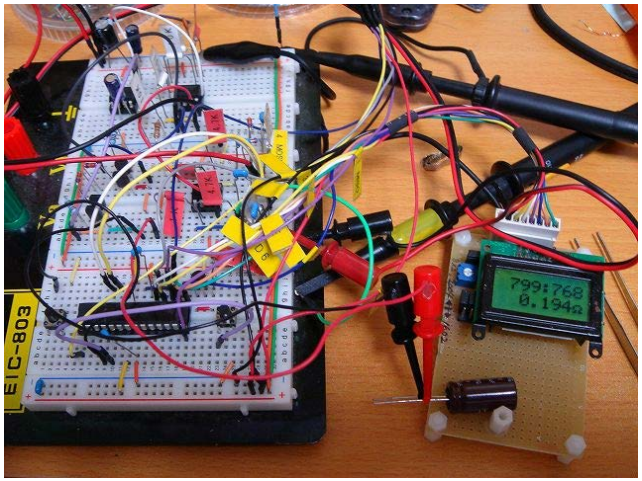
AVRを使ったコンデンサーESRメーターの製作

origin 2010-07-08

" 3 production of the tracking power supply using the terminal regulator last was the deterioration of the "(seems to be ...) While the electrolytic capacitor tried to compare capacity, from those who are always viewing this Web site, "relative merits determination of the capacitor ESR meter is convenient," I received your pointed out that by e-mail.

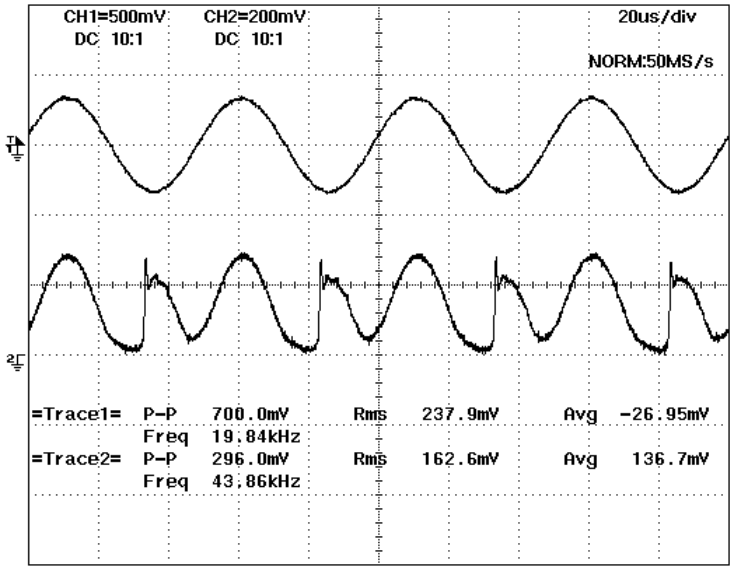
Incidentally we have to introduce the link to become a reference for the Web.

For ESR meter, How can saw around the Web site, it has been published a description and reproducibility of looks good circuit of the operating principle Bob's blog 's the "Experiments of ESR (Equivalent Series Resistor) meter with PIC16F819" Either that ... to reference, it was decided to create nearly intact.

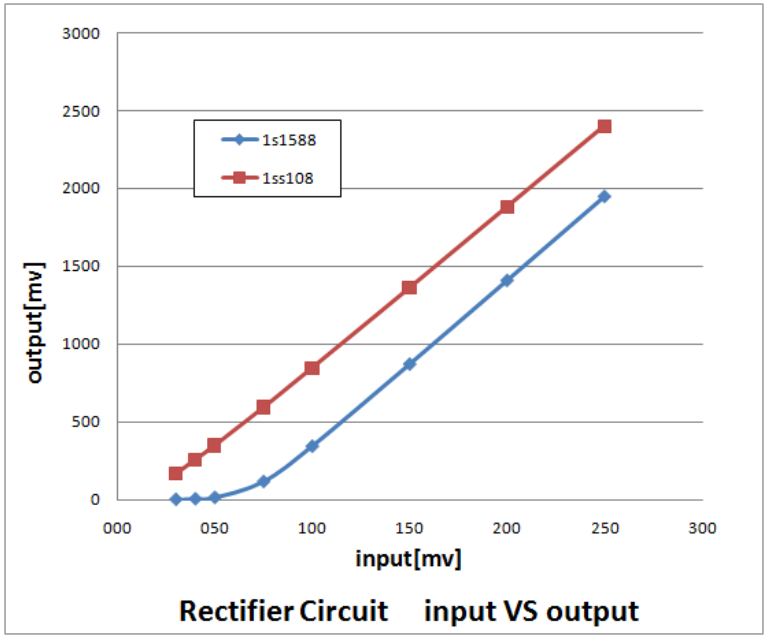


Bob's blog's also been variously attempt to rectifier circuit. In the full-wave rectification of using the diode, the error will increase and ESR increases.

I tried to test circuit and the like also in the same way of the ideal diode that uses an operational amplifier, but it seems hard to rectify the relatively high frequency of 100KHz. In the circuit using the LMC6482 to op amp distortion output waveform is a slew rate shortage at about 20KHz. And I tried the hand of 2 circuit containing an operational amplifier from thorough search, but did not go well. You need to use a large bandwidth with high slew rate operational amplifier.

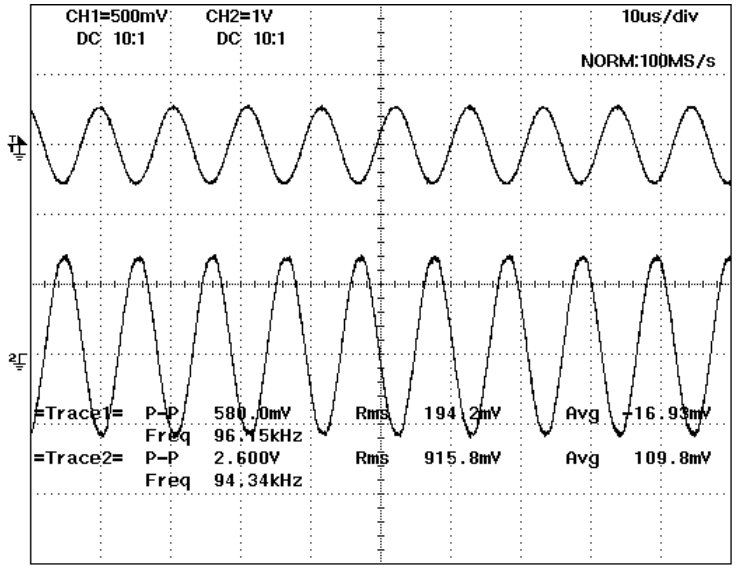


結Eventually, it was decided to create in the amplification + diode full−wave rectification by the op amp. Diode to be used, tried to compare with simulation LTspice the 1SS108 of SBD for 1S1588 a small signal of small signal diodes (Schottky barrier diode). When the signal is small I decided to use the linearity is good 1SS108 (when ... clogging ESR is large).



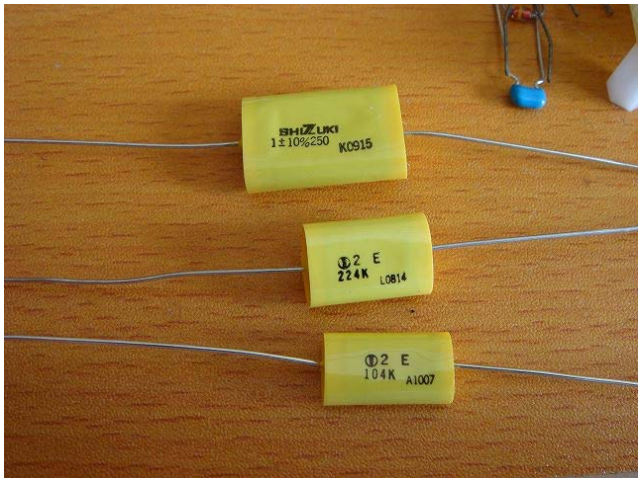
Rectifier Circuit input VS output

Frequency of the AC measurement signal has a 100KHz employed by other ESR meter. Using an operational amplifier was used bridged T−type oscillation circuit which is said to strain than Wien bridge oscillation circuit is small. It became the oscillation of 96KHz in the actual measurement. Clean sine wave from the oscilloscope FFT is I was able to confirm.



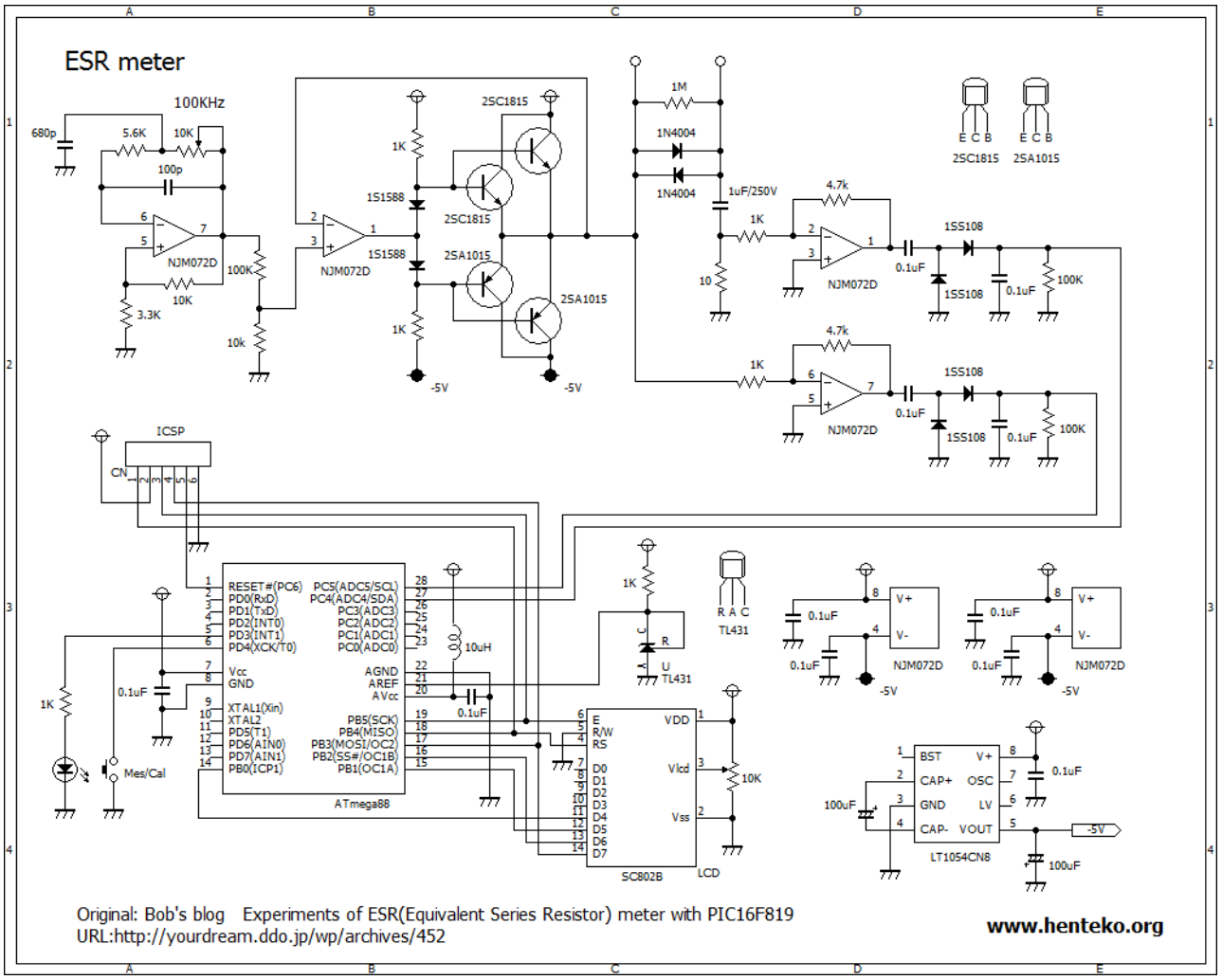
CH1 is bridged T−type oscillation circuit output. CH2 operational amplifier amplified output

Capacitors for high pressure cut to be inserted into the measurement end, it will use the hand of metallized film capacitors from the breakdown voltage of the relationship. At first, I was using a 0.22uF but, ESR total resistance value is increased at the time of the 4Ω near matching high ESR capacitor measurement, measurement error of ESR is now larger as a result. It looks good to better to use a large more than 1uF will reduce the measurement error, if possible.

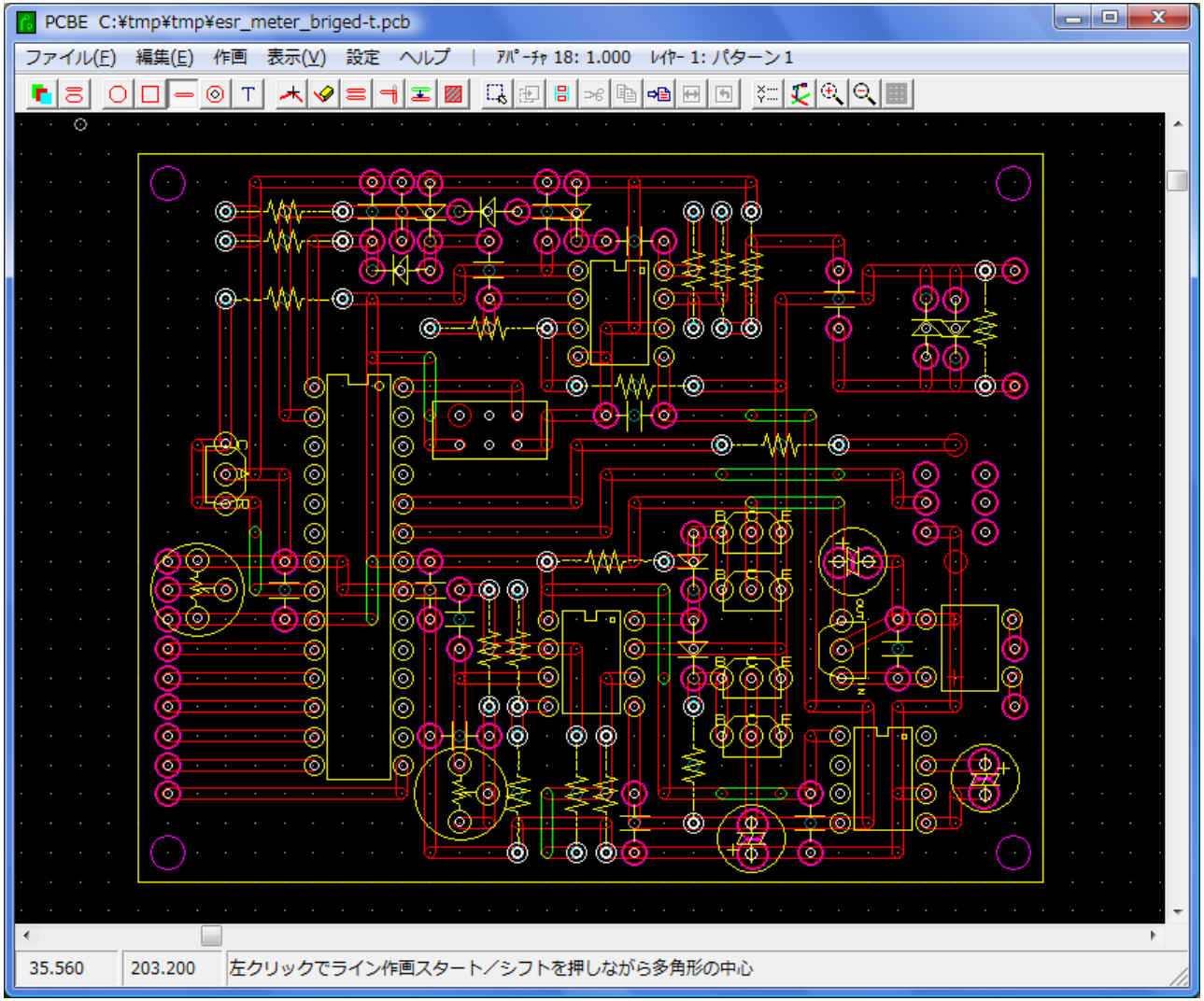


For reference, when we measure the ESR of the hand of metallized film capacitors in the finished ESR meter, 2.2uF is 0.16Ω, 1uF is 0.41Ω, 0.68uF is 0.62Ω, 0.1uF became 12.46Ω

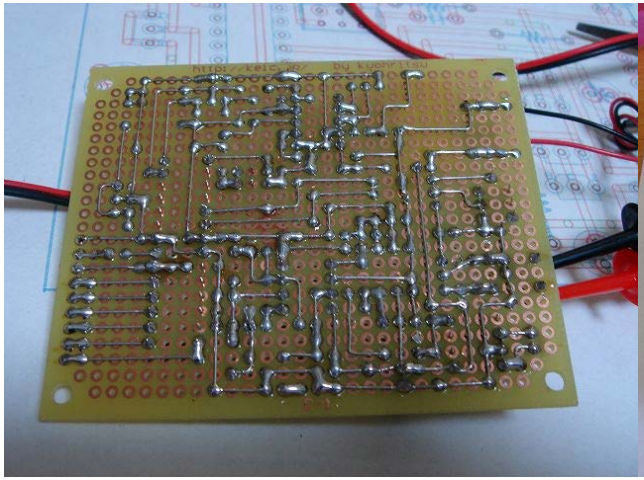
.It is the circuit diagram. Bob's blog Sanno and is almost the same configuration. Microcomputer use the ATmega88P of AVR. Initially, How can we use the ICL7660 switched−capacitor voltage converter IC to the negative voltage generation, waveform distortion is now largely rectified prior to amplification in output capacity shortage. Increase of waveform distortion, increase the measurement error as a result. Suddenly, it was replaced by raising the LT1054CN8 is a high−output version of the ICL7660 in Akizuki electronic. Because even this waveform is distorted when a large gain by the operational amplifier, and was made the amplification factor to be the Max2.5V about 5 times. 10−bit as well as 2.5V reference for the AD conversion was to be available in full.

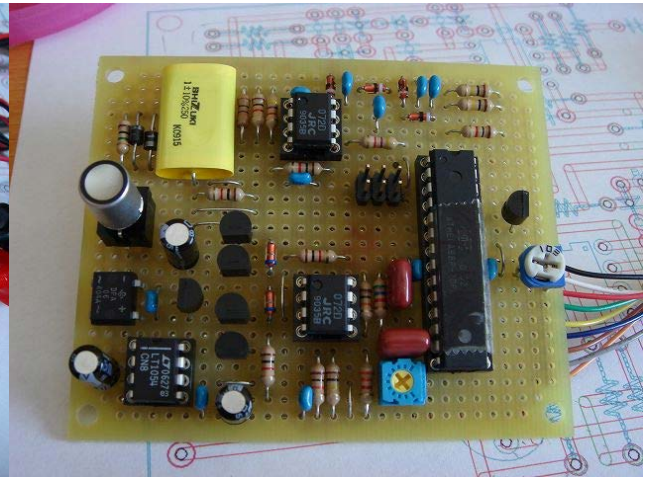


An implementation diagram of the substrate. Since the number of parts is often pretty tight. In order to take into Akizuki electrons in the polycarbonate case size uses the Kyoritsu original universal board. + 3 terminal regulator power supply of 5V also we've included. Even ± of external power source is either to put the bridge to the input we can cope.

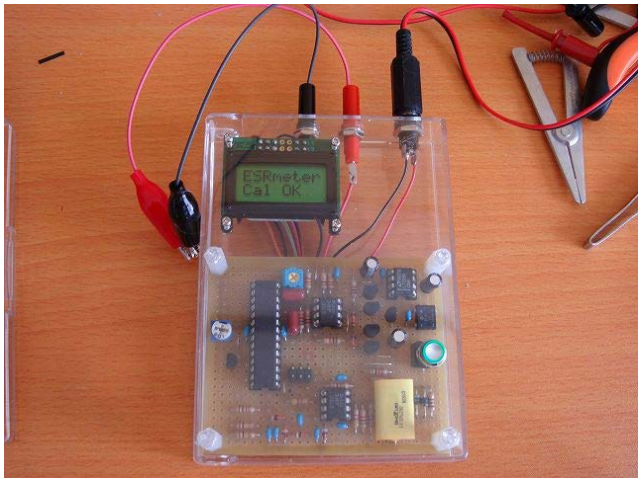


Capacitor and diode of measurement end might was good even outside board. Switch was implemented push switch of LED built on a substrate. The op amp was used NJM072D of four 200 yen in Akizuki electronic, but it is anything OK if JFET input type.

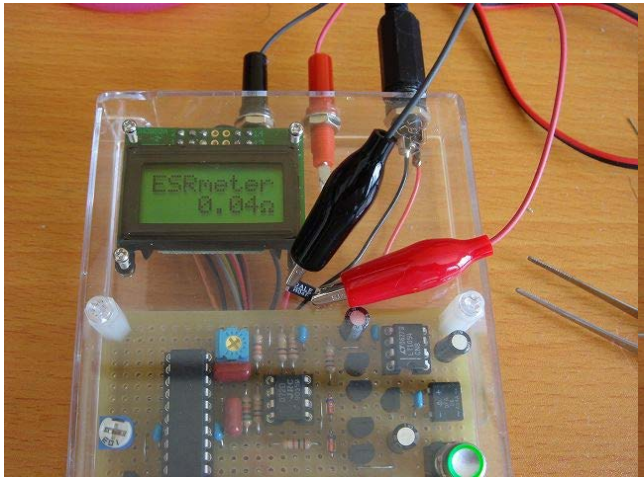


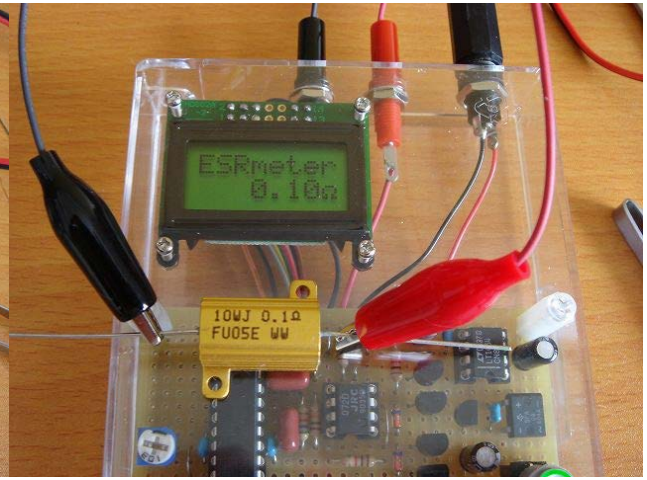


We were put in a case. Measurement, first press the measurement button to short the lead long, run the calibration of measuring the resistance value, including the lead. LED of the push switch is lit when the calibration is complete.

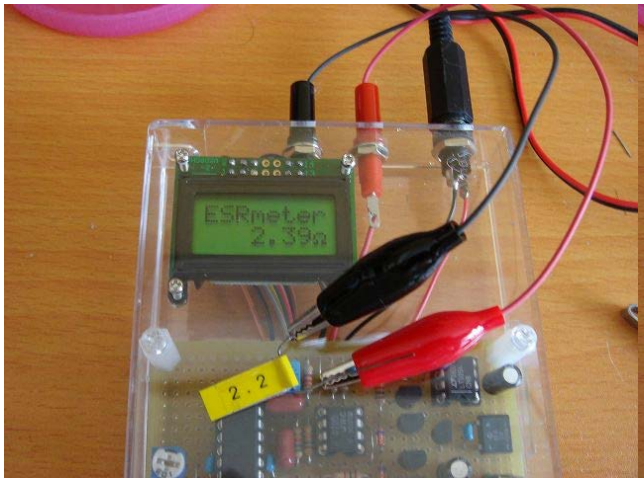


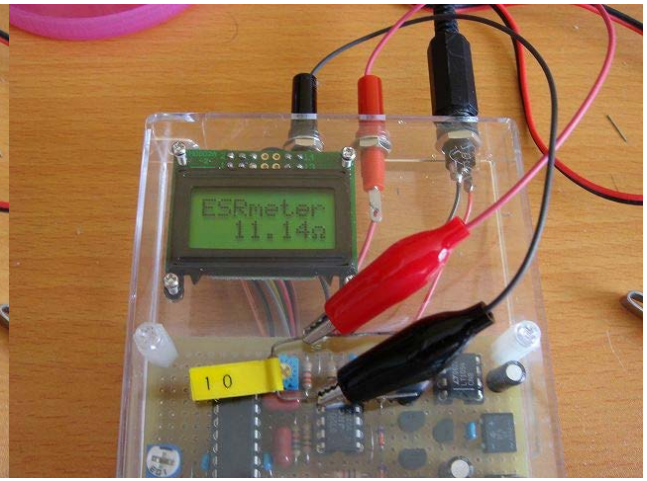
AC resistance and DC resistance is I think strictly speaking different, but I tried to measure the high−precision chip resistor 40mΩ for current detection. When measured several times, it becomes occasionally 0.03Ω, but will display a nearly exact 0.04Ω. It should be noted, because it is calculated from the AD conversion value of 10−bit, minimum resolution will be 12mΩ about even the smallest. Metal−clad resistance of 0.1Ω also can be measured the same value as the DC resistance value.



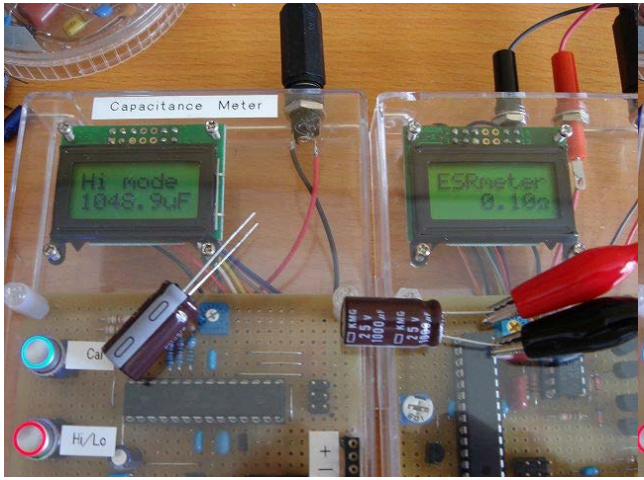


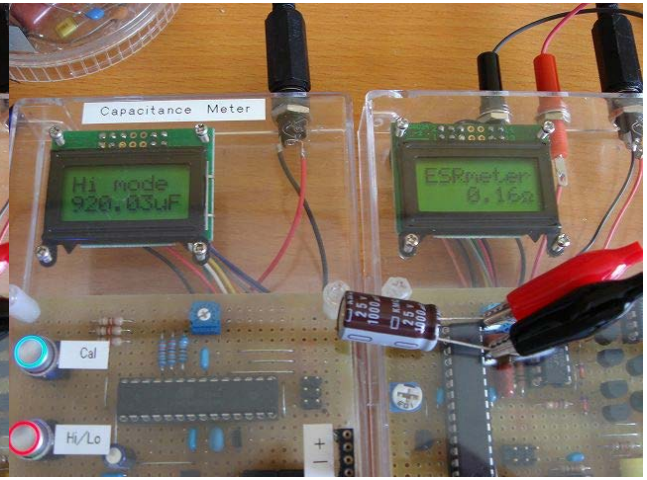
In a large resistance of more than a few Ω should error increases. When you measure the ordinary carbon resistance to trial, in the 10Ω of resistance it is also displayed a large value of 10% or more. It may be due to the increase of the resistance of the L component, but you must be careful that this is not an absolute value measurement.



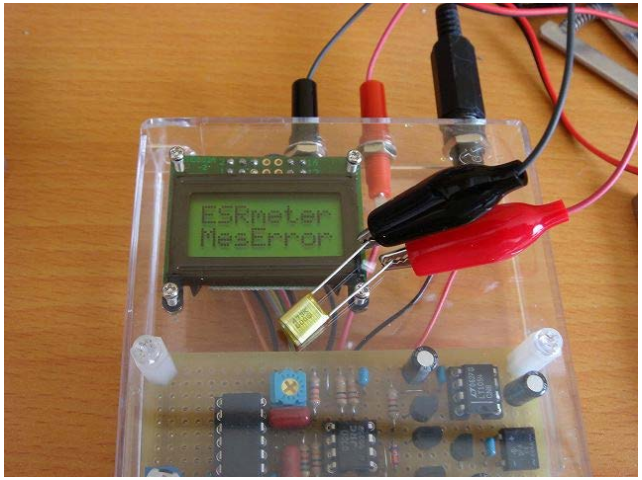


I tried to compare the things capacitor and normal that the high−temperature heat generation in power reverse connection of. Reduction of capacity (1048uF → 920uF) will also be seen but, ESR also slightly larger (0.10Ω → 0.16Ω).





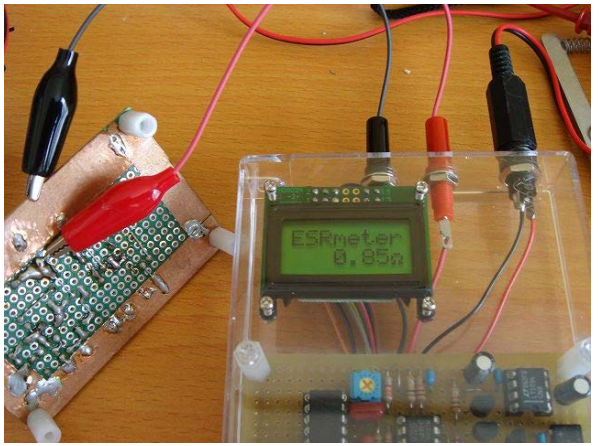
It can not be measured because the ESR is large, such as small−capacity film capacitor.
The program it is error handling more than 20Ω.



Because it is measured by the AC of the small signal it can be in−circuit measurement.
Measure in a state in which the power down of the target device, but the measurement of the charge has been capacitor requires attention. If not exceed the withstand voltage of the capacitor, which was placed in a measurement end I think that it is okay, but if you measure the high voltage circuit, such as a vacuum tube circuit, it would be safe to separately measured after discharge in the discharge lead (resistance built−in lead) .

The electrolytic capacitors used in the circuit experiments with breadboard was measured.
It is not a representative value because it contains those performance degradation in the reverse connection of the old and the power supply. We tried to compared with the ESR standard values .. that are linked from Bob's blog's site. A small capacitor of capacity, will appear slightly lower value, but it is generally a problem that seems.

capacitance	ESR[Ω]	note
0.47uF/50V	3.94	
1uF/50V	2.84	
2.2uF/50V	1.81	
4.7uF/50V	1.64	
10uF/25V	1.21	
10uF/16V	4.83	小型
22uF/50V	1.71	
47uF/25V	0.92	
100uF/16V	0.68	
100uF/25V	0.31	電源用低ESR
220uF/25V	0.36	
470uF/10V	0.19	
1000uF/25V	0.13	
2200uF/35V	0.06	
3300uF/50V	0.03	



Multilayer ceramic capacitor was also tried to measure.
There is no much sense to measure itself because the multilayer capacitor have heard that the ESR varies greatly depending on the frequency. However, we were able to measure lower ESR than the electrolytic capacitor of the same capacity.

capacitance	ESR[Ω]	note
0.1uF	15.20	
0.1uF	13.36	
0.47uF	1.22	
1.5uF	0.20	
4.7uF	0.13	
10uF	0.10	
100uF	0.03	

Condenser capacity meter to be used in combination with, I think that it can be used without problems in quality determination of capacitor. In addition, in-circuit measurements, it will be useful in the event of a fault of the equipment by the electrolytic capacitor deterioration. This is the AVR program source. We've developed in AVRStudio + WinAVR. It is measured by pressing the push button. When the power is turned on, long press (press and hold for about two seconds) the push switch in a state in which short the test lead and you need to be calibrated to. This calibration is configured in measuring the resistance component, including the measuring capacitor for lead or high-pressure cut, it is subtracted at the time of actual measurement. It is not possible to measure and display the error in a state where the calibration has not been completed. It should be noted that the calculation method of ESR I was the method used to directly calculate the AD conversion value in reference to Bob's blog's.

```
1  /*********************************************************************
2  ESR Meter
3      AVR: atmega88p
4  2010.06.17 www.henteko.org
5  *********************************************************************/
```

```
 5 ************************************************************************/
 6 #include <avr/io.h>
 7 #include <util/delay.h>
 8 #include <avr/pgmspace.h>
 9 #include <avr/interrupt.h>
10 #include <stdio.h>
11 #include <math.h>
12
13 #include "lcd.h"
14
15 #define cbi(addr, bit)    addr &= ~(1<<bit)
16 #define sbi(addr, bit)    addr |=  (1<<bit)
17
18 #define ADC_ENABLE (_BV(ADEN)|_BV(ADIF)|0b110)
19 #define ADC_START  (ADC_ENABLE|_BV(ADSC))
20
21 #define RC 9.938       // RC 10Ωの実測値
22 //#define DEBUG
23
24 FILE *fp;                    // File descriptor for LCD
25
26 /************************************************************************
27   milisecond order delay
28 ************************************************************************/
29 void delay_ms(unsigned int t) {   while(t--)  _delay_ms(1); }
30
31 /************************************************************************
32   AD convert
33 ************************************************************************/
34 unsigned int get_adc(unsigned char ch)
35 {
36   ADMUX = ch;
37   ADCSRA = ADC_START;
38   loop_until_bit_is_set(ADCSRA, ADIF);
39   return ADCW;
40 }
41
42
43 /************************************************************************
44   main routine
45 ************************************************************************/
46 int main(void)
47 {
48   unsigned char sw0_state;
49   double Zo;
50   unsigned int E, Ec;
51   unsigned int org;
52   unsigned int tim;
53
54    DDRB = 0b11111111;       // LCD
55   DDRC = 0b00000000;       // A/D input
56   DDRD = 0b00001000;       // PD4 SW input
57
58   PORTD = 0b00010000;    // PD4 pull up
59   DIDR0 = 0b11111111;
60
61   ADCSRA = ADC_ENABLE;
62
63   lcd_init();
```

```
64    lcd_cls();
65    fp = fdevopen(lcd_putch, NULL);       // Open File descriptor for LCD
66    lcd_goto(0, 0);
67    fprintf(fp, "ESRmeter");
68
69    sw0_state = 0;
70    org = 0;
71    tim = 0;
72
73    while(1) {
74      if(bit_is_clear(PIND, PD4)) {
75        sw0_state = 1;
76        delay_ms(25);
77        tim++;
78      }
79      if(sw0_state && bit_is_set(PIND, PD4)) {
80        sw0_state = 0;
81        tim = 0;
82        if(org == 0) {
83          lcd_goto(0, 0);
84          fprintf(fp, "ESRmeter");
85          lcd_goto(1, 0);
86          fprintf(fp, "CalError");
87          continue;
88        }
89        delay_ms(500);
90        E = get_adc(5);
91        delay_ms(200);
92        Ec = get_adc(4);
93
94        Zo = RC * (E - Ec - org) / Ec;
95        if(Zo > 20.0) {
96  #ifdef DEBUG
97          lcd_goto(0, 0);
98          fprintf(fp, "%4d:%3d", E, Ec);
99  #endif
100         lcd_goto(1, 0);
101         fprintf(fp, "MesError");
102         continue;
103       }
104       lcd_goto(0, 0);
105 #ifdef DEBUG
106       fprintf(fp, "%4d:%3d", E, Ec);
107 #else
108       fprintf(fp, "ESRmeter");
109 #endif
110       lcd_goto(1, 0);
111       fprintf(fp, "%7.2f%c", Zo, 0xf4);
112     }
113
114     if(tim > 60) {       // Calibration
115       sw0_state = 0;
116       tim = 0;
117       lcd_goto(1, 0);
118       fprintf(fp, "Cal.....");
119       loop_until_bit_is_set(PIND, PD4);
120       delay_ms(500);
121       E = get_adc(5);
122       delay_ms(200);
```

```
123         Ec = get_adc(4);
124         org = E - Ec;
125         if(org > 400 || org < 10) {       // calibration error
126 #ifdef DEBUG
127             lcd_goto(0, 0);
128             fprintf(fp, "%4d:%3d", E, Ec);
129 #else
130             lcd_goto(0, 0);
131             fprintf(fp, "NotShort");
132 #endif
133           lcd_goto(1, 0);
134           fprintf(fp, "Re Exec ");
135           org = 0;
136           cbi(PORTD, PD3);
137           continue;
138         }
139 #ifdef DEBUG
140         lcd_goto(0, 0);
141         fprintf(fp, "%4d:%3d", E, Ec);
142         lcd_goto(1, 0);
143         fprintf(fp, "%8d", org);
144 #else
145         lcd_goto(0, 0);
146         fprintf(fp, "ESRmeter");
147         lcd_goto(1, 0);
148         fprintf(fp, "Cal OK  ");
149 #endif
150         sbi(PORTD, PD3);
151       }
152
153   }
154 }
```