## 38 degrees hobbyists --38Hot Volt-Nuts meter reference tool electronics enthusiasts Professional Forum

Title: Voltgen (self-calibration of 6½ voltage source) TR_V1.0 DIY and debug

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Author: lilith **Time:** 2013-3-21 21:00
Title: Voltgen (self-calibration of 6½ voltage source) TR_V1.0 DIY and debugging first acknowledgment of TR successive draw me PCB, now finally out of a fairly tricky version. About not repeat the previous process, can refer to my previous post:
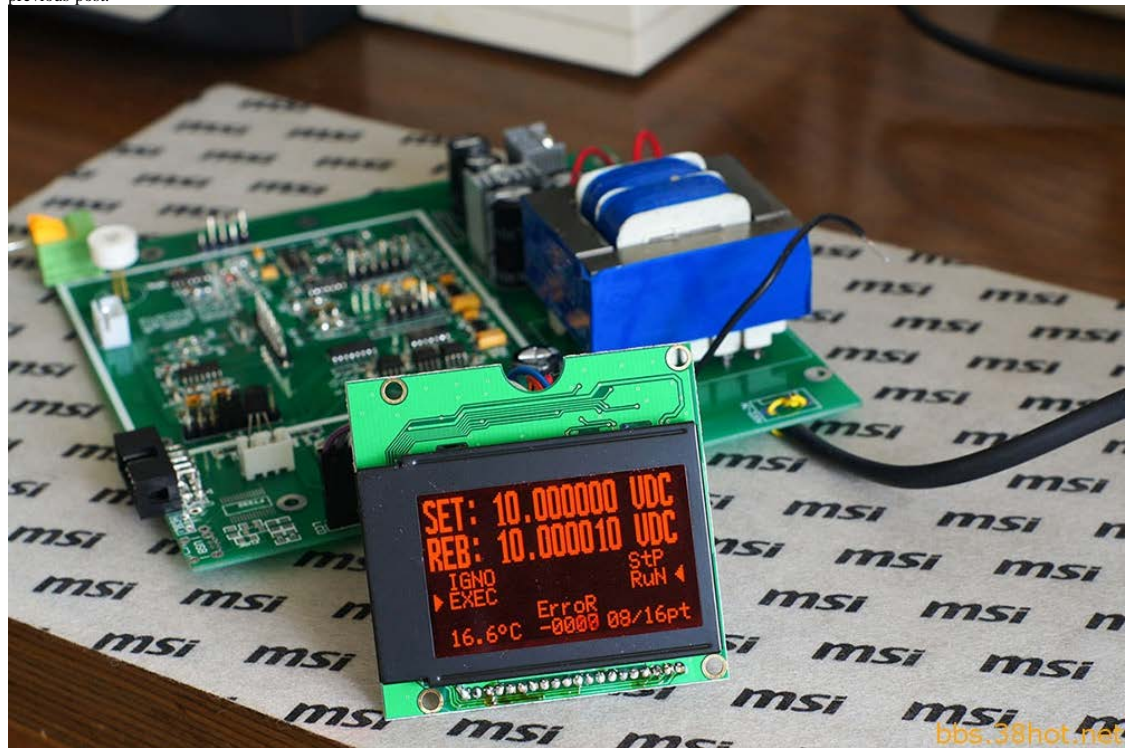
LTC2400 + MAX515, programmable voltage generator in trial
http://bbs.38hot.net/read-htm-tid-23835.html

Voltage Generator Version 0.1 Proofing initial success
http://bbs.38hot.net/read-htm-tid-29282.html

Self-calibration programmable digital closed-loop voltage generator 6½ trial and testing (based LTC2400 / AD5541)
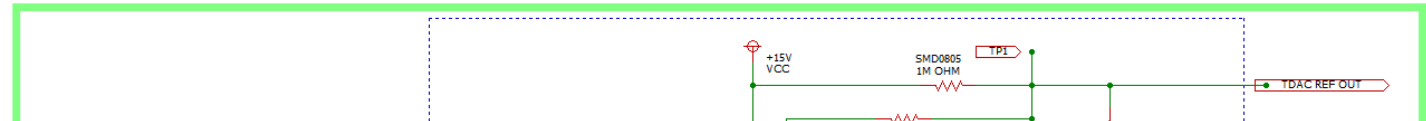http://bbs.38hot.net/read-htm-tid-29599.html

Now the initial setting program TR_V1.0, ADC is still using the LTC2400, DAC with AD5541 (16bit) + MAX515 (10bit), remaining substantially unchanged. Since TR own insistence, this PCB uses a 4 op amp package, which I disagree. You can use 4 op amp OPA4277 op amp or equivalent, higher cost. The following analysis of the device using one by one.
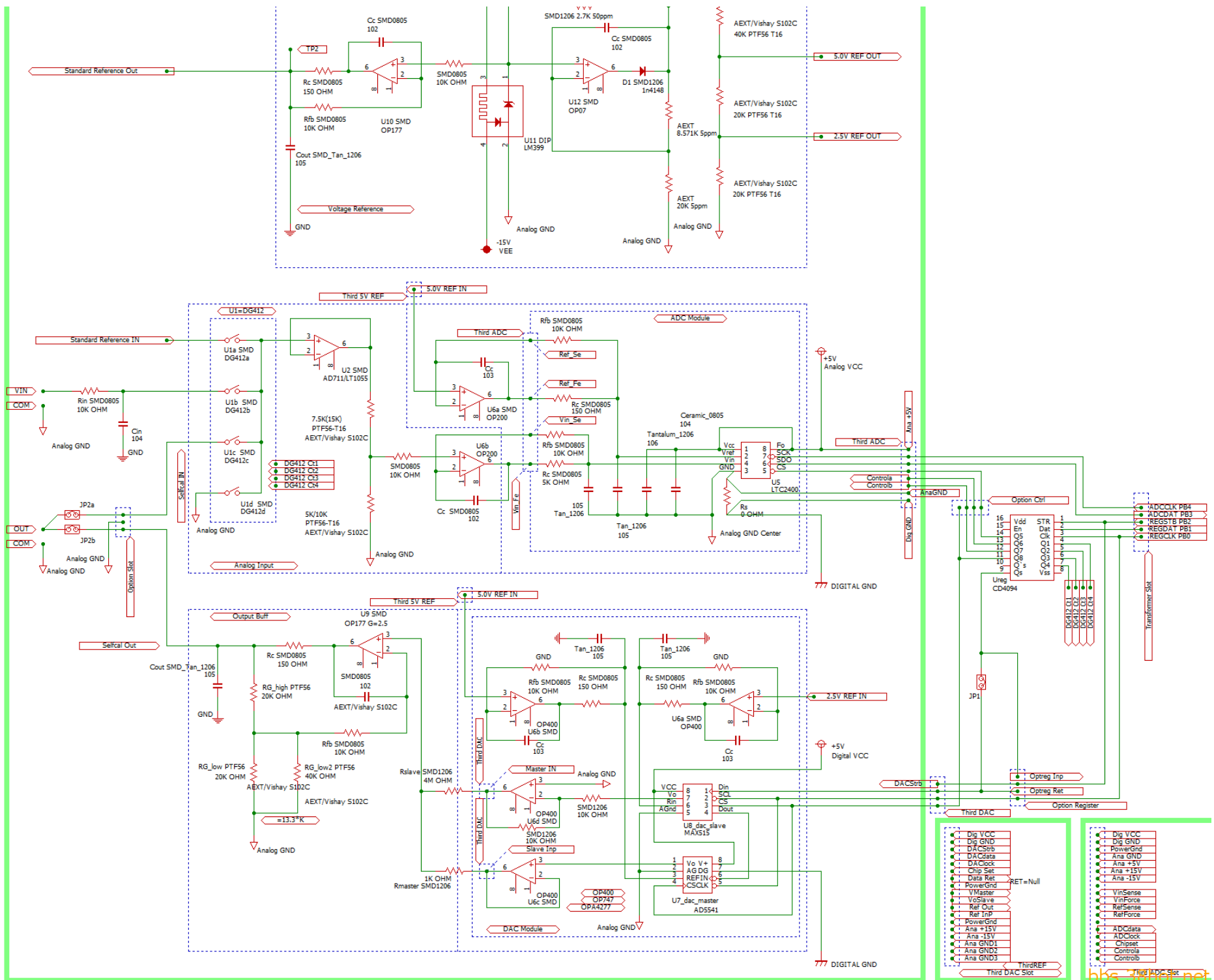
This paper roughly directory

1, the principle of self-calibration of 6½ voltage source (almost complete)
2, the device uses and Analysis (almost complete)
3, this version of PCB brief description (not yet written)
4, production and commissioning & lt; --- Key (almost complete)
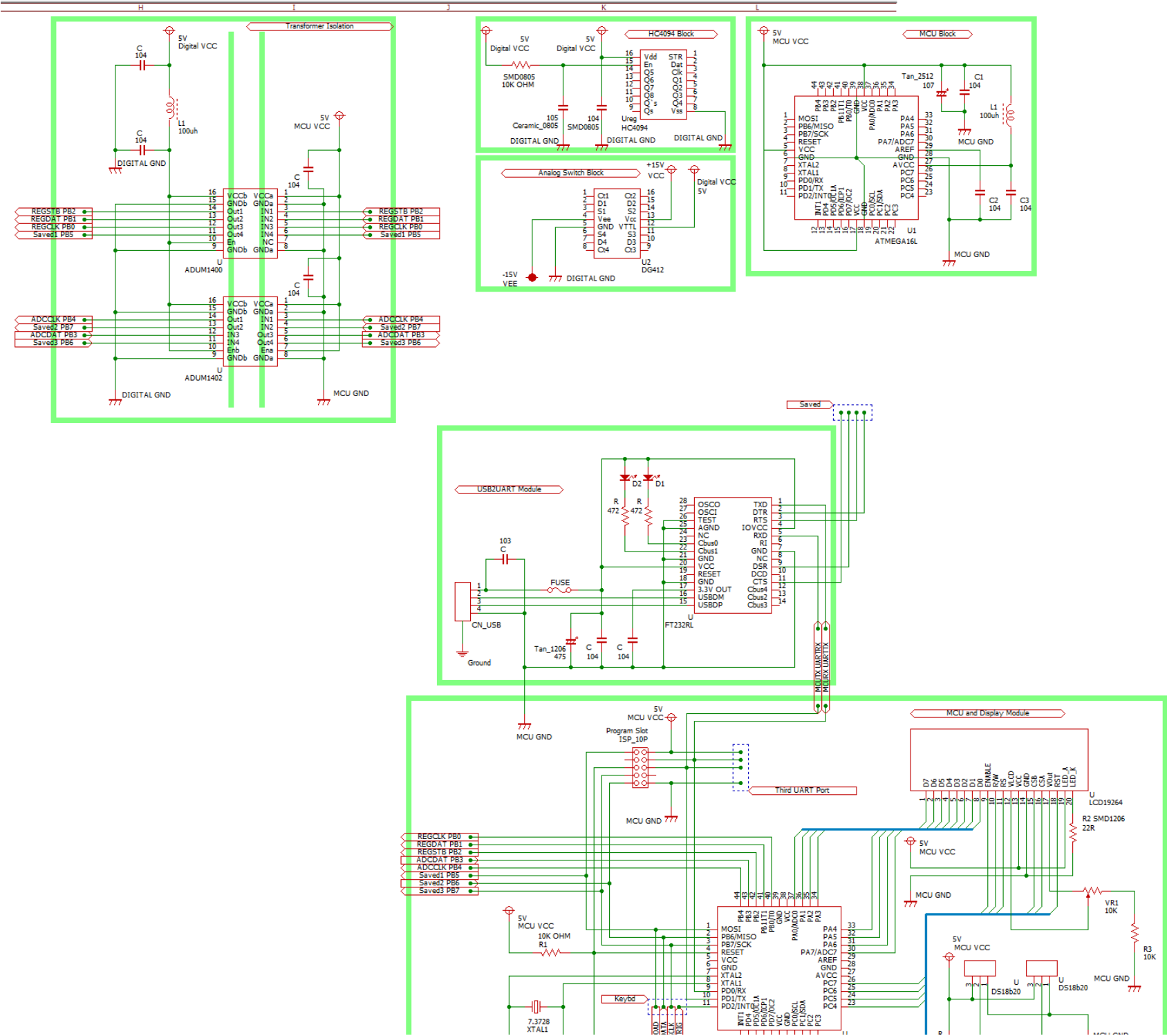5, the subsequent development of (not yet written)

General circuit diagram * PCB design principles and chassis shielding part deals with the figure does not include electromagnetic compatibility, because this part because of the need varies and depends to a large extent
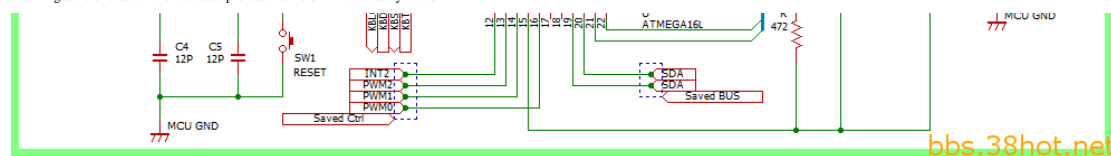
Analog portion

Standard Reference Out

Cc SMD0805 102
TP2
Rc SMD0805 150 OHM
Rfb SMD0805 10K OHM
Cout SMD_Tan_1206 105
U10 SMD OP177
GND

SMD0805 10K OHM
U11 DIP LM399

SMD1206 2.7K 50ppm
Cc SMD0805 102
U12 SMD OP07
D1 SMD1206 1n4148

AEXT/Vishay S102C 40K PTF56 T16
AEXT 8.571K 5ppm
AEXT 20K 5ppm

5.0V REF OUT
AEXT/Vishay S102C 20K PTF56 T16
2.5V REF OUT
AEXT/Vishay S102C 20K PTF56 T16

Voltage Reference

-15V VEE
Analog GND
Analog GND
Analog GND

Third 5V REF   5.0V REF IN
U1=DG412
Standard Reference IN
U1a SMD DG412a
Rin SMD0805 10K OHM
VIN
COM
U1b SMD DG412b
Cin 104
GND
Analog GND
U1c SMD DG412c
U2 SMD AD711/LT1055
7.5K(15K) PTF56-T16 AEXT/Vishay S102C
DG412 Ct1
DG412 Ct2
DG412 Ct3
DG412 Ct4
U1d SMD DG412d
5K/10K PTF56-T16 AEXT/Vishay S102C
Analog GND

Third ADC   ADC Module
Rfb SMD0805 10K OHM
Cc 103
Ref_Se
Ref_Fe
Rc SMD0805 150 OHM
Vin_Se
U6a SMD OP200
U6b OP200
Rfb SMD0805 10K OHM
Rc SMD0805 5K OHM
SMD0805 10K OHM
Cc SMD0805 102
Vin_Fe
105 Tan_1206

+5V Analog VCC
Ceramic_0805 104
Tantalum_1206 106
Vcc Vref Vin GND
Fo SCK SDO CS
U5 LTC2400
Tan_1206 105
Rs 0 OHM
Analog GND Center

Third ADC
Ana +5V
Controla
Controlb
AnaGND
Dig GND

DIGITAL GND

JP2a
JP2b
OUT
COM
Analog GND
Analog GND
Analog GND
Option Slot
Selfcal IN
Analog Input
Analog GND

Option Ctrl
16 Vdd STR 1
15 En Dat 2
14 Q5 Clk 3
13 Q6 Q1 4
12 Q7 Q2 5
11 Q8 Q3 6
10 Q's Q4 7
9 Qs Vss 8
Ureg CD4094
DG412 Ct1
DG412 Ct2
DG412 Ct3
DG412 Ct4
Transformer Slot

ADCCLK PB4
ADCDAT PB3
REGSTB PB2
REGDAT PB1
REGCLK PB0

Third 5V REF   5.0V REF IN
Output Buff
U9 SMD OP177 G=2.5
Selfcal Out
Rc SMD0805 150 OHM
Cout SMD_Tan_1206 105
SMD0805 102
RG_high PTF56 20K OHM
AEXT/Vishay S102C
Rfb SMD0805 10K OHM
RG_low PTF56 20K OHM
RG_low2 PTF56 40K OHM
AEXT/Vishay S102C
AEXT/Vishay S102C
=13.3*K
Analog GND
GND

Tan_1206 105
GND
Tan_1206 105
GND
Rfb SMD0805 10K OHM
Rc SMD0805 150 OHM
Rc SMD0805 150 OHM
Rfb SMD0805 10K OHM
OP400 U6b SMD
Cc 103
U6a SMD OP400
Cc 103
2.5V REF IN
+5V Digital VCC

Third DAC
Master IN   Analog GND
Rslave SMD1206 4M OHM
OP400 U6d SMD
SMD1206 10K OHM
Third DAC
SMD1206 10K OHM
Slave Inp
1K OHM
Rmaster SMD1206
OP400 U6c SMD
OP400
OP747
OPA4277
DAC Module

VCC Vo Rin AGnd
Din SCL CS Dout
U8_dac_slave MAX515

Vo V+
AG DG
REFIN
CSCLK
U7_dac_master AD5541
Analog GND

DACStrb
Optreg Inp
Optreg Ret
Option Register
Third DAC
JP1

DIGITAL GND

Dig VCC
Dig GND
DACStrb
DACdata
DAClock
Chip Set
Data Ret
PowerGnd
VMaster
VoSlave
Ref Out
Ref InP
PowerGnd
Ana +15V
Ana -15V
Ana GND1
Ana GND2
Ana GND3
RET=Null
ThirdREF
Third DAC Slot

Dig VCC
Dig GND
PowerGnd
Ana GND
Ana +5V
Ana +15V
Ana -15V
VinSense
VinForce
RefSense
RefForce
ADCdata
ADClock
Chipset
Controla
Controlb
Third ADC Slot

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Digital part (including isolation, the PC communications)

Transformer Isolation

5V Digital VCC
C 104
L1 100uh
C 104
DIGITAL GND
5V MCU VCC
C 104

U ADUM1400
16 VCCb VCCa 1
15 GNDb GNDa 2
14 Out1 IN1 3
13 Out2 IN2 4
12 Out3 IN3 5
11 Out4 IN4 6
10 En NC 7
9 GNDb GNDa 8

REGSTB PB2
REGDAT PB1
REGCLK PB0
Saved1 PB5

REGSTB PB2
REGDAT PB1
REGCLK PB0
Saved1 PB5

U ADUM1402
16 VCCb VCCa 1
15 GNDb GNDa 2
14 Out1 IN1 3
13 Out2 IN2 4
12 IN3 Out3 5
11 IN4 Out4 6
10 Enb Ena 7
9 GNDb GNDa 8

ADCCLK PB4
Saved2 PB7
ADCDAT PB3
Saved3 PB6

ADCCLK PB4
Saved2 PB7
ADCDAT PB3
Saved3 PB6

DIGITAL GND
MCU GND

HC4094 Block

5V Digital VCC
5V Digital VCC
SMD0805 10K OHM

16 Vdd STR 1
15 En Dat 2
14 Q5 Clk 3
13 Q6 Q1 4
12 Q7 Q2 5
11 Q8 Q3 6
10 Q's Q4 7
9 Qs Vss 8

105 Ceramic_0805
104 SMD0805
Ureg HC4094

DIGITAL GND DIGITAL GND DIGITAL GND

Analog Switch Block

+15V VCC
Digital VCC 5V

1 Ct1 Ct2 16
2 D1 D2 15
3 S1 S2 14
4 Vee Vcc 13
5 GND VTTL 12
6 S4 S3 11
7 D4 D3 10
8 Ct4 Ct3 9

U2 DG412
-15V VEE   DIGITAL GND

MCU Block

5V MCU VCC
Tan_2512 107
C1 104
L1 100uh
MCU GND

1 MOSI PA4 33
2 PB6/MISO PA5 32
3 PB7/SCK PA6 31
4 RESET PA7/ADC7 30
5 VCC AREF 29
6 GND GND 28
7 XTAL2 AVCC 27
8 XTAL1 PC7 26
9 PD0/RX PC6 25
10 PD1/TX PC5 24
11 PD2/INT0 PC4 23

U1 ATMEGA16L

C2 104   C3 104

MCU GND

Saved

USB2UART Module

D2 D1
R 472 R 472
103 C

28 OSCO TXD 1
27 OSCI DTR 2
26 TEST RTS 3
25 AGND RXD 4
24 NC IOVCC 5
23 Cbus0 RI 6
22 Cbus1 GND 7
21 GND NC 8
20 VCC DSR 9
19 RESET DCD 10
18 GND CTS 11
17 3.3V OUT Cbus4 12
16 USBDM Cbus2 13
15 USBDP Cbus3 14

U FT232RL

1
2 FUSE
3
4
CN_USB
Ground

Tan_1206 475
C 104
C 104

MGUTX UARTRX
MGURX UARTTX

MCU and Display Module

5V MCU VCC
MCU GND

Program Slot ISP_10P

Third UART Port

D7 D6 D5 D4 D3 D2 D1 D0 ENABLE R/W RS VLCD GND VCC CSB CSA VOut RST LED_A LED_K
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
U LCD19264

R2 SMD1206 22R

5V MCU VCC

REGCLK PB0
REGDAT PB1
REGSTB PB2
ADCDAT PB3
ADCCLK PB4
Saved1 PB5
Saved2 PB6
Saved3 PB7

5V MCU VCC
10K OHM R1

1 MOSI PA4 33
2 PB6/MISO PA5 32
3 PB7/SCK PA6 31
4 RESET PA7/ADC7 30
5 VCC AREF 29
6 GND GND 28
7 XTAL2 AVCC 27
8 XTAL1 PC7 26
9 PD0/RX PC6 25
10 PD1/TX PC5 24
11 PD2/INT0 PC4 23

MCU GND

5V MCU VCC

DS18b20
DS18b20
MCU GND

VR1 10K
R3 10K

Keybd

7.3728 XTAL1

MCU GND

Author: lilith **Time:** 2013-3-21 21:01

First, the principle of self-calibration of 6½ voltage source

DAC part of this design goal is

1, the basic range of 0-12V (see Part V of the expansion of the "Next")
2, programming and readback resolution of 6 and a half, which means the maximum count is 11.999,99, the voltage setting (programming) stepping minimum 10uV, the minimum resolution readback 10uV
3, with the temperature coefficient of 5ppm, 5ppm and 25ppm stability nonlinearity error, the goal is set relatively high, and the typical half-merchandise multimeter par 6, considered a vision can not be achieved by the last speaker data.

In order to achieve these goals, the first six and a half resolution, which means the equivalent DAC having log2 (1199999) = 20.2bit resolution, but only 20.2bit resolution, it is difficult to ensure the accuracy and nonlinear calibration requires gain calibration, so at least We need to have 10 times the theoretical resolution that 23.52bit resolution to achieve more reliable calibration target. Precision DAC product is not such a resolution, and stereo DAC, although with a higher resolution, but the temperature coefficient, monotonic, differential nonlinearity is not very good, linear indicators generally is a mess, so here after consideration, decided use of goods 16bit precision R-2R DAC and 12bit DAC synthetic way to achieve this DAC.

DAC section schematic. Of which the main DAC is AD5541, deputy DAC as MAX515, two DAC voltage generated by Rmaster = 249 ohms and Rslave = 1 megohm synthesis, into G = 2.5 in the output buffer and then output buffer.
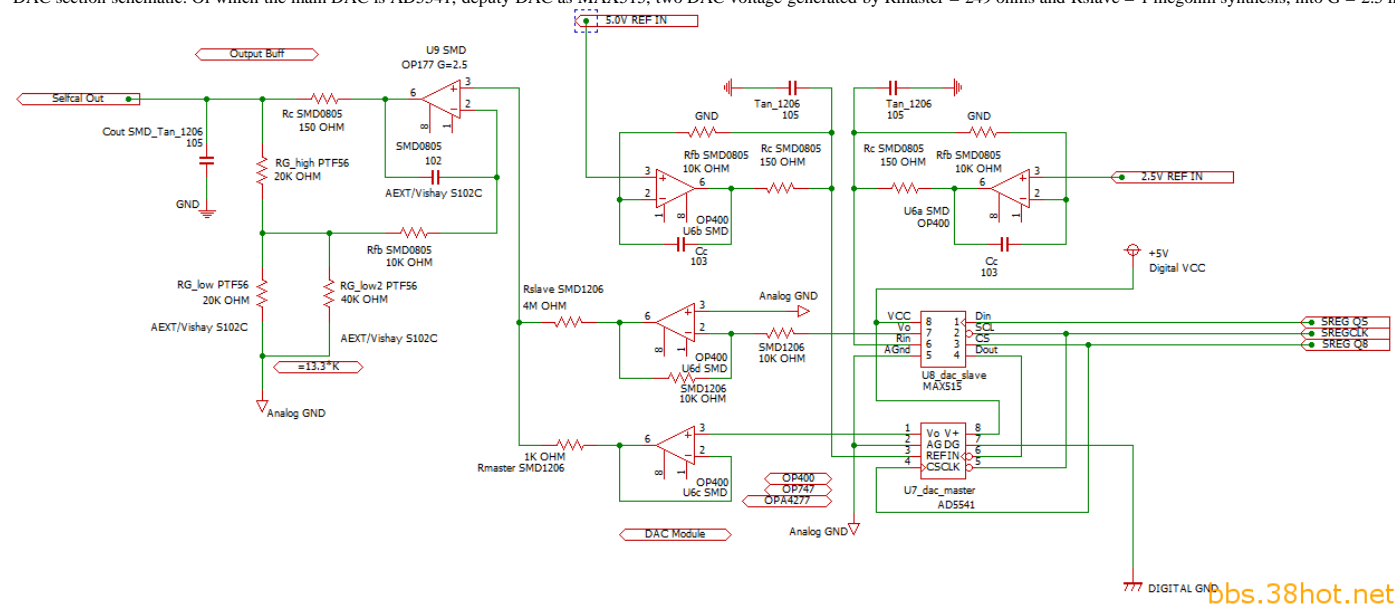
* MAX515 nominal 10bit DAC, but is actually 12bit DAC. Here the issue is not very important, because the main vice DAC DAC 16bit + 10bit even have 26bit.

Theoretically 16bit DAC and 12bit DAC if perfect synthesis, the result is a 28bit DAC, but in fact the voltage synthesis formula
Vout = (Vmaster * Rslave + Vslave * Rmsater) / (Rm + Rs)

Therefore, unless Rs: Rm = 1: 2 ^ 16, or preferably the synthesis is not established. Here, Rs taking 1M OHM, and Rm is 249 ohm, in fact, the ratio is about 1: 4016, it may be simply that Delta (VSlave) the impact of Vout is about 4000, and deputy of the DAC is 5V 1LSB / 2 ^ 12 = 1220uV, therefore the minimum step synthesis DAC is 303nV @ 5V, log2 (5V / 303nV) = 24bit, so in fact the synthesis DAC resolution is 24bit, and ADC just as [s: 12] Since the output buffer gain G = 2.5, so that the final output voltage at 0-12V (0.5V balance adjustment), the minimum voltage programming step is 758nV, designed for the case where 10uV, there are 13 times more resolution margin, very adequate.

ADC part in the design of a DAC to meet the goal after a problem is that, although we believe that an ideal DAC should satisfy f (Input Code) = Vout, Input Code and Vout is perfect linear relationship and constant. But in fact, due to the factors of accuracy and temperature coefficient devices *, in fact, the DAC input and output will not perfectly linear relationship was not that, among its specific Code input and output voltage, also because of temperature changes or devices aging bias. In particular, the design of the DAC output buffer gain temperature coefficient of resistance is not good, it needs to find ways to correct these errors.

* An additional factor is that, Vout = (Vmaster * Rslave + Vslave * Rmsater) / (Rm + Rs) This equation is based on the premise Vout load current 0 down, when in fact the load is here Vout buffer op amp input, which is about a few nA, for Vmaster is due to the combined resistance R = 249 ohms, which is insignificant; for Vslave, because Rslave = 1M in Europe, the impact is relatively large (approximately less than thousandth), the impact will be manifested as poor linearity of the end of a few LSB.

In general, the stability of the current Zener reference has been very high, factors that affect the stability of the entire circuit most other devices, particularly in relation to decisions gain resistance. So if there is a way to regularly check the ratio of the output voltage and the reference voltage, then the output voltage can be easily eliminated errors. To this end, where the introduction of a readback system, in a nutshell is dedicated to creating a basis to design a voltmeter, it regularly between the output voltage and the reference voltage back and forth to detect, since the reference voltage is very stable, so the default voltage decide the case, which is the ratio of the reference voltage is determined, just check the output voltage and the reference voltage and determining the ratio, if the ratio is not equal to the expected, indicating that the output voltage is changed, then the basis of the ratio change, be adjusted come back, we can guarantee the ratio of the output

voltage relative to the reference voltage stability, in effect maintaining a stable output voltage. Here, other than the error in the evaluation have been eliminated, and only the reference voltage and the output voltage will be taken to the result.
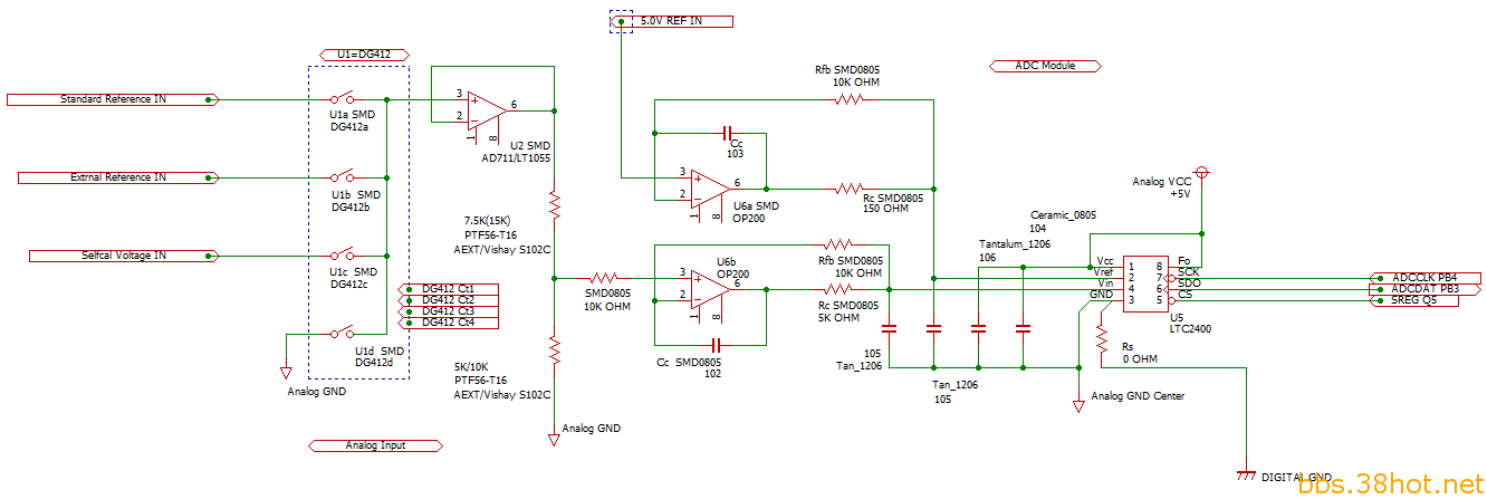
Read back part of the circuit, the entire readback part by the input multiplexer is microprocessor controlled, input buffers, and 24bit of ADC composition. Under the control of the microcontroller program, input multiplexer back and forth before the output voltage and the reference voltage switching, ADC to digitize and two voltage into the microcontroller, the ratio of both the microcontroller detects and adjusts the output voltage DAC in line with the preset ratio in order to maintain a stable output voltage.

Author: lilith **Time:** 2013-3-21 21:01
Second, the device uses and analyzes

The release key device
1, the voltage reference LM399
Analysis: LM399 is a proven, widely used in six and a half multimeter and programmable voltage source other equipment in the thermostat reference, with the use of simple, self-heated, etc., and is used extensively for six and a half multimeter merchandise fact that its long-term stable performance to meet the 25ppm / design of this vision. However, LM399 also have drawbacks, mainly noisy, this noise is the reference for the ADC problem is not great, because of the integral time can be well averaged out noise, but also the design of the program smoothing filter. However, as the DAC reference source problem is quite large, a direct result of a large-noise output voltage, and this voltage as the ADC input signal (not a reference), will be reflected in the results true, the result is the result of automatic calibration uncertainty increases.

Improved: There are several ways to further improve the baseline, one is the use of expensive but more stable, lower noise LTZ1000; one is another to establish a low-noise, but independent benchmark long-term stability less demanding as ADC and DAC reference source, the PCB aside the corresponding location on a third party can create their own reference board installed.

* Manual LM399 long stable data, one is the list 8ppm per S1000h, one note4 of 20ppm per S1000h, a long stable reference chart curve
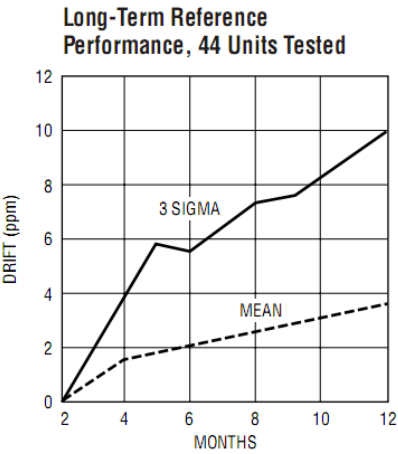
3 times the standard deviation statistics, 44 399 long stability of 10ppm, which means that if mass-produced, most of them are largely the product falling within this range, so for this design is to meet the design vision.

2, ADC's LTC2400

Analysis: As the resolution to meet the six and a half Goods sigma-Delta ADC, 2400 relatively cheap, relatively good welding, but it is not very good choice, it's non-linear error is relatively large, input noise is relatively large (about 6 to 7uVpp), which is unfavorable for self-calibration, it will lead to self-calibration results increased uncertainty.

Improvement: use lower noise ADC, such as LTC2440,2442, or ADS1255,1259.
* Some 24bit ADC performance comparison

	Speed	Noise(RMS/PP)	ENOD Bit	Linear	Offset Error	Gain Error	Offset Drift	Gain Drift	In/REF Current
LTC2400	6.25HZ	1.5uVrms	21.7bit	4ppm~15ppm	0.5ppm~2ppm	4ppm~10ppm	0.01ppm/℃	0.02ppm/℃	960nA
LTC2440	7-3KHZ	200nVrms	24.6bit	5ppm~15ppm	2.5uV~5uV	10ppm~30ppm	20nV/℃	0.2ppm/℃	22uA
LTC2442	7-8KHZ	220nVrms	24.4bit	2ppm~10ppm	2.5uV~5uV	10ppm~50ppm	20nV/℃	0.2ppm/℃	
ADS1232	10-80HZ	0.42uV/1.8uV	23.5 bit	2ppm~10ppm	0.2ppm~5ppm	10ppm~0.02%	0.3uV/℃	0.2ppm/℃	3nA/10nA
ADS1259		0.45uV/1.6uV	23.4bit	0.4ppm~10ppm	40uV~250uV	0.05%~0.5%	0.05~0.25uV	0.5~2.5ppm	

3, DAC's AD5541, MAX515 and voltage synthesis resistors RMaster, RSlave
Analysis: The main 16bit AD5541 is a precision DAC 8-pin, and the upper limit of the reference voltage source which can accept is + 5V, then as a final output of 0-12V this design, it requires a 2.5 gain of the output buffer, This results in relatively balanced, the output voltage performance after all largely depend on the main DAC. As fine-tuning deputy DAC, with the cheap MAX515 to reduce costs, according to the voltage synthesis formula
Vout = (Vmaster * Rs + Vslave * Rm) / (Rm + Rs)
Here Rmaster 249 ohms, Rslave is 1M ohm, deputy DAC voltage output is affected by the ratio is very small, so there is no need to choose overly expensive, high-performance devices. Similarly, the impact of RMaster, RSlave these two resistors on the output voltage has been weakened thousands of times, so that the two resistors is not necessary to use expensive high stability devices.
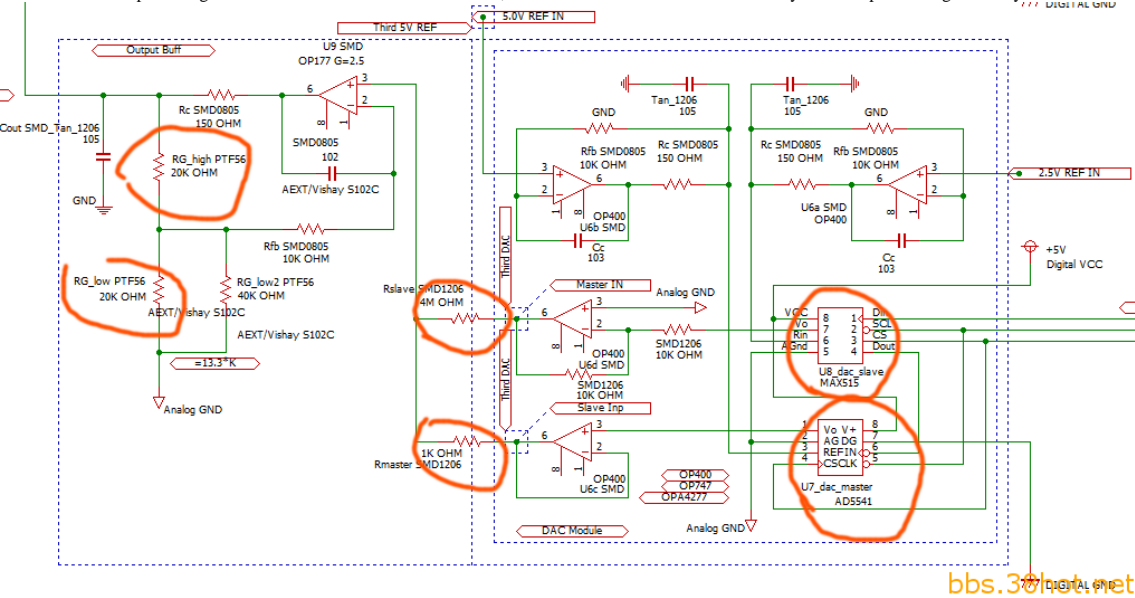
4, the external voltage reference circuit of the original, including the bootstrap operational amplifier OP07, the buffer op amp OP177, itself resistance to RHi, RLo, LM399 limiting resistor Rz
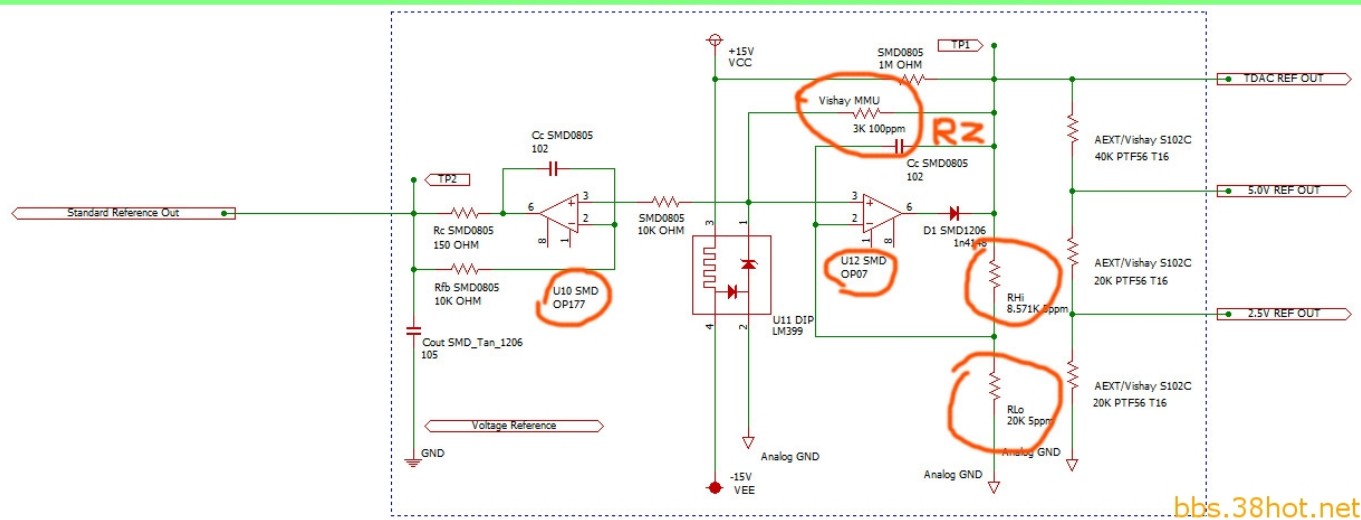
Analysis: The reference voltage is the only reference to the whole system, so even with self-calibration, but the reference itself changes can not be calibrated, so this circuit must strictly consider the impact of index at a preset vision, used every device These decisions affect the performance of the entire system.

In the voltage reference circuit, operational amplifier OP07 to bootstrap voltage reference LM399 as a reference by RHi, RLo a relatively stable proportion of the output voltage of 10V, 10V voltage through the current limiting resistor Rz LM399 to 399 of their own power, according to the LM399 manual Iz Vz given relationship and from the point of view is basically a function of the curve, with a typical value 6mV per (10-0.5) mA = 632uV / mA. Rz is 3K When this current is about 1mA, the range of parameters given in the manual. Here, I chose Vishay MMU / MMB cylindrical metal film resistors (MELF), its manual gives indicators
a, a temperature coefficient of 100ppm
b, P70 of Loadlift (longterm) of 0.3% per 8000h (almost a year), 1% per 225000h (25 years)
In it, the maximum power consumption of LM399 limiting resistor Rz = 3K, Iz = 1mA, Pr = I ^ R = 3mW, far lower than the P70, it has a long steady resistance (longterm) is much better than b set forth Loadlift It can be optimistic that change little. Well, mainly due to the effect of temperature analysis. Rz known temperature coefficient of 100ppm, then the temperature change of 1 degree change in resistance 3K * 0.01% = 0.3 Europe, Iz change (10V-7V) / 3K delta (0.3) = 0.0001mA, equivalent voltage Vz change 0.0632uV, 0.0632uV / 7V = 0.009ppm, ie Rz temperature coefficient of 100ppm weakening of 0.009ppm, weakened 11111 times.
Therefore, the change Rz is almost no need to worry, even if Rz 1% change in the voltage change is only 90ppm, which is under 25 years of index P70 does, in fact, since the resistance of the power is much lower than P70, so long is stable do not worry, because the LM399 long steady more rotten.
Then is RHi, RLo resistor, assuming use Vishay MMU / MMB resistance, and unfortunately the opposite hypothesis of resistance drift direction, so that the temperature change of 1 degree leads to 10V change 200ppm (rotten died), that is 2mV, equivalent to Iz change is 0.000667mA, equivalent Vz change 0.42uV, this effect is relatively large, there are 0.06ppm, the temperature can reach 20 degrees, then 1.2ppm.
Therefore, according to a preset target can be determined and the reference resistor adopted three related, I Rz selected Vishay MMU, it does not need to improve. However RHi, RLo use MMU is also possible, LM399 itself has zero temperature coefficient of several ppm, the impact on the resistance, in fact, far less than the LM399 itself. If the ultimate pursuit of better temperature coefficient performance indicators can be used 5ppm PTF56 or S102C and other resistance.

Since the above analysis of the bootstrap circuit stability, so the use of the bootstrap operational amplifier OP07 is sufficient; but 399 reference buffer output op amps chose OP177, this is because it is self-calibration program unique reference point, its temperature coefficient and stability is directly reflected in the output, then the OP07 1.3uV / degrees C temperature coefficient (Vos Drift / Temprature) becomes relatively large, if the temperature of 20 degrees, OP07 output may vary 26uV, relatively speaking 7V is 3.7ppm , is a relatively large change, hence the use of the temperature coefficient of the offset voltage of the op amp smaller OP177. This indicator OP177 is 0.3uV / degree, if the temperature of 20 degrees, the maximum output may vary 6uV, not in terms of the relative 7V 1ppm.

5, peripheral original voltage reference circuit for ADC and DAC reference voltage of 3 dividing resistors, as well as their buffer op amp; DAC voltage output buffer, and output buffer gain resistance analysis: In order to provide a baseline ADC and DAC 3 voltage dividing resistor is separated from the 10V from 5V reference voltage to ADC and DAC main use, and then separate the 2.5V reference voltage to the sub-DAC use. In the absence of self-calibration, they also have 100% of the output voltage of the absolute impact, but since the calibration procedure eliminates this error, so the short-term stability better Vishay MMU / MMB has sufficient resistance. Also determines the resistance DAC output buffer gain is the same.

Therefore, there is a buffer op amp can be used more general operational amplifier OP07, without using too expensive OP177 operational amplifier.

Improved: Due to the intervention of self-calibration procedure, so that the voltage source for non-stop adjustments and has poor short-term stability, in order to obtain better performance of short-term stability can be turned off from the calibration procedure performed in real time, when the temperature coefficient of the device can not be eliminated, then these resistors are resistance temperature coefficient less beneficial to obtain a better temperature coefficient performance closed the case since the calibration procedure performed under real-time. Obviously, the operational amplifier OP07 is replaced by the OP177 also help to reduce non-adjusting temperature coefficient state.

In this version the PCB, TR due to its stick with the 4 op amp package, not only a waste of the op amp, and most do not need to use the op amp OPA4277 (OP177 equivalent) grade op amp, and because OPA4277 more expensive (about 25 soft a sister coins), so I was very opposed to doing.

The main impact on performance of the device and the analysis above, the remaining impact of the device is little or no impact. Modulus isolation part, I advocate the use of low-power and high integration ADUM14xx series magnetic coupling, but TR to save the cost of using high-speed optocoupler cottage HCLP2631 (op amps he does not consider how to save money) combinations and 6N137, so The result is a more isolated part of the periphery of the original and circuit complexity, power consumption.

Author: lilith **Time:** 2013-3-21 21:03
Occupying 3
This version PCB brief description

Please refer TR write posts

Author: lilith **Time:** 2013-3-21 21:03
Fourth, production and commissioning

Production section 3 mentioned in the post also explained, will not repeat them here, this chapter focuses on how to debug. If you experience other in debugging problems, welcome to the "summary of the issues" raised posts
http://bbs.38hot.net/read-htm-tid-38857.html

This chapter describes only the components correctly installed and turned on after the burning process, through a subsequent debugging self-test.

0, ready to debug the equipment, this debugging need a reliable voltmeter, it should have at least more than six and a half of the resolution, 0.1ppm linearity and 8ppm accuracy specifications and calibrated. Recommended equipment for the Agilent (HP) 3458A, Advantest R6581, Fluke 8508, Datron 1281 and so on.

1, the reference voltage calibration (ADC full-scale gain calibration)

Since the program preset LM399 voltage of 7V, while in fact 399 voltage between 6.75V-7.25V distributed, so the new production of a good voltage source is first turned on, the program preset 10V output, in fact, is 10 * (399Vz / 7V), I do not recommend the purchase of second-hand disassemble the LM399, therefore in general closer to the new year are, they are slightly higher than the voltage of 7V, so the first boot of the output voltage is slightly higher than 10V, so to make a reference voltage source voltage calibration.
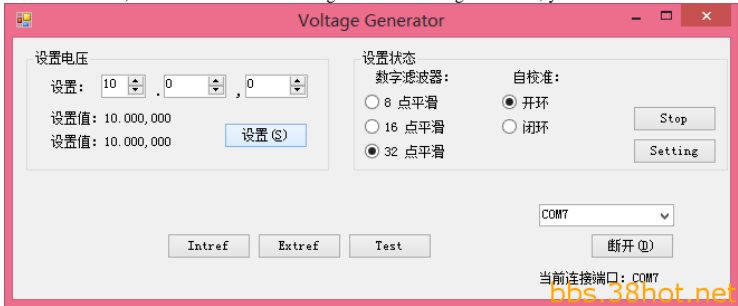
Calibration steps:
This time with a voltmeter measure the output voltage V1st., It is the ratio of 10V LM399 reference voltage and the ratio of 7V, The assumption measured output of 10V is 10.024578V, then the LM399's voltage should be 7.0172046V, to fill the reference section. This step calibration reference voltage, it will ensure the program is set to 10V when the output voltage is 10V.

2, the output buffer of the full-scale DAC gain calibration is due after a G = 2.5 buffer output, so the need for the actual gain of the buffer calibration, this one is not very necessary, because the self-calibration procedure of intervention, Even if do not do this step, self-calibration procedure can also be calibrated to the correct value (subject to reference voltage 399) output. However, if the gain deviation is large, self-calibration program will take longer to adjust the output voltage to come back, so this step was still meaningful.

Calibration steps:
The voltmeter connected to the output of the voltage source, and then press the "Reset" button to restart voltage source, during the first working cycle into the working interface after reading voltmeter and 10V is the ratio of full-scale gain calibration value, writes a column full-scale gain. If the reading is too late, you can insert the USB cable, and then run the PC program, set the working status of the open-loop, set the output voltage of 10V, and reading.

3, non-linear calibration

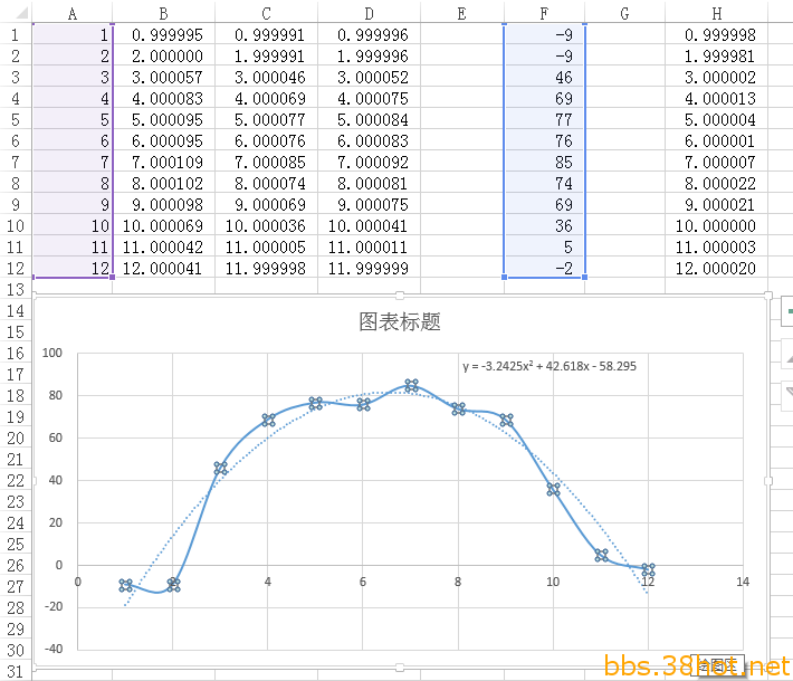Due to several factors, readback system there is a certain nonlinear error
a, ADC itself nonlinearity error
b, on-resistance analog switch on-resistance matching and leakage current
c, op amp drift and gain error

In general, after the reference voltage calibration, since the presence of auto-zero circuits and procedures, so 0:00 is no calibration, so the 0:00 and 10V point after calibration has been accurate, and the overall non-linearity error is substantially 0 A class of quadratic function curve between -10. After testing several prototypes later, I will be summarized into a quadratic trinomial writer, in general meet the application in most cases.

But it also found that the production of the prototype, a quadratic function of the gap between non-linear error curve with the desired number of prototype large, non-linear correction for a more perfect, can make their own specific non-linear error curve. Program provides secondary and tertiary quadranomial Trinomial two curve template. Before drawing a specific curve should be subject to the coefficients of the current curve of zero, so that the non-linear error correction function does not interfere with the work program, and then use a voltmeter connected to the output of a reliable source on the PC using the PC program in order to set 0-12V The 13 points, and read the voltmeter actual voltage value this 13 point, the error between them and the setting is that every point of "total unadjusted error", the error and set the value of the total unadjusted do XY graph (X-axis position is set to a value, Y axis error value), you can get a total unadjusted error curves, quadratic or cubic curve fit this total unadjusted error curve, two or three times to get the curve coefficient can be backfilled into the program.

Note the use of the PC to set the output voltage of the voltage source, because of the implementation of self-calibration procedure takes time, should set up a new voltage after a period of time and then reading from the voltmeter, which generally takes about 10 second, you can observe a voltage source at the bottom right of the screen Run Setp, when completed at least one cycle (0-16) to read, or read back the value of the voltage source to observe the second line is equal to the set value of the first row When will the readings from the voltmeter.

Model: voltmeter readings fill the table column C, and set its value (table columns A) the error is calculated, fill in the table column F, and then do the column A as X-axis, Y-axis column F for the XY relationship map and fitting this curve. Table column H is retesting the case after you apply this curve, showing the nonlinear error is corrected relatively perfect.
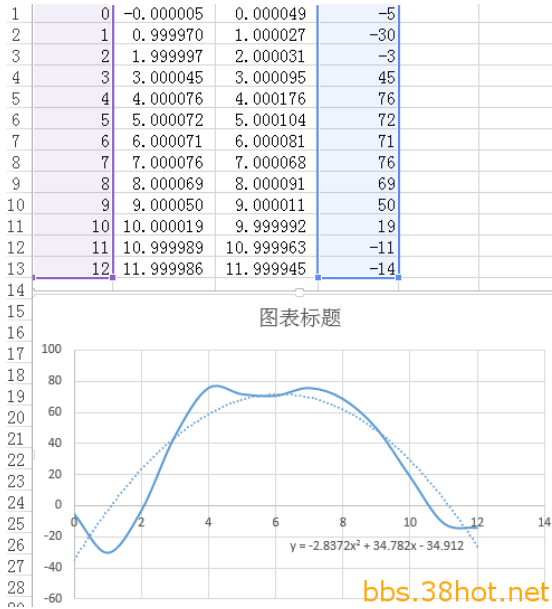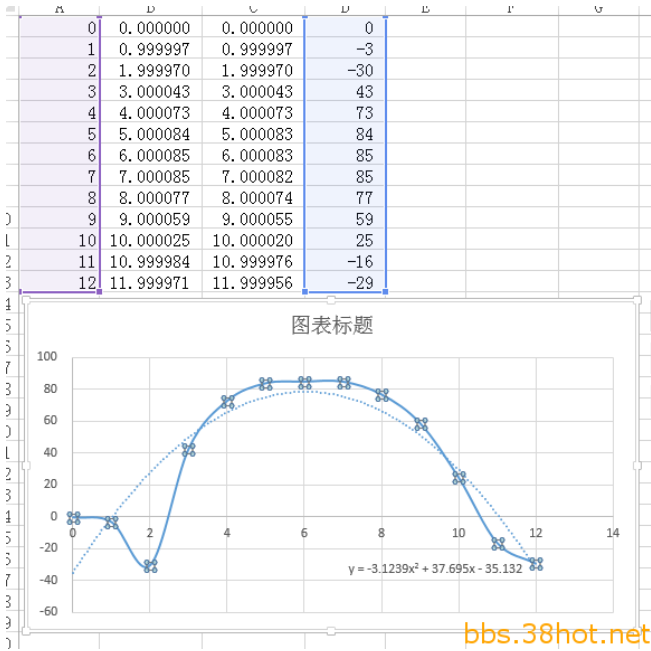
	A	B	C	D	E	F	G	H
1	1	0.999995	0.999991	0.999996		−9		0.999998
2	2	2.000000	1.999991	1.999996		−9		1.999981
3	3	3.000057	3.000046	3.000052		46		3.000002
4	4	4.000083	4.000069	4.000075		69		4.000013
5	5	5.000095	5.000077	5.000084		77		5.000004
6	6	6.000095	6.000076	6.000083		76		6.000001
7	7	7.000109	7.000085	7.000092		85		7.000007
8	8	8.000102	8.000074	8.000081		74		8.000022
9	9	9.000098	9.000069	9.000075		69		9.000021
10	10	10.000069	10.000036	10.000041		36		10.000000
11	11	11.000042	11.000005	11.000011		5		11.000003
12	12	12.000041	11.999998	11.999999		−2		12.000020

图表标题

$y = -3.2425x^2 + 42.618x - 58.295$

Source code templates built nonlinear error

```
0035                    ' Constant
0036 '////////////////////////////////////////////////////////////////////
0037 Const fMasterReference = 7.042581E+00     'LM399 Voltage Value
0038 Const fDACReference = 5.000000E+00        'DAC Voltage Reference Value
0039 Const fDACenter = 2.500000E+00           'Slave DAC Default Output Voltage Value
0040 Const fDACGain = 2.500000E+06            'DAC Output buff Gain
0041 Const fMResistance = 2.49E+02            'DAC Voltgae Compound Resistance, the Master
0042 Const fSResistance = 1E+06              'DAC Voltgae Compound Resistance, the Slave
0043 'Const Cubic = -3.566e-01
0044 Const Quadratic = -3.2425e+00           'No-line Error Adjuest Quadratic Coefficient    二次项系数
0045 Const Linear = 4.262e+01               'No-line Error Adjuest Linear Coefficient       一次项系数
0046 Const Constant = -5.8295e+01            'No-line Error Adjuest Offset Coefficient       常数
0047 Const fDacal = 1.005288e+00            'DAC Fullscale Error Adjuest Vale
0048 Const Synthesis = &b00000001            ' Analog Switch = Synthesis Voltage Output    | DG412 Pin
0049 Const Reference = &b00000010            ' Analog Switch = Internal Reference(LM399)   | DG412 Pin
0050 Const ExternaIN = &b00000100            ' Analog Switch = Externa Voltage Input       | DG412 Pin
0051 Const GndOffset = &b00001000            ' Analog Switch = Auto Zero                    | DG412 Pin
0052 '
0053 '  No.4
0054 '       Ref = 7.038939e+00     Quadratic = -3.2425e+00     Constant = -5.8295e+01
0055 '       DAC = 1.006520e+00     Linear = 4.262e+01     Refnew = 7.038941E+00@2013-02-28
0056 '  No.5
0057 '       Ref = 7.012488E+00     DAC = 1.002406e+00
0058 '       Noline Adj like No.4
0059 '
0060 '  No.1 mod 1
0061 '       Ref = 7.032585e+00     DAC = 1.0052706e+00
0062 '
0063 '  No.3
0064 '       Ref = 7.042602E+00     DAC = 1.005294e+00     Constant = -1.7462e+01
0065 '       Cubic = -3.566e-01     Quadratic = 6.1434e+00  Linear = -2.2633e+01
0066 '       DAC = 1.005288e+00     Ref = 7.042581E+00 this line @2013-03-08
0067 '
0068 '  No.2
0069 '       Ref = 7.080451E+00     DAC = 1.012783e+00
0070 '       Noline Adj like No.4
0071 '////////////////////////////////////////////////////////////////////
0072                    ' String Variables
0073 '////////////////////////////////////////////////////////////////////
```
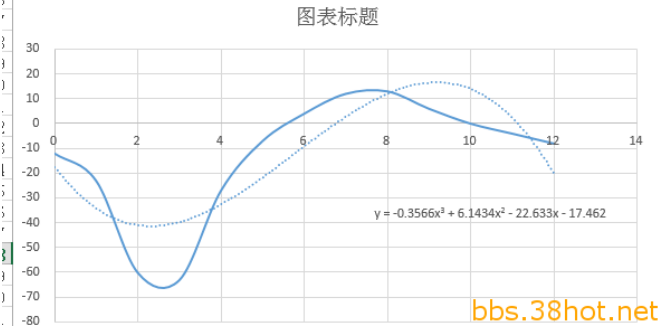
Nonlinear not every station can be corrected more perfect, two prototypes of the following non-linear error similar to the above example, even if the same curve better results can be obtained:

	A	B	C	D	E	F	G
0	0.000000	0.000000	0			
1	0.999997	0.999997	−3			
2	1.999970	1.999970	−30			
3	3.000043	3.000043	43			
4	4.000073	4.000073	73			
5	5.000084	5.000083	84			
6	6.000085	6.000083	85			
7	7.000085	7.000082	85			
8	8.000077	8.000074	77			
9	9.000059	9.000055	59			
10	10.000025	10.000020	25			
11	10.999984	10.999976	−16			
12	11.999971	11.999956	−29			

图表标题

$y = -3.1239x^2 + 37.695x - 35.132$

1	0	−0.000005	0.000049	−5	
2	1	0.999970	1.000027	−30	
3	2	1.999997	2.000031	−3	
4	3	3.000045	3.000095	45	
5	4	4.000076	4.000176	76	
6	5	5.000072	5.000104	72	
7	6	6.000071	6.000081	71	
8	7	7.000076	7.000068	76	
9	8	8.000069	8.000091	69	
10	9	9.000050	9.000011	50	
11	10	10.000019	9.999992	19	
12	11	10.999989	10.999963	−11	
13	12	11.999986	11.999945	−14	

图表标题

$y = -2.8372x^2 + 34.782x - 34.912$

The prototype of this total unadjusted curve is very bad, prior to use common curve fitting is very bad, then use it three times a particular four formula better

o6581	n6581	set		err	adj_genera	adj_cubic2
−0.000012	−0.000009	0		−12		
0.999977	0.999981	1		−23	1.000000	1.000008
1.999940	1.999944	2		−60	1.999932	1.999987
2.999937	2.999941	3		−63	2.999912	2.999978
3.999973	3.999978	4		−27	3.999942	4.000014
4.999993	4.999997	5		−7	4.999945	5.000018
6.000004	6.000008	6		4	5.999955	6.000025
7.000012	7.000016	7		12	6.999978	7.000024
8.000013	8.000017	8		13	7.999978	8.000023
9.000006	9.000009	9		6	9.000001	9.000008
10.000000	10.000000	10		0	10.000006	10.000005
11.000004	11.000007	11		−4		
12.000008	12.000005	12		−8		

图表标题

$y = -0.3566x^3 + 6.1434x^2 - 22.633x - 17.462$

bbs.38hot.net

Subsequent adjustments:

After the application of non-linear error correction curve shall be retested 0V and 10V point is shifted, if a large shift occurs, you can consider re-alignment of these two points. Because of the nonlinear has been calibrated, it can be considered at this time is a linear function of the voltage source, the input (set value on the PC program) between the output (voltage) and a first order function, so the first error correction 0:00, this error can be corrected by a constant term non-linear calibration template will subtract 0:00 this error on the multimeter fill reflected back to fix error 0:00. 0:00 after error correction, and then re-calibrate the reference voltage of the first term (ADC full-scale gain calibration) that can point error correction 10V.

Author: lilith **Time:** 2013-3-21 21:04
Placeholder 5
Subsequent development

Author: ccpoint **Time:** 2013-3-21 21:08
Strong support element scarcity, can only have the opportunity to re-imitation,

---

Author: draco **Time:** 2013-3-21 21:09
After the first look at the top

Author: Highrise small village **Time:** 2013-3-21 21:25
[S: 2] [s: 2] [s: 2]

Author: lp206 Time: 2013-3-21 21:28
Alas, not inserted into the floor, the top lz

Author: puff **Time:** 2013-3-21 21:33
Like this one could not help but insert

Author: laisla Time: 2013-3-21 21:36
[S: 2] I came, insert floor with.

The floor for some of my practice in the design of PCB's explanation

About quad op amp:
In fact, I do not want such a high cost element. However, due to the alignment problem on a board, so I can not in practice too many and too complicated about the power cord (the first was pointed out in my power to have problems, it is a manual board, and only one, easy to find the reason). And every one op amp must be three lines. Such power line and other lines cross will be a lot, interspersed with lines and more crowded in some places you can only use a finer line, so the moderator if the intention to reduce the op amp power supply wire, determined not currently When the problem is gradually 4 op amps replace single op amp.

About optical coupling:
Light lotus power consumption than the magnetic lotus large, so the heat is also large, slower than the magnetic coupling, and out of the signal also needs an integer, the disadvantage is obvious.
But no optical coupling magnetic interference, as to whether this version there magnetic interference, and magnetic lotus itself is magnetic interference problem is solved, there is no conclusion, but a magnetic lotus adapter board can be replaced with optical coupling portion of the magnetic coupling, there is You need to contact me.

Author: tkdr2001 Time: 2013-3-21 21:36

Learn, every day

Author: Yu as **Time:** 2013-3-21 21:37
And other customized version! ! ! ! ! ! ! ! ! ! ! [S: 3]

Author: src100 Time: 2013-3-21 21:38
Learning.

Author: niceman Time: 2013-3-21 21:54
Move the stool, serious lectures! Learn, every day! [S: 7]

Author: zy_sh_npk Time: 2013-3-21 21:54
Washu every day! [S: 31]

Author: winsonma Time: 2013-3-21 21:54
First sit down and lectures, and other customized version after! ! ! [S: 3]

Author: fffofo Time: 2013-3-21 22:43
I quickly put out the second edition came out simplified

Author: Lu BMW **Time:** 2013-3-21 23:11
Front placeholder [s: 7]

Study: Arctic wind **Time:** 2013-3-22 08:10
Very good learning materials, must be the top!

Author: zwei13 Time: 2013-3-22 08:17
[S: 14] .....

Author: A cup of tea **Time:** 2013-3-22 10:28
First sit down and lectures, and other customized version after!

Author: jameserik Time: 2013-3-22 10:45
Title: Back laisla Posts

> laisla : [s: 2] I came, insert floor with.
>
> The floor for some of my practice in the design of PCB's explanation
>
> About quad op amp:
> .... (2013-03-21 21:36)

Internal magnetic coupling magnetic isolation, can be used to do some experiments magnet

---

Author: laisla Time: 2013-3-22 10:56
Title: Back jameserik Posts

> jameserik : magnetically coupled with a magnetic isolation inside, you can do some experiments with a magnet (2013-03-22 10:45)

The magnet test alone could not see any effect of it.
Or do and so do the magnetic lotus conclusion of the test after someone, if the magnetic lotus in simplified section line is not a problem, it can be considered for use.

Author: zsxlh Time: 2013-3-22 12:37
Come in lectures, study hard.

Author: dy008 Time: 2013-3-22 13:10
[S: 14] Well, or the like Kit now!

Author: wangyn0114 Time: 2013-3-22 16:17
And other packages it, really good

Author: aa2206 Time: 2013-3-22 16:30
Circuit diagram is too small to see. Can you send a bigger,

Author: bigeblis Time: 2013-3-22 16:40
Top experts use quad op amp is beneficial to take the power cord, then, can be considered to increase the power level.

Author: minideerx Time: 2013-3-22 18:25
Strongman, must be the top, saying, red and black crystal so beautiful, seeking links ~

Author: minideerx Time: 2013-3-22 18:26
Excellent articles, support! n God horses are clouds

Author: strong brother **Time:** 2013-3-22 18:52
Move the stool, serious lectures! Learn, every day! [S: 32]

Author: htbst Time: 2013-3-22 21:45
Expert, must be supported by

Author: kkshell Time: 2013-3-22 21:46
First sit down and lectures, and other customized version after! ! ! [S: 11] [s: 7] [s: 7] [s: 7]

Author: pizicai0330 Time: 2013-3-22 22:15
Cattle ah. I do not know can not buy from the finished ah

Author: kernelhmm Time: 2013-3-22 22:45
Passing lectures

Author: cdma **Time:** 2013-3-23 08:41
Occupying the front row. . .

Author: shushiquan Time: 2013-3-23 11:46
The successful development, buy the copyright [s: 7]

Author: henserlu Time: 2013-3-23 12:08
LZ can consider increasing the oversampling principle A / D resolution, but that the bandwidth A / D is reduced too quickly ...... But this change in frequency low voltage reference, and should be considered!

Author: tudou204 Time: 2013-3-23 12:08
Excellent articles, support! n God horses are clouds, to learn.

Author: jj3055 Time: 2013-3-23 18:21
Congratulations, finally out of the official version. With this thing, you can put those resistance turns 10 op amp booster 7 What gave Bidiao.

Author: lilith **Time:** 2013-3-23 19:04
Title: Back minideerx Posts

> minideerx : strongman, must be the top, saying, red and black crystal so beautiful, seeking links - (2013-03-22 18:25)

Help me draw PCB and buy the actual production of TR [s: 12] I did not say it, you ask TR look [s: 173]

Author: lilith **Time:** 2013-3-23 19:08
Title: Back henserlu Posts

> henserlu : LZ can consider increasing the oversampling principle A / D resolution, but that the bandwidth A / D is reduced too quickly ...... But this change in frequency low voltage reference, and should be considered! (2013-03-23 12:08)

LTC2400 output data format is 1bit symbol address, 1bit overrange bit, 24bit data bit, 4bit "redundant data" bit, so this is actually far more than 24bit, 24bit = 16,777,216 and even count, more than enough here, so it seems there is no need to continue oversampling.

And in fact there's a constraint that is, floating-point compiler provides a single-precision floating-point, integer 7, far below the data and DAC hardware synthesizer provides a resolution of 2400 [s: 164]

Author: lilith **Time:** 2013-3-23 19:18
Title: Back jj3055 Posts

> jj3055 : Congratulations, finally out of the official version. With this thing, you can put those resistance turns 10 op amp booster 7 What gave Bidiao. (2013-03-23 18:21)

This is also too early to say [s: 18]

In reference are the same, the resistance of the op amp + 10V, long-term stability and temperature stability and long-term stability depends on the temperature coefficient of resistance (op amp influence is very small), under the relentless feeding through here if + test screening, can achieve a good indicator, in fact Fluke 731B / 732A is not just that thing [s: 32]

However, most people in most cases quite superfluous, the material + high price under the relentless screening test, so my proposal is actually an inexpensive alternative to solve a disguised stability 7to10 resistance, but the effect is actually worth deliberate the [s: 12] First, the key components of the system used, such as ADC, Analog switch also will be aging, their impact and the extent of resistance rather, there is no answer to this question; secondly, it is reliability, the whole system is too complicated, too many links, analog switch, an input buffer, ADC, output buffer, and the entire digital section, as well as algorithms, are to a large extent affect the output voltage, the reliability is clearly more than just the two resistors to be worse on lot.

Finally, there is a problem is the noise, having been tested to see whether the device is better able to further reduce the noise, but because too many devices pile, on the whole than the simple noise op amp + resistance, may still be a lot of difference .

Therefore, the focus of the production is the "Indicators 25ppm" self-calibration, and 0-12V, 6 and a half of the Resolution, so I call it Voltage Generator instead Voltage Reference (Standard) [s: 28]

Author: zhengrob Time: 2013-3-23 19:39
Like this one!

Another landlord circuit diagram is what painting tools, looking very comfortable.

Author: lilith **Time:** 2013-3-23 19:41
Title: Back aa2206 Posts

> aa2206 : circuit diagram is too small to see. Can you send a bigger, (2013-03-22 16:30)

38 Forum program seems to be a problem, you try to click on the picture to open if changes to its original size in a new window? I am here, I am made up of original size [s: 171] [s: 172]

Author: downwind Hall **Time:** 2013-3-23 21:35
The screen is very beautiful, where to buy? How much is it

Author: wtchen **Time:** 2013-3-23 22:08
Good complex first and then wait for a simplified version of the support and then carefully study the principles of

Author: wangyn0114 **Time:** 2013-3-23 22:27
Wait for the finished product, really good

Author: wudecao **Time:** 2013-3-23 22:50
The landlord said the LCD screen of this model Well, there are Friends of the altar know Well,
Feeling is red oled, but it does not look like Jesus.

Author: aa2206 **Time:** 2013-3-24 00:35
See, thank you.

Content from [message]

Author: laisla **Time:** 2013-3-24 01:04
The screen is anti-red color backlit LCD

Author: wyj2004 **Time:** 2013-3-24 15:24
The landlord is a dual panel it? 4 layers mess interference, ground the problem should have been resolved to give it

Author: get off the ground **Time:** 2013-3-25 00:33
Only from a distance, we look forward to the finished product.

Author: cxq200300 **Time:** 2013-3-25 11:12
Starting post is really good information to have a place to learn ,, do not understand
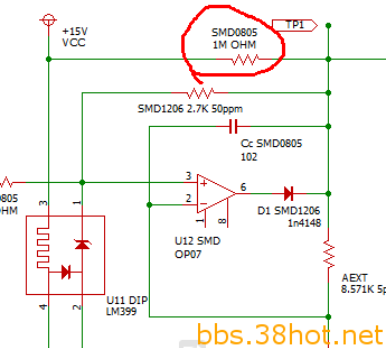
Will this red circle in the 1M resistor what role it? Current this resistor only 0.005mA ah.
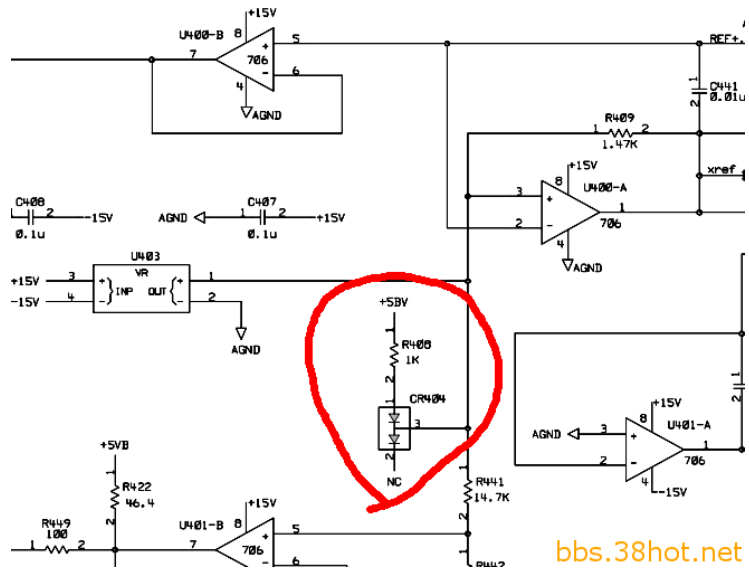
Author: laisla **Time:** 2013-3-25 13:09
Title: Back cxq200300 Posts

> cxq200300 : good information starting post is really a place of learning ,, do not understand
> [Attach] 207954 [/ attach]
> Will this red circle in the 1M resistor what role it? Current this resistor only 0.005mA ah. (2013-03-25 11:12)

My own understanding is that the op amp to 3 feet when the power potential of providing a pull, but after the work of this potential by the operational amplifier to provide their own.

Author: cxq200300 **Time:** 2013-3-25 13:23
I think it is not the role of this part of the circuit with the same hp24401?

provide a bias to assure that the reference zener biases to +7 V during power up. (excerpt from 34401 Maintenance Guide)

Author: cxq200300 Time: 2013-3-25 13:23
Title: Back laisla Posts

  laisla : My own understanding is that when the power to the op amp 3 pin provides a pull-up potential, but this potential after work by the operational amplifier to provide their own. (2013-03-25 13:09)

Just forget the quote, to see upstairs

Author: laisla Time: 2013-3-25 13:37
Do not know, I just felt that the resistor is used to provide a voltage not provide current.

Author: ascetic_wn Time: 2013-3-26 20:13
perfect! ! ! ! ! ! ! ! ! ! ! ! !

Author: pingqq Time: 2013-3-27 10:01
A suite or debugged finished it, really admire, strong attention!

Author: dzkenan Time: 2013-3-27 23:35
What screen landlord very nice ah

Author: songyufeng9 Time: 2013-3-28 07:06
The suite, the whole play!
Serious support [s: 2] [s: 2]

Author: kernelhmm Time: 2013-3-28 14:05
Red lcd true ecstasy. . .

Author: ahhui Time: 2013-3-28 22:17
Getting better and better.

Author: hb2004 Time: 2013-3-30 20:34
Came lectures!

Author: touren Time: 2013-3-31 14:35
Too, came to learn

Author: chem Time: 2013-4-1 22:09
To lectures ....

Study: 38 degrees fever **Time:** 2013-4-3 19:19
I have come to learn, master a lot of ah

Author: jjcky Time: 2013-4-7 08:23
I came to buy ready-made play, the landlord can tell to purchase?

Author: xuwuyang Time: 2013-4-10 21:33
He urged the kit!

Author: apple16588 Time: 2013-4-11 03:28

Table a few old hands refuse to see that you would like to put forward a reference Bihuabihua fear this weapon is low ah estimated costs do not afford [s: 12] saliva it ....

Author: tanjianchao Time: 2013-4-12 19:28

I came to buy ready-made play, the landlord can tell to purchase?

Author: yanjcai Time: 2013-4-12 22:02

Lectures, speak very good landlord, in addition there is a doubt, is how to synthesize the two DAC? Seems to be through the resistor to the figure together with the non-inverting input of OP177, OP177 take the form of inverting amplifier? But not summer, I only know of inverted adder.

==

Just went back to read, is one all the way back and the other way DA DA synthesis, right? Low DA is turned into a negative voltage, and a high positive voltage DA subtraction, and then subtract and then into the OP177 is, is not it

---

Author: x131431511 Time: 2013-4-19 22:18

Speed sets out, my table to wait on this stuff sent!

Author: bearded **Time:** 2013-4-27 17:46

Learning

Author: dy008 Time: 2013-4-28 10:36
Title: Back bearded Posts

> [Beard](#) : learning (2013-04-27 17:46) Gui / color] [?]

Is it with a big beard? [S: 11] [s: 11]

Author: lzyjack Time: 2013-5-4 16:26

The landlord intends to package it? I want to set out the case!

Author: lzyjack Time: 2013-5-4 16:30

Suddenly I found that there are many mixed in there AMO friends! !

Author: qdsongpeng Time: 2013-5-15 11:05

Amazing!

Author: redtony Time: 2013-5-19 10:48

Master ah!

Author: hkl Time: 2013-5-20 04:44

Learning are educated.

Author: dory_m Time: 2013-5-22 07:48

Thank you, learn! ! ! [S: 7]

Author: wandering **Time:** 2013-5-25 13:53

Which out of a finished product?

Study: Arctic wind **Time:** 2013-5-25 19:58

DIY yourself have fun.

Author: xuplastic Time: 2013-6-1 12:15

Ask the landlord to have a voltage generator, coupled with the sampling resistor, is not programmable analog resistive can be made up? According to the sampling voltage and outputs a voltage sampling resistor

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Author: foxbone Time: 2013-6-2 11:21

The cattle, like, is there a package plan? [S: 7]

Author: lsstudy Time: 2013-6-9 20:20

Which out of a finished product?

Author: Explorers **Time:** 2013-6-10 20:16

Too calendar harm.

Author: zw1235 Time: 2013-6-12 23:55

Haotie ~ mark ~ Learning ~

Author: laomao Time: 2013-6-17 10:42

From the torch to kill the altar here ......

Author: phones Time: 2013-6-17 13:31

A finished product.

Author: toolboy Time: 2013-6-26 22:12

Without this module, which is really good

Author: dm8510 Time: 2013-6-27 10:02

Seek kit. . .

Author: mychestnut Time: 2013-6-27 22:53
This is the testimony of strength, learning

Author: tv88 Time: 2013-7-8 08:27
You can book it? To one!

Author: hkl **Time:** 2013-7-8 21:22
He developed a kit

Author: Apple Juice **Time:** 2013-7-12 05:38
Hello, this voltage source there is finished it? Adjustable output voltage is it?

Author: duxingxia747 Time: 2013-7-12 23:42
We look forward to the finished product