGLVL3
To 500Hz
Pass Fil
R3
10k~
PHASE
IC1
PIC16C72/JW
PIC16C72A-20I/SP
28P
.3" DIL
MCLR
AN0
AN1
RA2
RA3
RA4
RA5
VSS
OSC1
OSC2
RC0
RC1
RC2
RC3
RB7
RB6
RB5
RB4
RB3
RB2
RB1
RB0
VDD
VSS
C5
20 MHZ
22 pf
X1
C6
C7 .1uf
R7
R6
R5
R4
L4
L3
L2
L1
68~
Rouge
180°
LED17
202.5°
225°
247.5°
LED24
270°
LED25
292.5°
315°
337.5°
LED32
L3
L4
TO ANT SWITCHER
ANT1
ANT2
ANT3
ANT4
FB
FB43-101
opt. res.for ant. switcher
SIGLVL
R8 2.7m~
C8 .47uF
D2
1n4148
R9
10k~
PHASE
Amp & 500 Hz
8th order LP
500Hz Pass
filter
Phase
Detect
LP
filter
Voltage
Follower
500 Hz digital
Pass Filter
SW4
R17
1m~
R18
Slow/Fast
|---IC3 MAX494 14P DIL-----|
IC2
MAX294/293CPA
CLK
IN
V+
GND
OUT
V-
R12
2.2k~
R16 680k~
C15
.01uF
C16
.01uF
R14 62k~
R15
1500~
C17 .47uF
C18
.01uF
R23
33k~
R24
33k~
R19
62k~
R20
33k~
R21
47k~
C19 .01uF
C28
C27
C26
C25
C24
C23
C22
C21
.1uf
IC4 74HC4051
O/I
INH
VEE
V-
R22 1k~
C20 .1uf
AUDIO IN FROM RX
C9
.01uF
R10
51k~
RV3
10~
C11
.1uf
C1
C2
R11
1m~
R13
2.2k~
C13
47uF
C14
.1uf
C1+C2
TOTAL ≈680pf
Mica or Poly
ADJ FOR 500 Hz
knee at pin 5
RADIO GONIOMÈTRE
PIC 16C72
VE2EMM DOPPLER DF
JACQUES BRODEUR
V 3.07
12- 99

Liste des pieces pour le Goniometre Montreal
Montreal DOPPLER parts list V3.06 Dec 99

Sections alimentation & numerique - Power & digital sections

C1,3 = 470 uF 25 V electrolytic axial leads
C2,4,7 = .1 uF ceramic
C5,6 = 22 pF ceramic
D1 = Any rectifier diode ex.: 1N4001 - 1N4007
F1,2 = 3AG 1/2 Amp fuse
IC1 = Windowed PIC16C72/JW DIGI-KEY
  or PIC16C72-20I/SP No upgrade then possible DIGI-KEY
LED 1 = Green diffused high brithness LED
LED 2-16,LED 18-32 = Red diffused high brithness LED
LED 17 = Green diffused high brithness LED
LED 33 = Red or green diffused high brithness LED
R1 = 560 Ohms 1/4 Watt
R2,3 = 10 kOhms 1/4 Watt
R4,5,6,7 = 68 Ohms 1/4 Watt
REG1 = 7805 5 V regulator TO-220 DIGI-KEY
RV1,2 = 10 kOhms 1/4 Watt variable DK pn. D4AA14-ND
SW1 = Miniature toggle SPST
SW2 = N.O. miniature push button
SW3 = Miniature toggle SPDT
X1 = 20mHz microprocessor Xtal DIGI-KEY

Section traitement audio - Audio processing section

C8 = .47 uF ceramic
C9,15,16 ,18,19 = .01 uF ceramic
C11,14,20,21,22,23,24,25,26,27,28, = .1 uF ceramic
C12 = TOTAL of 2 capacitors = 680 pF MICA OU POLY. trimm for 500 Hz
C13 = 47 uF electrolytic 10 V axial leads
C17 = .47uF ceramic
D2 = 1N4148
IC2 = MAX294CPA Low pass filter MAXIM free sample or Web purchase
IC3 = MAX494CPD quad rail to rail OP amp DIGI-KEY or MAXIM
IC4 = 74HC4051 do not substitute
R8 = 2.7 mOhms 1/4 Watt
R9 = 10 kOhms 1/4 Watt
R10 = 51 kOhms 1/4 Watt
R11,17,18 = 1 mOhms 1/4 Watt
R12,13 = 2.2 kOhms 1/4 Watt
R14,19 = 62 kOhms 1/4 Watt
R15 = 1.5 kOhms 1/4 Watt
R16 = 680 kOhms 1/4 Watt
R20,23,24 = 33 kOhms 1/4 Watt
R21 = 47 kOhms 1/4 watt
R22 = 1 kOhms 1/4 Watt
RV3 = 10 Ohms 1 Watt variable or 10 Ohms fixed resistor
SW4 = Miniature toggle SPST

Divers : - Misc. :

Box, connectors, wire, PC boards etc...

January 19, 2000

Mr. Brodeur,

Digikey distributes only a small handful of our many products.

The MAX293/MAX294 should still be available through the free samples request page, and through "Maxim Distribution" as well. From Canada you can call:

Canada Maxim Distribution 888-MAXIM-IC

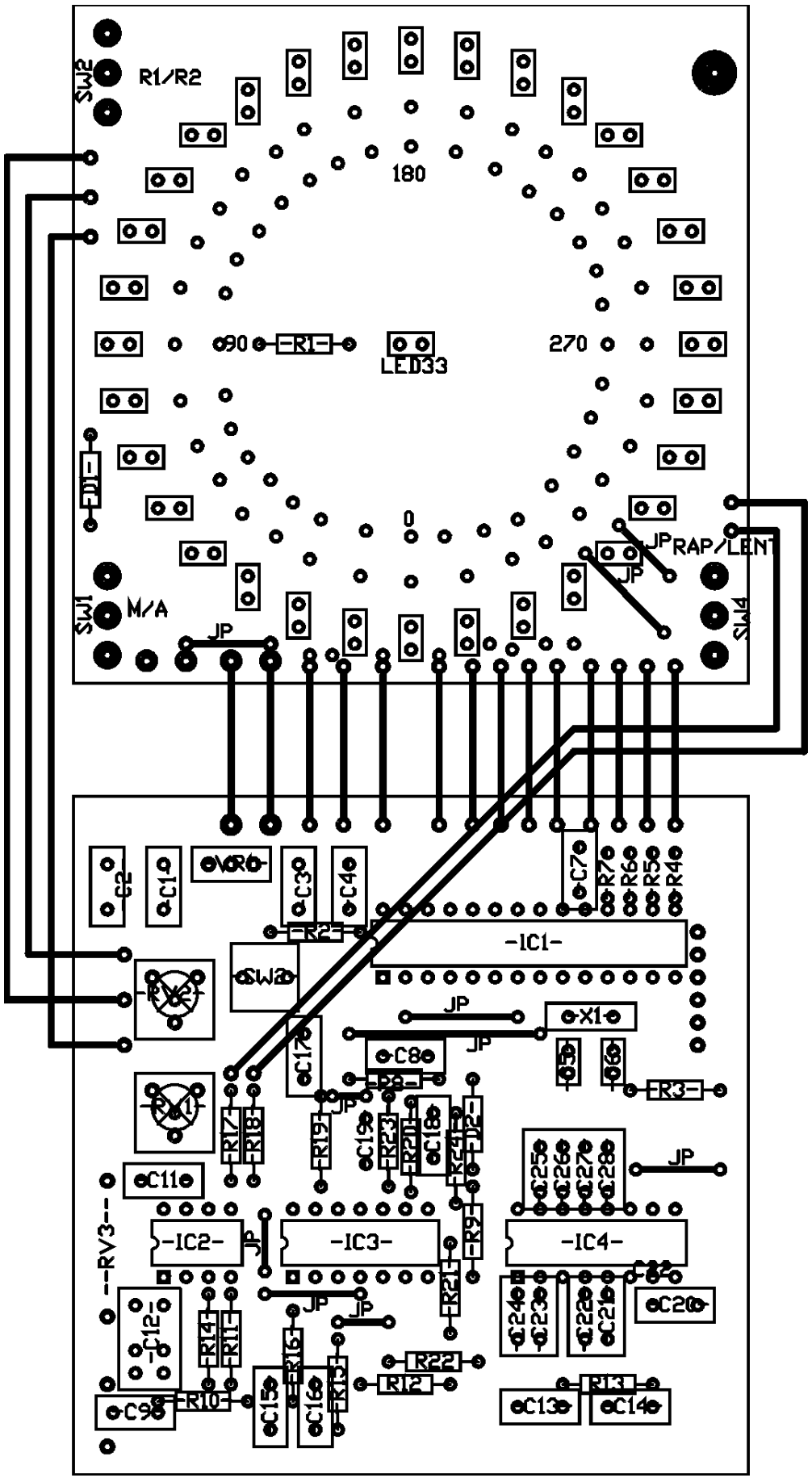
There is one technical issue with the current parts. There has been a redesign which should be tested this engineering quarter. The current parts have occasional internal oscillator problems. If you're using an external oscillator, the problem is not an issue. However, if using the internal oscillator, the oscillator may operate intermittantly, stall, then restart, etc. There is a "waiver" form which states that operation with internal oscillator is not guaranteed.

Many customers use an external oscillator for more accurate corner frequencies, and those customers are unaffected by the problem.

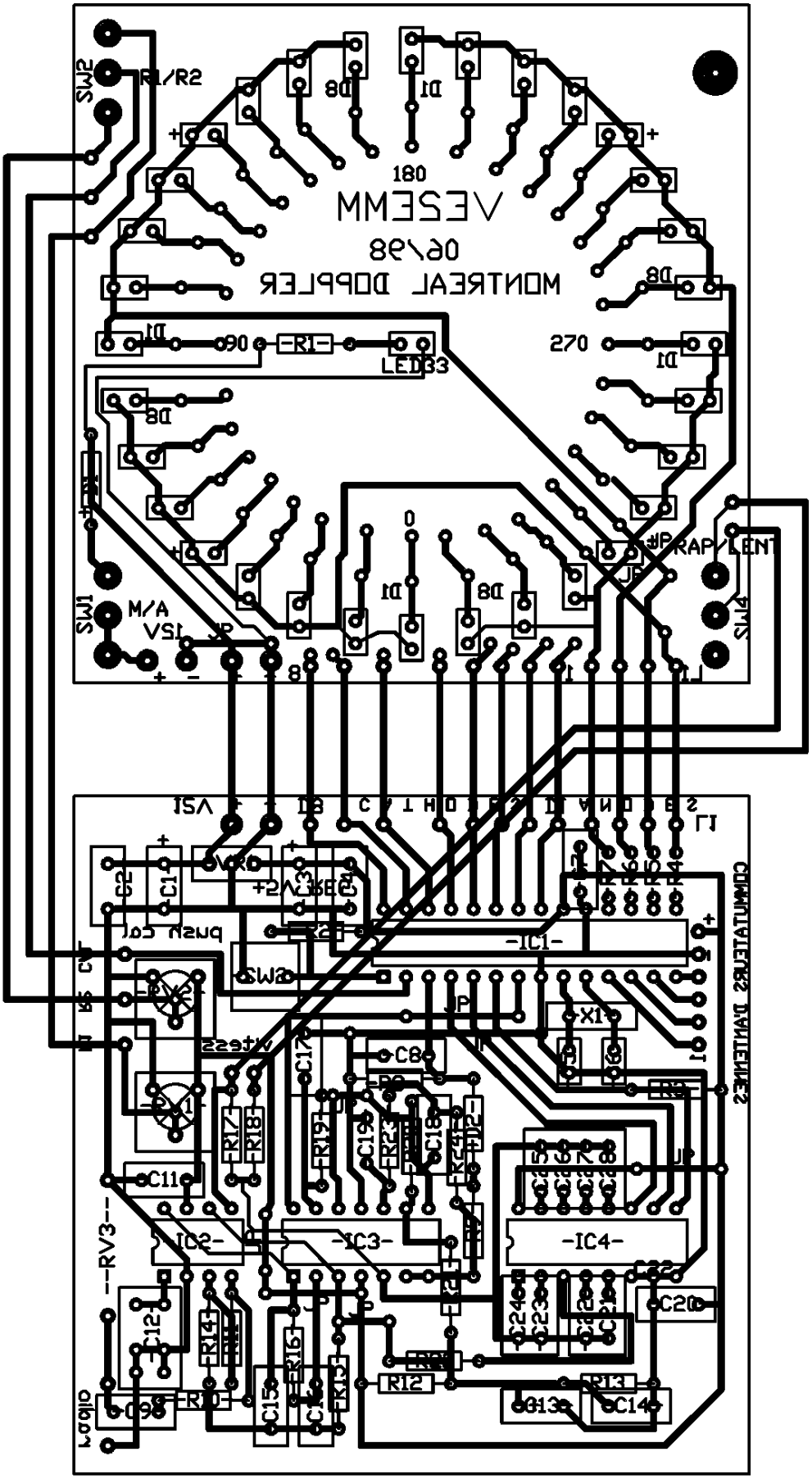
Best Regards,

AppsTechsupport
Maxim Applications Engineering
MH012000-104

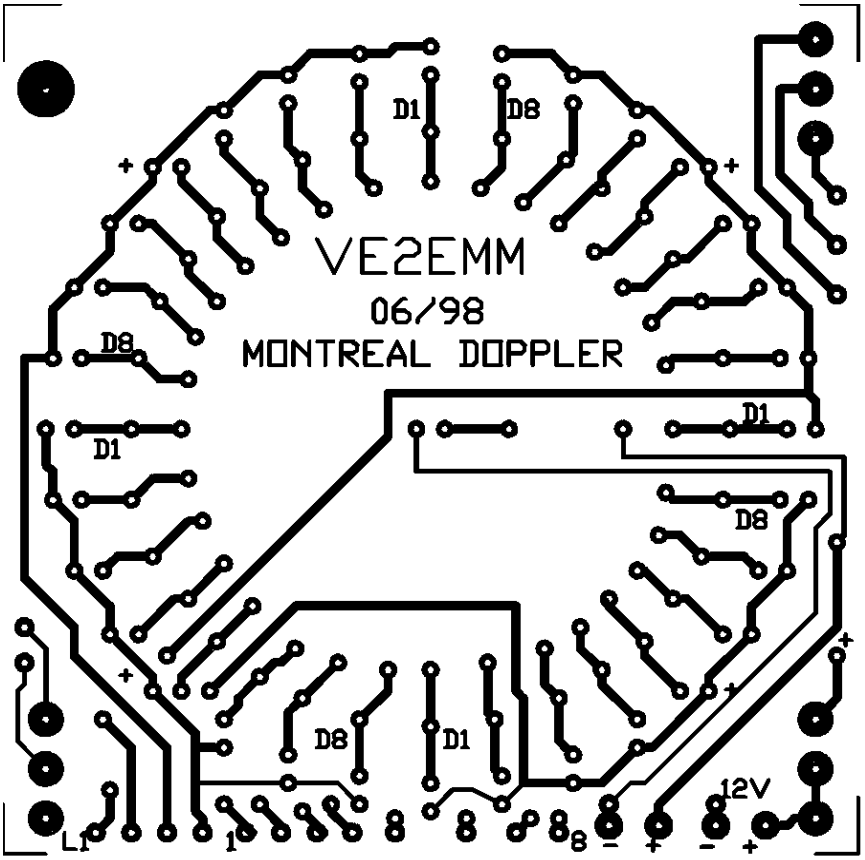
p.s. other dist.
US/Canada Distributors
Name Phone
Maxim Distribution 888-MAXIM-IC
Arrow Electronics 800-777-2776
CAM RPC 412-963-6202
Digi-Key Corp. 800-344-4539
Elmo Semiconductor 818-768-7400
Avnet Electronics Marketing 800-332-8638
Nu Horizons 516-396-5000

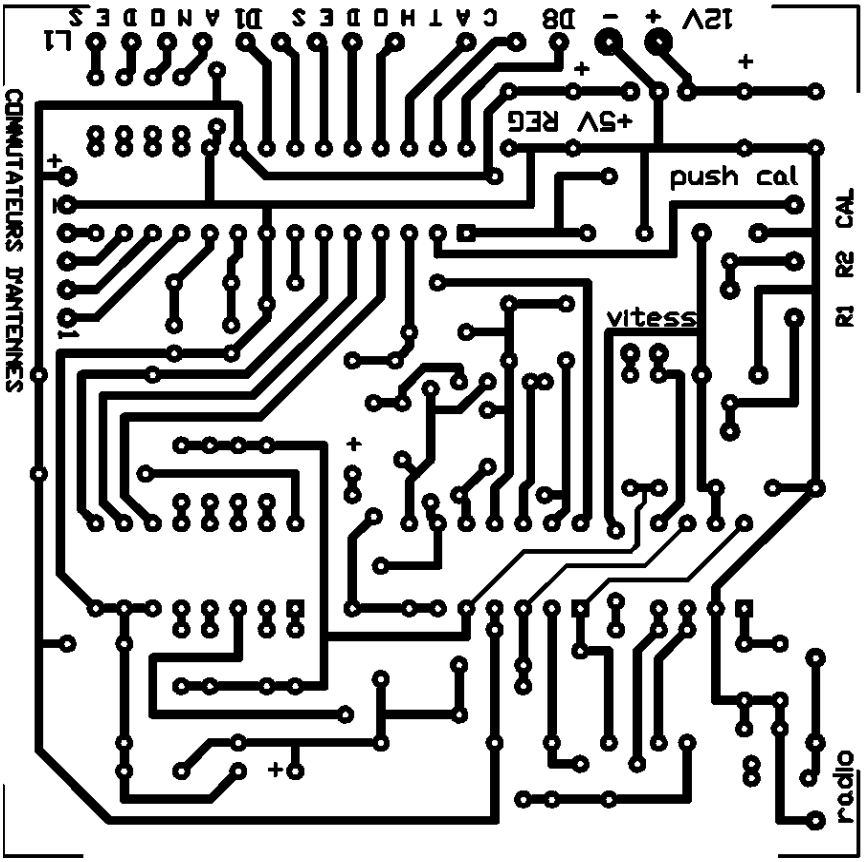


Component Location



Components Location and PCB


VE2EMM
06/98
MONTREAL DOPPLER
D1
D8
12V
L1


L1
DIANODES
CATHODES
D8
12V
+5V REG
push cal
CAL
R2
R1
vitess
radio
COMMUTATEURS D'ANTENNES
3 1/16"
3"

User Comments and Suggestions:

From Ian, G8PWE:

Thu, 02 Sep 1999 00:07:08 +0100
From:
Ian Ashford <ian.ashford@dtn.ntl.com>
Cher Jacques,
Today I tested your design of DF unit .
I was very Impressed with the performance ESPECIALLY the averaging work of the PIC controller.
I have sent you some photos of my build for you to publish if you want.
Notes:
1)The unit is built in double sided PCB (painted green)
2)I had to decouple PIC noise from antenna array switching wires with 47uh series choke.
3)Antenna array is Roanoke wideband with switchbox magnetic mount on roof -very pleased with its performance compared with earlier designs.
4)Roanoke antenna - the 5v-3v dropper is a green LED in the switchbox which checks DC operation of system.
5) I will put your callsign on the top panel now work is finished.
6)Next stage is to interface to APRS using N7lLUE unit.

a bientot
Ian G8PWE

From Mike, K5ATM:

Hello all
I just completed the construction of my Montreal Doppler / wide band antenna array and thought I would pass on my comments and suggestions. In particular I had a great deal of trouble with calibration stability. See below for details. You will also see in the pictures I have not labeled the unit yet. I am still waiting for my white dry transfer letters to arrive.

Construction

I ordered the 3 board plus PIC chip set from Far Circuits. This set includes a display board, a controller board and a wide range antenna switcher board (see Joe Moell's web site (http://members.aol.com/homingin/newdopant.html).This made construction very straight forward. The only surprises were:

- Some holes on the PC boards were not drilled
- The controller board is not designed to supply the 3.7 volt "ground" needed by the wide range antenna switcher. I used an LED / resistor combo to generate the required "ground".
- The display board needs a large number of jumpers. I used wire-wrap techniques for this step.

Here is a picture of the inside of my unit. The box is from Radio Shack (270-274, $12.99). Note the amp attached to upper corner of the speaker. This provides the ability to control the amplitude of the audio without effecting the signal level presented to the Doppler electronics. The amp was obtained from Radio Shack in kit form (RSU 12126918, $12.99) and can produce up to 7W of power. The metal frame of the speaker serves as a heat sink for the amp chip.

Here is a picture of the outside of my unit. The controls along the bottom (from left to right) are:

Power
Audio volume
Fast/Slow
Radio 1 / Radio 2
Audio select (see below)

The VU meter is connected to the output of the synchronous detector (pin 7 of IC3) through a 10uF capacitor. This provides a way to monitor the signal level that is presented to the PIC chip. The 10uF capacitor gives just enough coupling to cause the overload LED to flash just as the needle enters the red area of the meter.

The LED above the VU meter is the LED used to generate the 3.7 volt "ground".

The "audio select " switch selects what signal is sent to the 7 watt audio amp. In one position the audio from the radio is selected. This gives the user the ability to monitor the raw signal from the radio. In the other position, the output from the synchronous detector is sent to the amplifier. This gives the user the ability to monitor the pure 500Hz Doppler tone.

Friction of the LEDs against the holes drilled in box is all that holds the display board / electronics board in place.

Here is a drawing of the modifications I made to the base design.

Antenna

I did not use a solid piece of copper for the base of the antenna array. I placed a 4" by 4" piece of copper in each corner of the wooden base and connected copper clad steel welding rods to the pads. This was much cheaper and seems to give good results.

I wound my own coils for the antenna switcher board. Each coil consisted of 24 turns of #26 magnet wire on a 3/16 inch drill. I did not have any Q-dope so I used clear finger nail polish to hold the coils together.

MPN-3401 PIN diodes are much easier to work with than EGC555. The EGC part is a "through-hole" part but is very close to a surface mount device in terms of size. Get the 3401s if you can.

Testing

I used an MFJ antenna analyzer to test the antenna array. I suspect any SWR meter with a QRP transmitter would work. I stress low power though. Don't blow up your PIN diodes!!! I connected 3.7v to the "ground" terminal on the switched board and grounded (0 volts) the antenna 1 select lead (the wire that would normally go to IC1 pin 11). This forwarded biased the diodes associated with antenna 1. I then connected the antenna analyzer to the cable that would normally go to the receiver and verified the antenna was "turned on" and trimmed the welding rod to a good SWR. I repeated for antennas 2-4. I ended up with an SWR of 1.3 at 146 Mhz on all 4 antennas.

After verifying the PIC chip was running (by looking at the antenna select lines with a scope) I used the PIC chip / antenna array to generate a test signal that would allow me to debug the analog electronics on the bench. I connected the "bottom" of a 20K pot to ground (not the floating ground) and the wiper to audio in. I then connected the "top" of the pot to the copper clad welding rod used to make antenna 1 and adjusted the pot to give a good signal (one non flashing LED on the display board). I then moved the "top" of the pot to antenna 2, then antenna 3 and then antenna 4. Each time, the direction indicated on the display board would jump 90 degrees. This signal was also used to adjust the 500Hz low pass filter by watching the waveform on pin 5 of IC2 while adjusting capacitors attached to pin 1 of IC2.

A problem with calibration

I installed the unit in my truck and set off to gain some experience using a Doppler DF unit. Calibration went as expected and the unit seemed to work as advertised. Later I noticed the unit continued to work but the calibration seemed to have shifted by 90 degrees or so. I figured I simply made a mistake in the initial calibration and recalibrated. Again the unit worked for a while but then the calibration slipped. A while later is slipped back.

To make a long story short, I spent several weeks trying to find out what was wrong. The unit would work for days at a time on the bench without so much as a hiccup but would fail to keep calibration in the truck. The problem seemed to be environmental and I suspected vibration in the antenna array or dirty power.

I finally tracked the problem down to temperature sensitive capacitors. Specifically C9, C15, C16, C18, and C19. These are all .01uF capacitors used to filter the audio signal. My original capacitors were Digikey P4300A-ND. These capacitors seem to be EXTREMELY sensitive to temperature changes. I eventually found that calibration would change by over 180 degrees between a cold car in the morning and a car that had become hot inside after being parked outside for a few hours! Replacing these capacitors with high quality units fixed the problem.

It really was necessary to replace all 5 capacitors. Once I understood what was going on I could use a hair dryer to to make the unit fail. I replaced the capacitors one at a time--testing after each replacement. Each

time performance improved but did not become solid until all 5 were replaced.

How does it work

The unit works great! Most of my experience so far is with local repeaters. The display is solid (+/- 1 one light) as I drive around town. Not much experience on weak signals yet.

I find it is important to keep moving to get accurate bearings.

What would I do different?

The physical layout of the boards makes mounting difficult. There is just no place to drill mounting holes except near the 225 degree light. I think if I was to start over I would connect the two boards together with a set of .01 inch headers. The combination of the header/pin set at one end and a bolt / spacer combo at the other would make for a tightly coupled unit.

The LEDs I used for the dial were clear high brightness units. In retrospect this was probably a mistake. I was worried bright sunlight might make viewing the LEDs difficult. On axis these LEDs are very bright. At night they are too bright. Off axis the defused LED used for the "floating ground" is much easer to see than the dial LEDs. This is important if you have a co-pilot who must also see the display.

I also think I will eventually scrap the antenna and go to the mag mount antenna array described on Joe Moell's page. It just seems cleaner. Maybe I will mount the current antenna array to the roof of my house and make a base direction finder.

Would I do it again?

You bet! Thank you very much Jacques Brodeur. A great project!!!!

Parts List

Here is a parts list I generated. Please, if you use this list only consider this as a start. Double check all part numbers. Prices were from the catalog in effect in February 2000.

K5ATM, mycall@rt66.com

Label	Description	Quantity	Source	Part Number	Price	Total	Comments
C1,3	470 uF 25 V electrolytic axial leads (I think radial)	2	Digikey	P5155-ND	0.44	0.88	
C2, 4, 7, 11, 14, 20, 21, 22, 23, 24, 25, 26, 27, 28	.1 uF ceramic	20	Digikey	P4201-ND	0.23	4.60	(must order in lots of 10)
C5,6	22 pF ceramic	10	Digikey	P4016A-ND	0.10	1.00	(must order in lots of 10)
C8, 17	.47uF ceramic	2	Digikey	P4967-ND	0.72	1.44	
C9, 15, 16, 18, 19	.01 uF ceramic		See note under testing above				
C10 -- unused							
C12a	120pF	1	Digikey	P3121-ND	0.24	0.24	Combine to total 680pF
C12b	100pf	1	Digikey	P3101-ND	0.24	0.24	Combine to total 680pF
C12c	150pF	1	Digikey	P3151-ND	0.24	0.24	Combine to total 680pF
C12d	560pF	1	Digikey	P3561-ND	0.24	0.24	Combine to total 680pF
C12e	4.5-65 pF trimmer	1	Digikey	SG3009-ND	1.68	1.68	Combine to total 680pF
C13	47 uF electrolytic 10 V radial leads	1	Digikey	P5137-ND	0.17	0.17	

D1 (+ two diodes for the 3.7v "ground"	Diode,1N4001, 1N4007, etc.	1	Digikey	1N4001MSCT-ND	0.43	0.43	cut tape -- 10 units
D2	Diode, 1N4148	1	Digikey	1N4148MSCT-ND	0.53	0.53	cut tape -- 10 units
F1,2	3AG 1/2 Amp fuse	1	Digikey	F112-ND	1.95	1.95	(package of 5)
Fuse Holder	2 position fuseholder board	1	Digikey	3537K-ND	1.57	1.57	
IC1	PIC16C72-20/SP É OR	0	Digikey	PIC16C72-20/SP-ND	7.35	0.00	This chip comes with the Far Ckt 3 board set
IC1	PIC16C72/JW	0	Digikey	PIC16C72/JW-ND	14.03	0.00	Use this if you want to change pgm
IC2	MAX293CPA (MAX294CPA) Low pass filter	0	Maxim	MAX293CPA	5.92	0.00	Try getting a free one!
IC3	MAX494CPD quad rail to rail OP amp	0	Maxim	MAX494CPD	6.42	0.00	Try getting a free one!
IC4	74HC4051 8-channel analog mux	1	Digikey	MM74HC4051N-ND	0.66	0.66	
Socket-1	28 pin IC socket	2	Digikey	AE9814-ND	0.57	1.14	Need 2. Digikey 28 pin sockets are .6 inches wide

Socket-2	8 pin IC socket	1	Digikey	AE9808-ND	0.36	0.36	
Socket-3	14 pin IC socket	1	Digikey	AE9814-ND	0.57	0.57	
Socket-4	16 pin IC socket	1	Digikey	AE9816-ND	0.65	0.65	
REG1	7805 (LM340) 5 V regulator TO-220	1	Digikey	LM340T-5.0-ND	0.70	0.70	
LED 1, 33	Green high brithness LED (40 mcd) See "What would I do different" above	2	Digikey	160-1131-ND	0.23	0.46	0 deg and power. I used high brightness clear LED for max daytime visibility
LED 2-16, LED 18-32	Red high brithness LED (40 mcd)	3	Digikey	160-1128-ND	1.75	5.25	misc deg. Light (3 pkg of 10)
LED 17	Yellow high brithness LED (40 mcd)	1	Digikey	160-1134-ND	0.23	0.23	180 deg. Light
R1	560 Ohms 1/4 Watt	1	Digikey	560QBK-ND	0.28	0.28	(package of 5)
R2,3,9	10 kOhms 1/4 Watt	1	Digikey	10KQBK-ND	0.28	0.28	(package of 5)
R4,5,6,7	68 Ohms 1/4 Watt	1	Digikey	68QBK-ND	0.28	0.28	(package of 5)
R8	2.7 mOhms 1/4 Watt	1	Digikey	2.7MQBK-ND	0.28	0.28	(package of 5)

R10	51 kOhms 1/4 Watt	1	Digikey	51KQBK-ND	0.28	0.28	(package of 5)
R11,17,18	1 mOhms 1/4 Watt	1	Digikey	1.0MQBK-ND	0.28	0.28	(package of 5)
R12,13	2.2 kOhms 1/4 Watt	1	Digikey	2.2KQBK-ND	0.28	0.28	(package of 5)
R14,19	62 kOhms 1/4 Watt	1	Digikey	62KQBK-ND	0.28	0.28	(package of 5)
R15	1.5 kOhms 1/4 Watt	1	Digikey	1.5KQBK-ND	0.28	0.28	(package of 5)
R16	680 kOhms 1/4 Watt	1	Digikey	680KQBK-ND	0.28	0.28	(package of 5)
R20,23,24	33 kOhms 1/4 Watt	1	Digikey	33KQBK-ND	0.28	0.28	(package of 5)
R21	47 kOhms 1/4 watt	1	Digikey	47KQBK-ND	0.28	0.28	(package of 5)
R22	1 kOhms 1/4 Watt	1	Digikey	1.0KQBK-ND	0.28	0.28	(package of 5)
RV1,2	10 k 1/4 Watt variable	2	Digikey	D4AA14-ND	0.33	0.66	
RV3	10 Ohms 5 Watt variable	1	Digikey	CT2151-ND	3.20	3.20	
SW1, SW3, SW4	Miniature toggle SPDT	0	Digikey	CKN1021-ND	3.75	0.00	On/Off, Radio 1/2, Fast/Slow. I did not order. I had these

SW2	N.O. miniature push button	1	Digikey	P8070SCT-ND	0.30	0.30	Push to calabrate switch
FB1-5	Ferrite beads (Miller FB43-101)	5	Digikey	M2304-ND	0.12	0.60	No FB43-101 in Miller cat. Used FB43110
X1	20mHz uProcessor Xtal	1	Digikey	CTX062-ND	0.94	0.94	
C101-109	680 pF poly (for switcher)	9	Digikey	P3681-ND	0.24	2.16	
L101-104	1.5 uH coil (for switcher)						Hand wind, air core, 24 turns of #26 wire on 3/16" form. Radio Shack has wire.
R101-104	220 Ohm 1/4 Watt (base of antennas)	1	Digikey	220QBK-ND	0.28	0.28	(package of 5) Also use 1 in the 3.7V ckt--or order a 330 Ohm
D101-108	MPN-3401 PIN diodes (switcher and base of antennas)	8	www.debco.com	MPN-3404	1.00	8.00	$1 each + $5 min shippingso buy extra. I like these better than EGC555 (easer to mount)

PC board set + PIC	3 board set + PIC chip	1	Far Circuits		35.00	35.00	Check to see if all holes are drilled before starting!!!!
controller to antenna connector							I used a Radio Shack 6 pin DIN connector
Antenna feed line (from switcher to controller)	RG-58	X feet					I picked up at "junk" store
Antenna to switcher coax	RG-174	~80"					I pickes up at "junk" store
Antennas	1/4 wave antenna	4					I used 3/32 copper clad steel welding rod. All radials and antennas were about $6.00
Antenna connectors	BNC connectors (Male)	4					I used the method in Joe Moell's book. $ used connectors were $2.00
Radials	1/4 wave radial	8					See antenna note above
Radial connectors	Terminal lugs (from local hardware store) ~$1.50						I used the method in Joe Moell's book.

Antenna ground plane	19" x 19" double sided PC board	1					
Antenna base	19" x 19" x 1/2" plywood	1					
Box							
				Total		~$80.00	

key words for altavista, yahoo, etc:

Montreal Doppler, building a Montreal Doppler, testing the Montreal Doppler, calibration problems with the Montreal Doppler.

```
;== DOPPLER DF PAR JACQUES BRODEUR == VE2EMM ======================== REV. 1
;
;Free use granted to HAM RADIO OPERATORS only for HAM RADIO purpose.
;Please mention VE2EMM when  using it. It is my only reward.
;No resale permitted.
;
;               DOPPLER DF, CONTROLE PAR PIC16C72
;
;               Liste des entrees/sorties du microcontrolleur
;
;               8  sorties lampes affichage   | B0-B7
;               4  communs lampes affichage               | C4-C7
;               4  sorties antennes           | C0-C3
;               1  Entree analogue CAL                    | A0   ;Direction des lampes
;               1  Entree analogue SIGLVL                 | A1   ;Niveau du signal
;               3  Sorties filtre digital ROANOKE         | A2-A4
;               1  entree signal de phase PHASE/          | A5
;
;-------------------------------------------------------------------------
;
                LIST        P=16C72
                RADIX       HEX
                INCLUDE     P16C72.INC
                __CONFIG    _HS_OSC&_PWRTE_ON&_CP_OFF&_WDT_ON&_BODEN_ON
;
;-------------------------------------------------------------------------
;               ALLOCATION DES MEMOIRES, VALEURS ET BITS

                CBLOCK      0X20
                STA_W                   ;STACK POUR LE W
                STA_STATU               ;STACK POUR LE STATUS
                ROSE                    ;COMPTEUR DE DEGRES
                DIR_1                   ;DIRECTION MOYENNE DE LA PHASE
                DIR_2                   ;DIRECTION DE LA PHASE
                ECAR
                DIRECTION               ;POUR AFFICHER
                MEMTMP1                 ;Memoire temporaire tout usage
                MEMTMP2
                DRAPEAU                 ;Flags
                                        ;b0=lecture de la direction deja faite
                                        ;b1=SIGLVL overload
                                        ;b2=Demander une conversion de SIGLVL
                                        ;b3=SIGLVL recepteur silentieux
                PHASAGE                 ;Deplacement de la direction (CAL)
                SIGLVL                  ;Niveau du signal au filtre
                TIMR1                   ;pour le clignoteur 180 degree
                TIMR2                   ;Pour le clignoteur squelch
                BIT                     ;Memoire pour la bit a clignoter
                ENDC
;
;---DEBUT DU PROGRAMME----------------------------------------------------
;
                ORG         0X000
                GOTO        INIT
;
;-------------------------------------------------------------------------
;=== INTERRUPTION ========================================================
;
                ORG         0X004
                MOVWF       STA_W       ;PUSH le reg W
                SWAPF       STATUS,W    ;PUSH le reg STATUS
                MOVWF       STA_STATU
```

```
            MOVLW   D'178'      ;178 pour 20 mHz pour 500Hz
            MOVWF   TMR0        ;RESET TMR0
;
;--CHANGER D'ANTENNE----------
;
            MOVF    ROSE,W      ;CHANGER LES CONDENSATEURS DU FILTRE DIGITAL
            MOVWF   PORTA       ;bits 2,3,4

ANT1        MOVLW   D'0'        ;ANTENNE 1
            XORWF   ROSE,W      ;TESTER POUR 0 degree
            BNZ     ANT2
            BCF     PORTC,0     ;Activer L'antenne 1
            NOP
            BSF     PORTC,3     ;Deconnecter l'antenne 4

ANT2        MOVLW   D'8'        ;ANTENNE 2
            XORWF   ROSE,W      ;TESTER POUR 90 degrees
            BNZ     ANT3
            BCF     PORTC,1     ;Activer L'antenne 2
            NOP
            BSF     PORTC,0     ;Deconnecter l'antenne 1

ANT3        MOVLW   D'16'       ;ANTENNE 3
            XORWF   ROSE,W      ;TESTER POUR 180 degrees
            BNZ     ANT4
            BCF     PORTC,2     ;Activer L'antenne 3
            NOP
            BSF     PORTC,1     ;Deconnecter l'antenne 2

ANT4        MOVLW   D'24'       ;ANTENNE 4
            XORWF   ROSE,W      ;TESTER POUR 270 degrees
            BNZ     TESTER
            BCF     PORTC,3     ;Activer L'antenne 4
            NOP
            BSF     PORTC,2     ;Deconnecter l'antenne 3
;
;--TESTER LE SIGNAL----------
;
TESTER      BTFSS   DRAPEAU,3 ;Si SIGLVL < SQUELCH  clignoter lentement
                              ;l'affichage
            GOTO    AFF_OVERL           ;SIGLVL au dessus du SQUELCH
            BTFSS   TIMR2,0     ;SIGLVL sous le SQUELCH * * * * * * *
            GOTO    AFFICHER    ;Allumer la lampe
            MOVLW   0XFF        ;Eteindre la lampe *
            MOVWF   PORTB
            GOTO    AVANCER     ; * * * * *

AFF_OVERL           BTFSS   DRAPEAU,1 ;Tester pour OVERLOAD du niveau de signal
            GOTO    PHASE       ;Afficher la direction * * * *
            BTFSS   TIMR1,6     ;Clignote rapidement la lampe OVERLOAD, 180 deg.
            GOTO    CLI_ON
            MOVLW   D'32'       ;Lampe eteinte
            MOVWF   DIRECTION
            GOTO    AFFICHER    ;Afficher la direction
CLI_ON      MOVLW   D'16'       ;Lampe allumee
            MOVWF   DIRECTION
            GOTO    AFFICHER    ;Continuer * * * * * * *
;
;--LIRE LA PHASE----------
;
PHASE                           ;Tester pour 1 changement par revolution
            BTFSS   PORTA,5     ;Lire la PHASE
            GOTO    LIREPHASE ;0=lire
```

```
            BCF     DRAPEAU,0 ;1=ne pas lire
            GOTO    AVANCER
LIREPHASE   BTFSC   DRAPEAU,0 ;Deja lu si 1, Lire si 0
            GOTO    AVANCER   ;Terminer direction est deja lu
            MOVF    ROSE,W    ;Ramasser la direction de ce cycle
            MOVWF   DIR_2     ;DIR_2=Direction presente -- DIR_1=Direction precedente
            BSF     DRAPEAU,0 ;Indique que la lecture est faite, bit a 1
;
;--CALCULER LA MOYENNE DE 2 RETOURS-
            MOVF    DIR_2,W   ;Dir_2 doit etre plus grand que DIR_1
            SUBWF   DIR_1,W
            BTFSS   STATUS,C
            GOTO    CALCUL    ;Si DIR_1 plus petit que DIR_2

            MOVF    DIR_1,W   ;Echanger DIR_1 et DIR_2
            MOVWF   MEMTMP1
            MOVF    DIR_2,W
            MOVWF   DIR_1
            MOVF    MEMTMP1,W
            MOVWF   DIR_2

CALCUL      MOVF    DIR_1,W   ;ECAR = DIR_2 - DIR_1
            SUBWF   DIR_2,W
            MOVWF   ECAR
            CLRC              ;DIR_1 = (ECAR / 2) + DIR_1
            RRF     ECAR,W
            ADDWF   DIR_1,F

            MOVLW   D'16'     ;IF ECAR <16  THEN  LECT_FAITE  ELSE
            SUBWF   ECAR,W
            BNC     CAL

SUITE       MOVLW   D'16'     ;Si DIR_1 < 16
            SUBWF   DIR_1,W
            BNC     ADD16

            MOVLW   D'16'     ;IF NOT  DIR_1 = DIR_1 - 16
            SUBWF   DIR_1,F
            GOTO    CAL

ADD16       MOVLW   D'16'     ;IF DIR_1 < 16  THEN  DIR_1 = DIR_1 + 16
            ADDWF   DIR_1,F
;
;--CALIBRER--------------------------
;
CAL         MOVF    PHASAGE,W         ;Ajouter la calibration
            ADDWF   DIR_1,W
            MOVWF   DIRECTION
            MOVLW   D'32'
            SUBWF   DIRECTION,W       ;
            BC      SOUSTRAIRE        ;Si 32 et plus soustraire
            GOTO    AFFICHER
SOUSTRAIRE  MOVLW   D'224'            ;Soustraire 32
            ADDWF   DIRECTION,F
;
;--AFFICHAGE-------------------------
;
AFFICHER    MOVLW   0X02              ;Aller a la page 0x200
            MOVWF   PCLATH
            CLRC                      ;Afficher les lampes de direction
            RLF     DIRECTION,W
            CALL    LAMPES
            MOVWF   PORTB             ;*****Cathode des lampes
```

```
            RLF     DIRECTION,W         ;Chercher les anodes
            ADDLW   0X01
            CALL    LAMPES
            MOVWF   MEMTMP1  ;*****Sauver les anodes des lampes
            CLRF    PCLATH
            MOVF    PORTC,W
            ANDLW   B'00001111'  ;Charger les antennes
            IORWF   MEMTMP1,W           ;Ajouter les lampes
            MOVWF   PORTC       ;*****Mise a jour du port C
;
;--AVANCER LE COMPTEUR----------
;
AVANCER     INCF    ROSE,F      ;AVANCER LE COMPTEUR
            MOVLW   D'32'
            SUBWF   ROSE,W      ;TESTER SI COMPTE MAXIMUM
            BNC     POP         ;ARRETER LE COMPTEUR A 31
            CLRF    ROSE        ;Commencer a 0
            BSF     DRAPEAU,2 ;Commander une conversion du SIGLVL
            INCF    TIMR1,F
            SKPNZ
            INCF    TIMR2,F
;
;--TERMINER-------------------------
;
POP         BCF     INTCON,T0IF ;Rappeler lE FLAG T0IF de L'OVERFLOW
                                ;DE TMR0
            SWAPF   STA_STATU,W         ;Restorer le reg STATUS
            MOVWF   STATUS
            SWAPF   STA_W,F     ;Restorer le reg W
            SWAPF   STA_W,W
            RETFIE
;
;================================================================================
;--- INITIALISATION ET LECTURE DE LA CALIBRATION ----------------------------
;
INIT        CLRF    PORTA
            CLRF    PORTB
            CLRF    PORTC
                                ;Charger la calibration de l'affichage
            BSF     STATUS,RP0          ;Page 1
            MOVLW   B'00000100'
            MOVWF   ADCON1      ;Analogue AN0 AN1 AN3
            BCF     STATUS,RP0          ;Page 0
            MOVLW   B'11000001'  ;Clock RC, convertir AN0
            MOVWF   ADCON0      ;
            MOVLW   D'60'
            MOVWF   MEMTMP1
WAIT        DECFSZ  MEMTMP1,F
            GOTO    WAIT        ;Stabiliser l'entree
            BSF     ADCON0,GO           ;Demarrer le convertisseur A/N
ANCONVER    BTFSC   ADCON0,GO           ;Si 0, terminee
            GOTO    ANCONVER;Attendre la fin de conversion
            MOVF    ADRES,W     ;
            MOVWF   PHASAGE     ;Sauver la calibration
            CLRC
            RRF     PHASAGE,F ;127 max
            CLRC
            RRF     PHASAGE,F ;67 max
            CLRC
            RRF     PHASAGE,F ;31 compte max
;
;---Operation normale----------
;
```

```
                CLRF    ADCON0
                BSF     STATUS,RP0              ;Page 1
;               MOVLW   B'00000110'  ;RA TOUT DIGITAL
;               MOVWF   ADCON1
                MOVLW   B'00100011'  ;0-1,5 entrees 2-4 sorties PORTA
                MOVWF   TRISA
                MOVLW   B'00000000'  ;Tout en sortie PORTB
                MOVWF   TRISB
                MOVLW   B'00000000'  ;Tout en sortie PORTC
                MOVWF   TRISC
                MOVLW   B'11010001'  ;OPTION TOCS=internal CLK, PRE=/2, PSA=TMR0
                MOVWF   OPTION_REG
                MOVLW   B'10100000'  ;INTCON GIE T0IE
                MOVWF   INTCON
                BCF     STATUS,RP0              ;Page 0

                MOVLW   D'00'           ;Conditions de depart des memoires
                MOVWF   ROSE
                MOVWF   DIR_1
                MOVWF   DIR_2
                MOVWF   DIRECTION
                MOVLW   0X0F            ;Deconnecter les antennes
                MOVWF   PORTC
                MOVLW   B'00000001'
                MOVWF   DRAPEAU
                MOVLW   D'178'
                MOVWF   TMR0
;
;---BOUCLE PRINCIPALE-------------------------------------------------------
;
PRINC           CLRWDT
                BTFSS   DRAPEAU,2 ;Temps de faire une conversion?
                GOTO    PRINC           ;Non
                BCF     DRAPEAU,2 ;Oui
                MOVLW   B'11001001'  ;Clock RC, convertir AN1
                MOVWF   ADCON0      ;
                MOVLW   D'60'
                MOVWF   MEMTMP2
WAIT1           DECFSZ  MEMTMP2,F
                GOTO    WAIT1           ;Stabiliser l'entree
                BSF     ADCON0,GO               ;Demarrer le convertisseur A/N
ANCONVER1               BTFSC   ADCON0,GO               ;Si 0, terminee
                GOTO    ANCONVER1               ;Attendre la fin de conversion
                MOVF    ADRES,W     ;
                MOVWF   SIGLVL      ;0 a 256 = 0 a 5 volts
                MOVLW   D'115'          ;Test de bas niveau 2.2 VOLTS
                SUBWF   SIGLVL,W
                BNC     SQUELCH     ;Signal faible
                BCF     DRAPEAU,3 ;Signal plus grand que le minimum
                GOTO    TESTOVERL
SQUELCH         BSF     DRAPEAU,3 ;Pour eteindre l'affichage
TESTOVERL               MOVLW   D'170'          ;(256/5V)*3.4V=174 (Niveau de crete)
                SUBWF   SIGLVL,W
                BNC     SIGBON      ;Enlever le flag
                BSF     DRAPEAU,1 ;Indication de OVERLOAD
                GOTO    PRINC           ;Attendre
SIGBON          BCF     DRAPEAU,1 ;Pas de OVERLOAD SIGLVL bon
                GOTO    PRINC
;
;---LAMPES------------------------------------------------------------------
;
                ORG     0X200
LAMPES          ADDWF   PCL,F
```

```
RETLW   B'11111110'  ;D1  0
RETLW   B'00010000'  ;L1
RETLW   B'11111101'  ;D2  1
RETLW   B'00010000'  ;L1
RETLW   B'11111011'  ;D3  2
RETLW   B'00010000'  ;L1
RETLW   B'11110111'  ;D4  3
RETLW   B'00010000'  ;L1
RETLW   B'11101111'  ;D5  4
RETLW   B'00010000'  ;L1
RETLW   B'11011111'  ;D6  5
RETLW   B'00010000'  ;L1
RETLW   B'10111111'  ;D7  6
RETLW   B'00010000'  ;L1
RETLW   B'01111111'  ;D8  7
RETLW   B'00010000'  ;L1
RETLW   B'11111110'  ;D1  8
RETLW   B'00100000'  ;L2
RETLW   B'11111101'  ;D2  9
RETLW   B'00100000'  ;L2
RETLW   B'11111011'  ;D3  10
RETLW   B'00100000'  ;L2
RETLW   B'11110111'  ;D4  11
RETLW   B'00100000'  ;L2
RETLW   B'11101111'  ;D5  12
RETLW   B'00100000'  ;L2
RETLW   B'11011111'  ;D6  13
RETLW   B'00100000'  ;L2
RETLW   B'10111111'  ;D7  14
RETLW   B'00100000'  ;L2
RETLW   B'01111111'  ;D8  15
RETLW   B'00100000'  ;L2
RETLW   B'11111110'  ;D1  16
RETLW   B'01000000'  ;L3
RETLW   B'11111101'  ;D2  17
RETLW   B'01000000'  ;L3
RETLW   B'11111011'  ;D3  18
RETLW   B'01000000'  ;L3
RETLW   B'11110111'  ;D4  19
RETLW   B'01000000'  ;L3
RETLW   B'11101111'  ;D5  20
RETLW   B'01000000'  ;L3
RETLW   B'11011111'  ;D6  21
RETLW   B'01000000'  ;L3
RETLW   B'10111111'  ;D7  22
RETLW   B'01000000'  ;L3
RETLW   B'01111111'  ;D8  23
RETLW   B'01000000'  ;L3
RETLW   B'11111110'  ;D1  24
RETLW   B'10000000'  ;L4
RETLW   B'11111101'  ;D2  25
RETLW   B'10000000'  ;L4
RETLW   B'11111011'  ;D3  26
RETLW   B'10000000'  ;L4
RETLW   B'11110111'  ;D4  27
RETLW   B'10000000'  ;L4
RETLW   B'11101111'  ;D5  28
RETLW   B'10000000'  ;L4
RETLW   B'11011111'  ;D6  29
RETLW   B'10000000'  ;L4
RETLW   B'10111111'  ;D7  30
RETLW   B'10000000'  ;L4
RETLW   B'01111111'  ;D8  31
```

```
                RETLW       B'10000000'  ;L4
                RETLW       B'11111111'  ;    32  Toutes les lampes eteintes
                RETLW       B'00000000'  ;
;
;================================================================================
;
                END
```