Heal Force®

Prince 120 Body Fat Measuring Apparatus

Service Manual

Version: 2008.08.01

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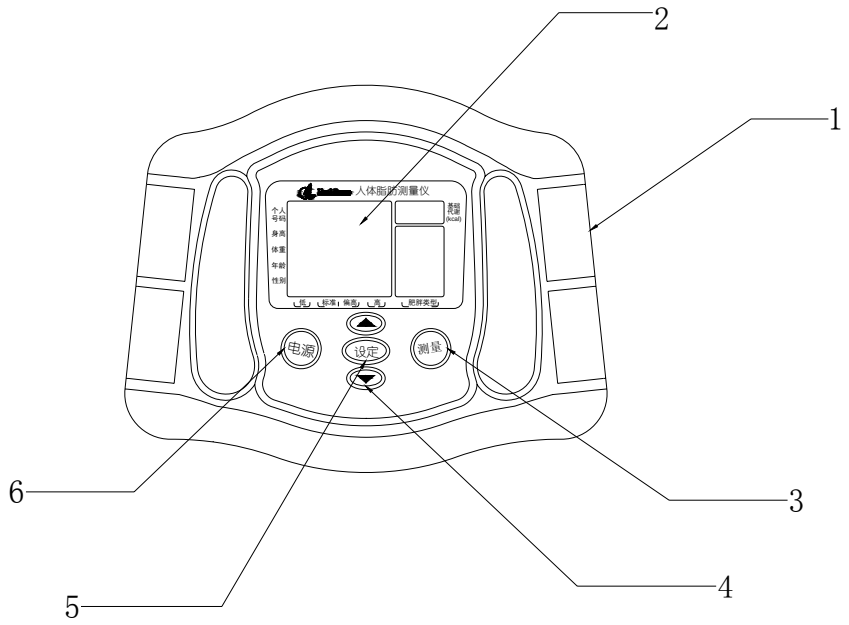
I. Panel and functions of body fat measuring apparatus

Front view of the apparatus:



Item	Description	Function
1	Electrode handle	Weak detection current to be routed during test
2	Display area	Display the settings and measurements
3	Test key	After setting, push the key to start the test with appropriate posture
4	Up and down keys	Set the personal data (height, weight, age, sex). Furthermore, you may select the personal code from 1 to 9.
5	Set key	Set the personal code and data
6	Power key	Turn on/off

II. Disassembly and maintenance of mechanical parts

Maintenance tools

Big and small Phillips screwdriver	Nipper pliers	Art knife
Big and small flat tip screwdriver	Diagonal cutting pliers	Iron, solder stick
Tweezers		

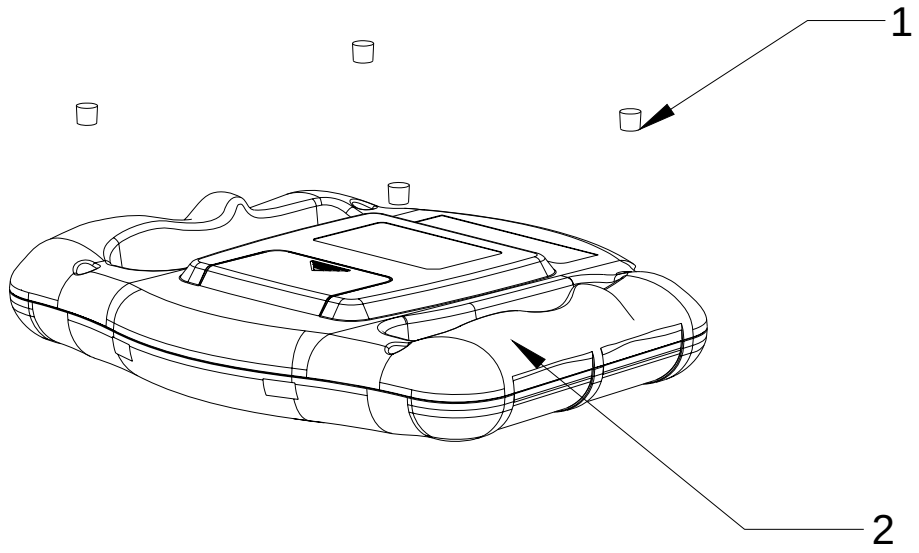
Unless otherwise specified in the disassembly diagram, the installation shall be progressed in the reverse sequence as shown in the diagram.

Components and parts shall be only replaced with those from OEM and the maintenance people must follow the graphic directions in the manual without modification at their discretion.

Note: On reinstallation following replacement of components and parts, each screw shall be painted with thread adhesive before being fastened.
For maintenance, the body fat measuring apparatus shall be properly placed on the robust horizontal table.
During the assembly:
1: All components and parts shall have the surface free of score, scratch, etc.
2: During the installation, please note the assembly location and direction of each component and part.

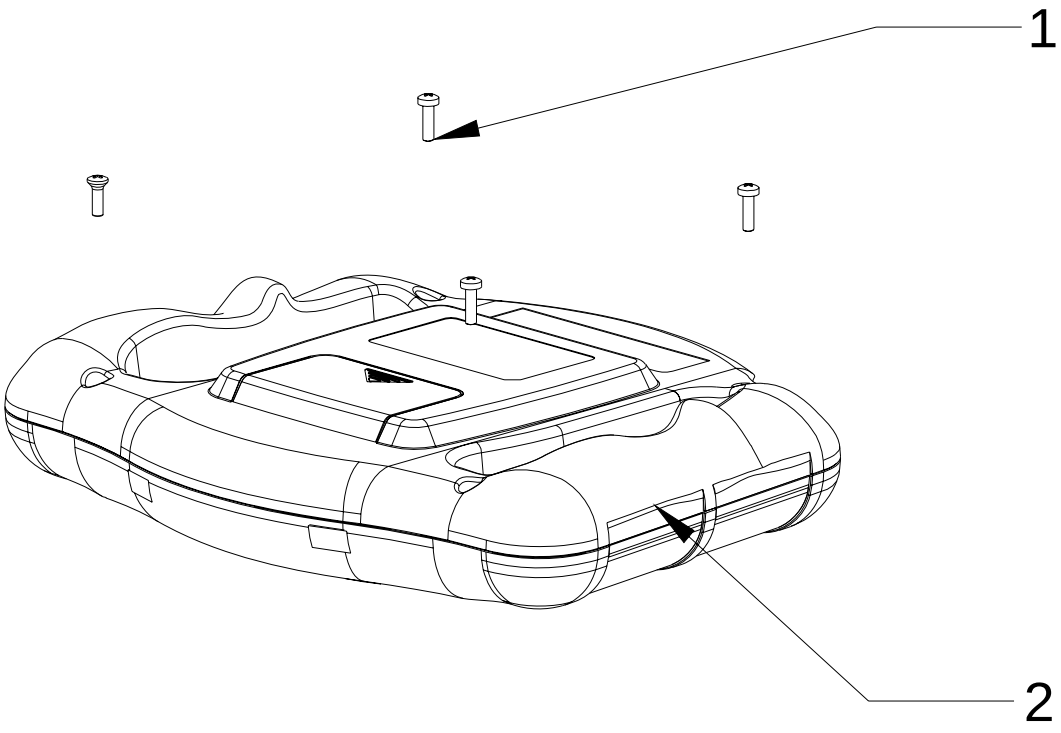
III. Steps on disassembly of body fat measuring apparatus

1. Turn the body fat measuring apparatus over and unscrew 4 fittings.



Item	Description	Quantity
1	Fitting	4
2	Housing of body fat measuring apparatus	1

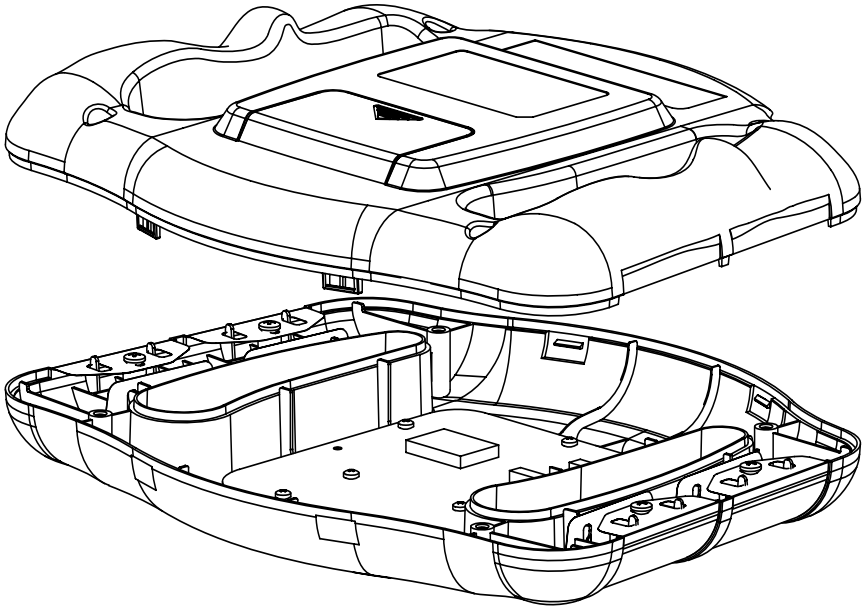
2. Open the lower cover:



Unscrew 4 cross tapping screws located at the lower cover, as shown in the diagram:

Item	Description	Quantity
1	ST2.9*9.5 tin-coated tapping screw (Type F)	4
2	Housing of body fat measuring apparatus	1

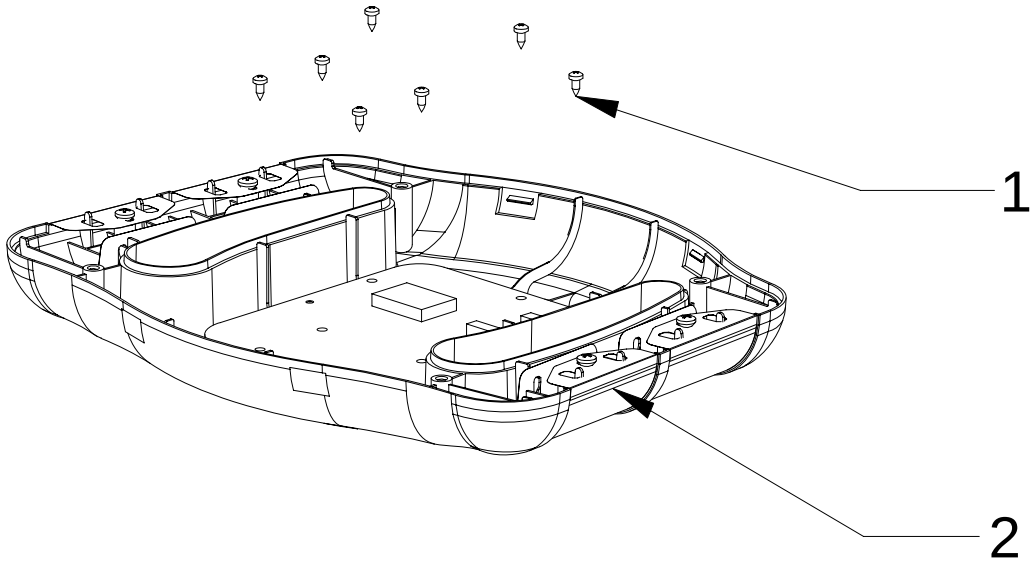
3. Open the rear cover



As shown in the diagram, detach the upper and lower covers, And be caution to make damage to the power wire linking to the battery cable. to the power cable linking the battery. In case of need to removal of power cable, use the iron to remove the cable.

4. The disassembly steps to check the bottom of upper cover

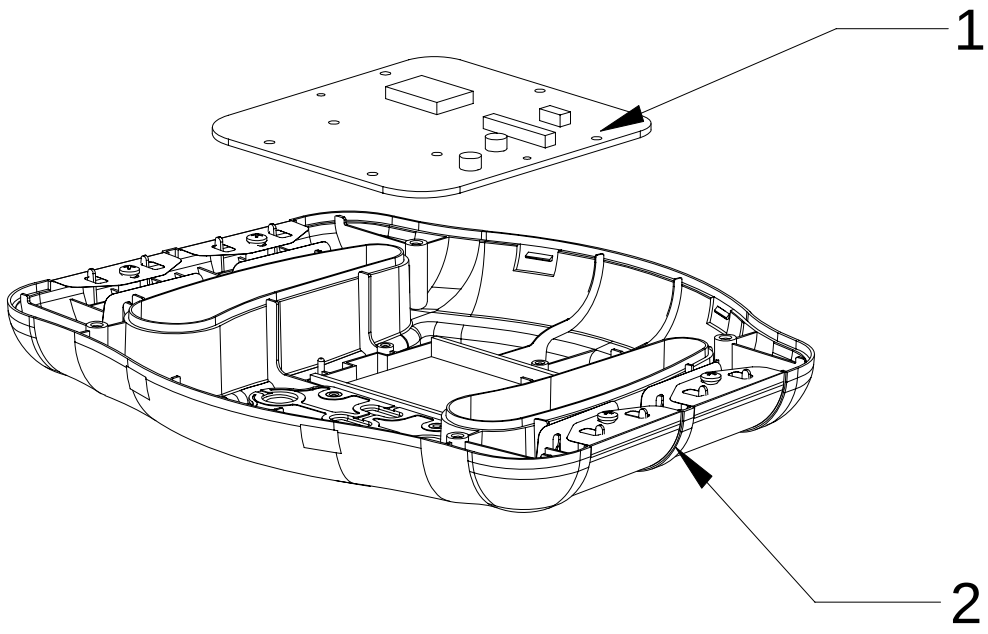
Step 1: Take off 7 screws as indicated in the diagram.



After the screws are removed, please properly keep them from loss.

Item	Description	Quantity
1	ST2.9*7 tin-coated tapping screw (Type F)	4
2	Upper cover of body fat measuring apparatus	1

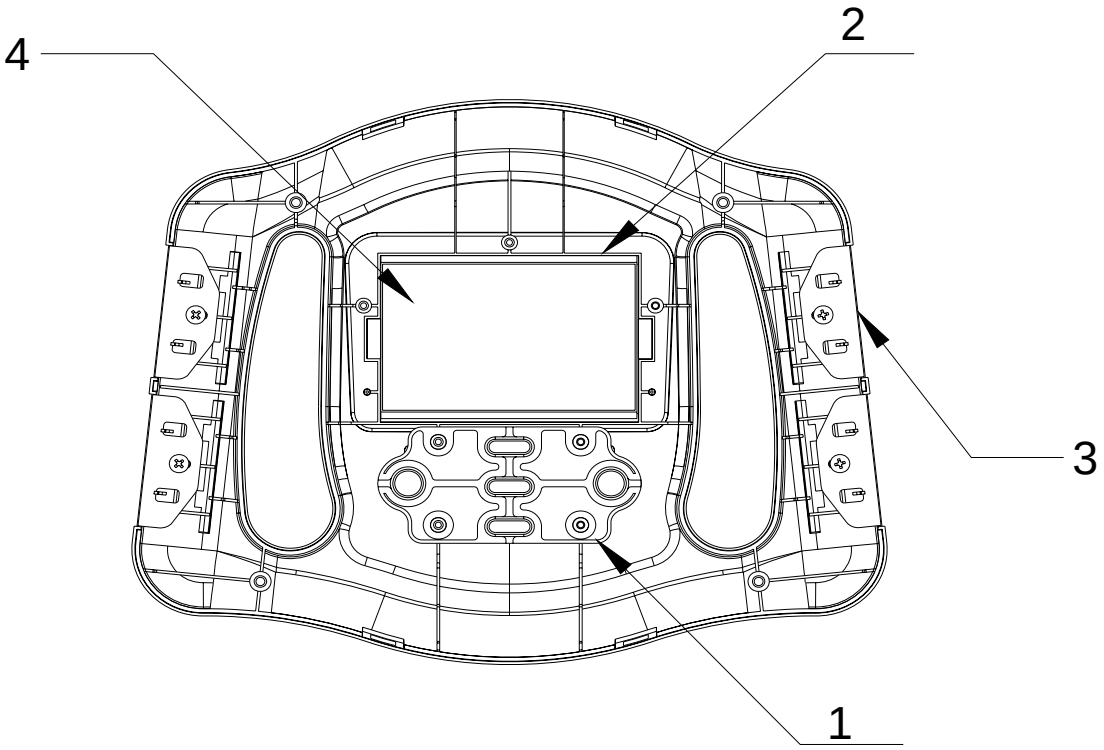
Step 2: Remove PCB board



Item	Description	Quantity
1	PCB board	1
2	Upper cover on housing of body fat measuring apparatus	1

On removal of PCB board, please avoid damage to the power cable linking to the battery. It is advised to use the iron to remove the cable and then the circuit board.

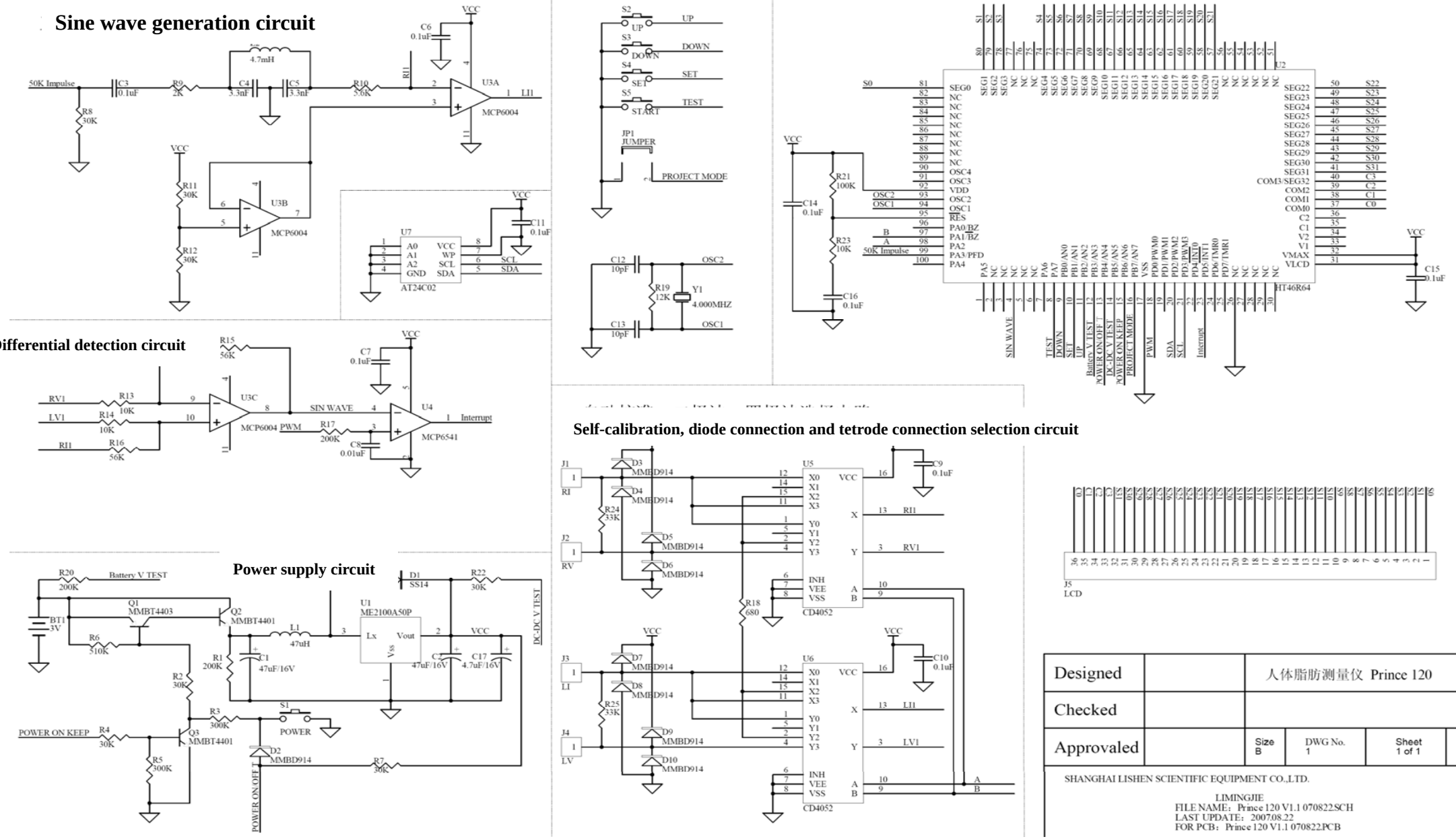
5. Bottom of Upper cover



Item	Description	Quantity
1	Key frame and conductive rubber	1
2	LCD screen foaming adhesive strip	2
3	Electrode pad	4
4	LCD screen	1

IV. Introduction on circuit of body fat measuring apparatus

General circuit diagram



Dia. <2-1> Principle diagram for prince 120 v1.1

As shown in the diagram above, Prince 120 circuit principle diagram is divided into **a) main control MCU circuit (including LCD interface circuit and external crystal oscillator); b) power supply circuit; c) sine wave generation circuit; d) self-calibration, diode connection and tetrode connection selection circuit; e) differential detection circuit.** These sub-functional circuits will be described in details later.

Both hands hold the 4 electrodes at both ends of body fat measuring apparatus: RI and RV, LI and LV. Alternating current is introduced to the human body via RI and LI terminal and then produces output voltage from RV and LV terminals. When the voltage generated arrives at the differential comparator circuit controlled by the analog switch CD4052, the voltage RV and LV from the analog switch will obtain via differential comparator circuit (difference of RV and LV) a RI-superposed sine wave identified as SIN_WAVE. The SIN_WAVE is compared with PWM which generated by MCU during the operational amplification of MCP6541 and it may be calculated by successive approximation approach via PWM at the analog terminal. Thus, it will produce an interruption at high point and low point respectively. Then, the apparatus may calculates the resistance value through the human body based on the resistance value which is corresponding to the voltage while interruption

V. Functional description on sub-circuits:

1. MCU control circuit:

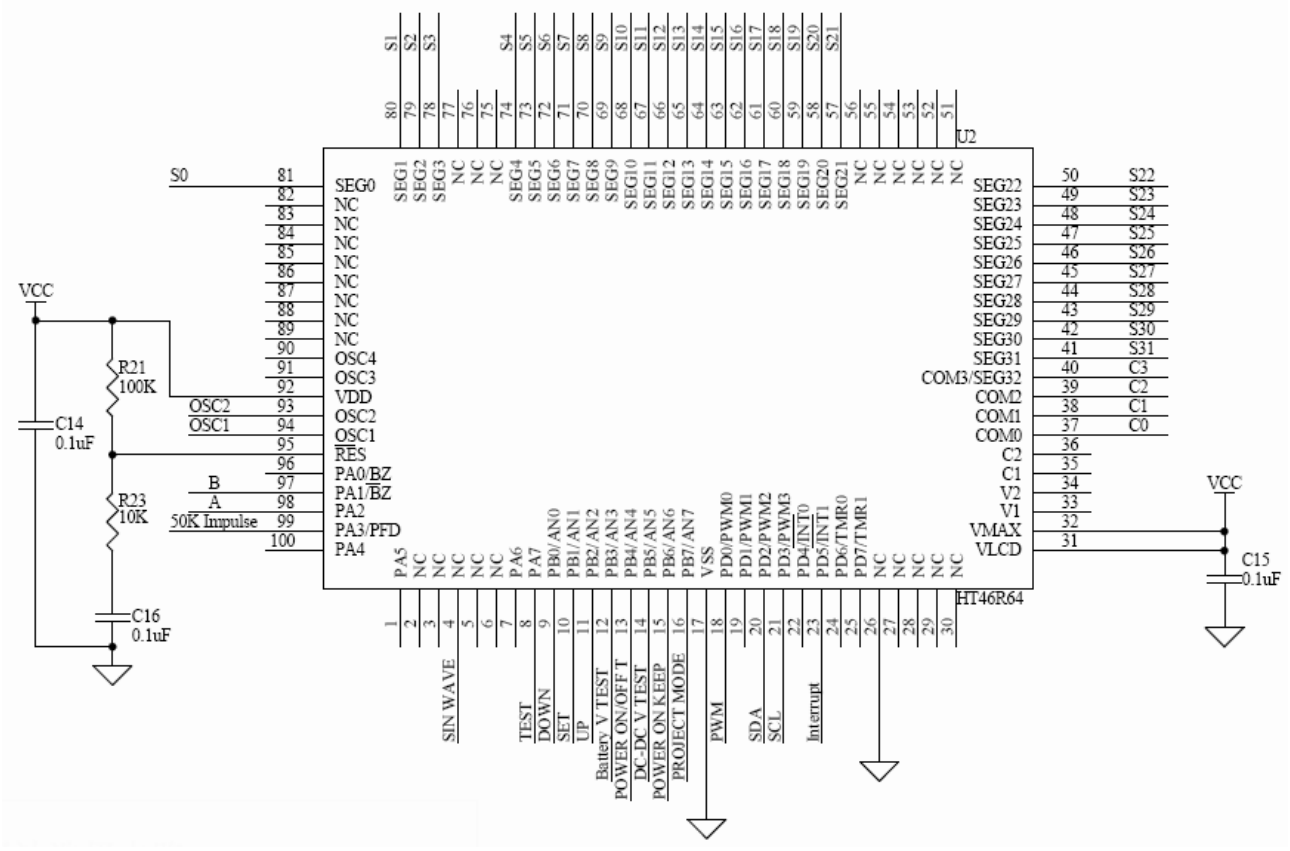


Diagram <5-1> MCU control circuit

The diagram above shows the main control MCU chip circuit, which is designed to play the role of the signal generating, DA sampling, LCD displaying and signal proceeding of body fat measuring. The exact pins are defined below:

Pin	Name	Signal (I/O)	Functional description
4	SIN WAVE	I	Sinusoidal signal reception and analog input terminal
8	TEST	I	Test key reception pin when low voltage enable
9	DOWN	I	Down key reception pin when low voltage enable
10	SET	I	SET key reception pin when low voltage enable
11	UP	I	UP key reception pin when low voltage enable
12	Battery V TEST	I	Battery voltage test pin when low voltage enable
13	POWER ON/OFF T	I	Power supply switch pin
14	DC-DC V TEST	I	Regulated power supply voltage testing pin
15	POWER ON KEEP	I	Startup stabilization testing pin
16	PROJECT MODE	I	Project mode control pin (controlled by JP1 jumper)
18	PWM	O	Analog voltage output pin
20	SDA	I/O	I^2C circuit data pin
21	SCL	O	I^2C circuit clock pin
23	Interrupt	I	External interruption pin
37~81	Cx, Sxx	I/O	LCD screen drive pin
97	B	O	Analog switch control pin
98	A	O	Analog switch control pin
99	50K Impulse	O	50khz square wave pulse output pin

2. Power supply circuit:

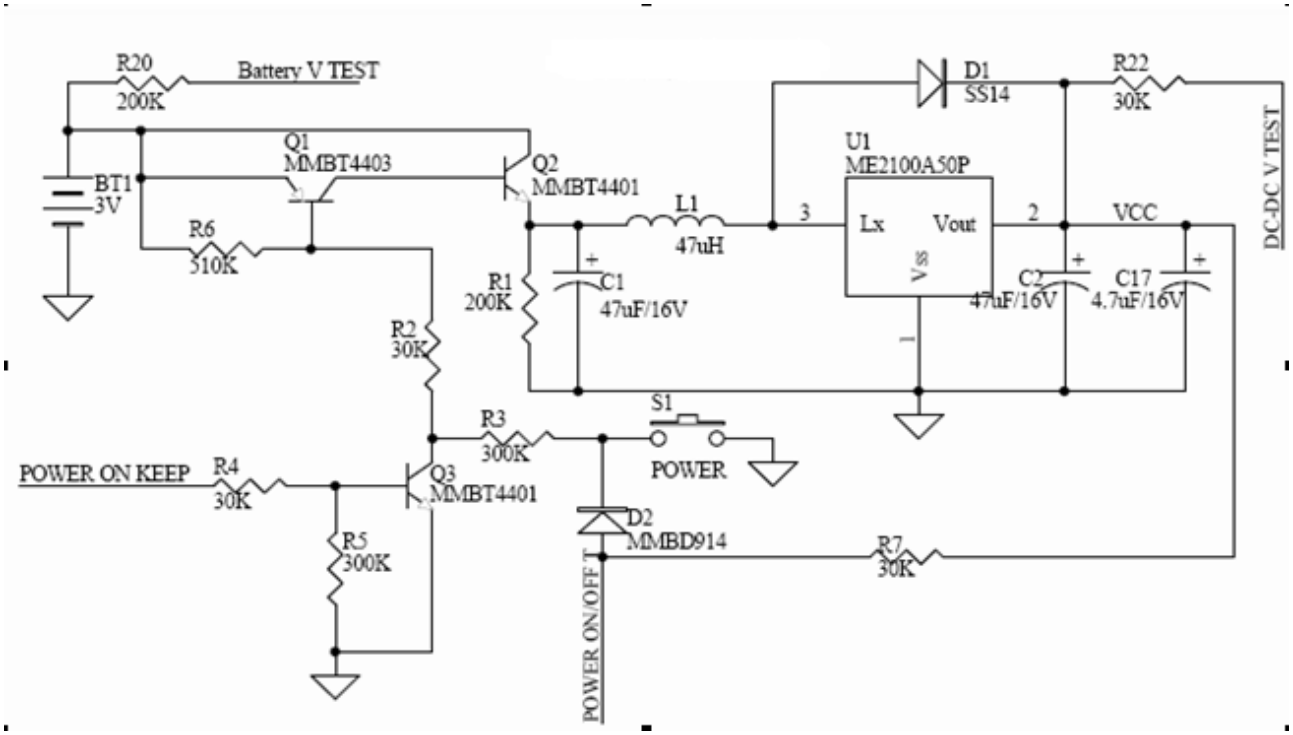


Diagram <5-2> Power supply circuit

As shown above, the circuit is designed to provide DC-DC voltage test function (DC-DC V TEST), POWER-ON stabilization function and power-off control function in addition to the regular DC-DC step-up function.

The switch of the power supply circuit is controlled by S1. BT1 is the battery power supply of 3v. Battery V TEST (the battery will be exhausted at about 2.4v and then display on the screen) is the test pin for voltage test. connected to MCU analog terminal (MCU #12 pin), test voltage will judge whether there is power remaining at less than 2.4v. PNP triode Q1 and NPN triode Q2 constitute the Darlington transistor that drive PFM switch-type DC/DC step-up converter U1 ME2100A of low static current manufactured by CMOS process. The step-up converter ME2100A may have voltage of pulse waveform at #3 pin while #2 pin is the output voltage (+5V, voltage accuracy of ±2.5%).

When S1 is pressed for the 1st time, Q1 and Q2 work to drive U1 and output VCC.
When S1 is released for the 1st time, Q1, Q2 and Q3 work together and output POWER ON KEEP signal.
When S1 is pressed for the 2nd time, Q3 shutoff and POWER ON KEEP signal is lowered.
When S1 is released for the 2nd time, Q1 and Q2 shutoff and U1 stop work.

3. Sine wave generation circuit:

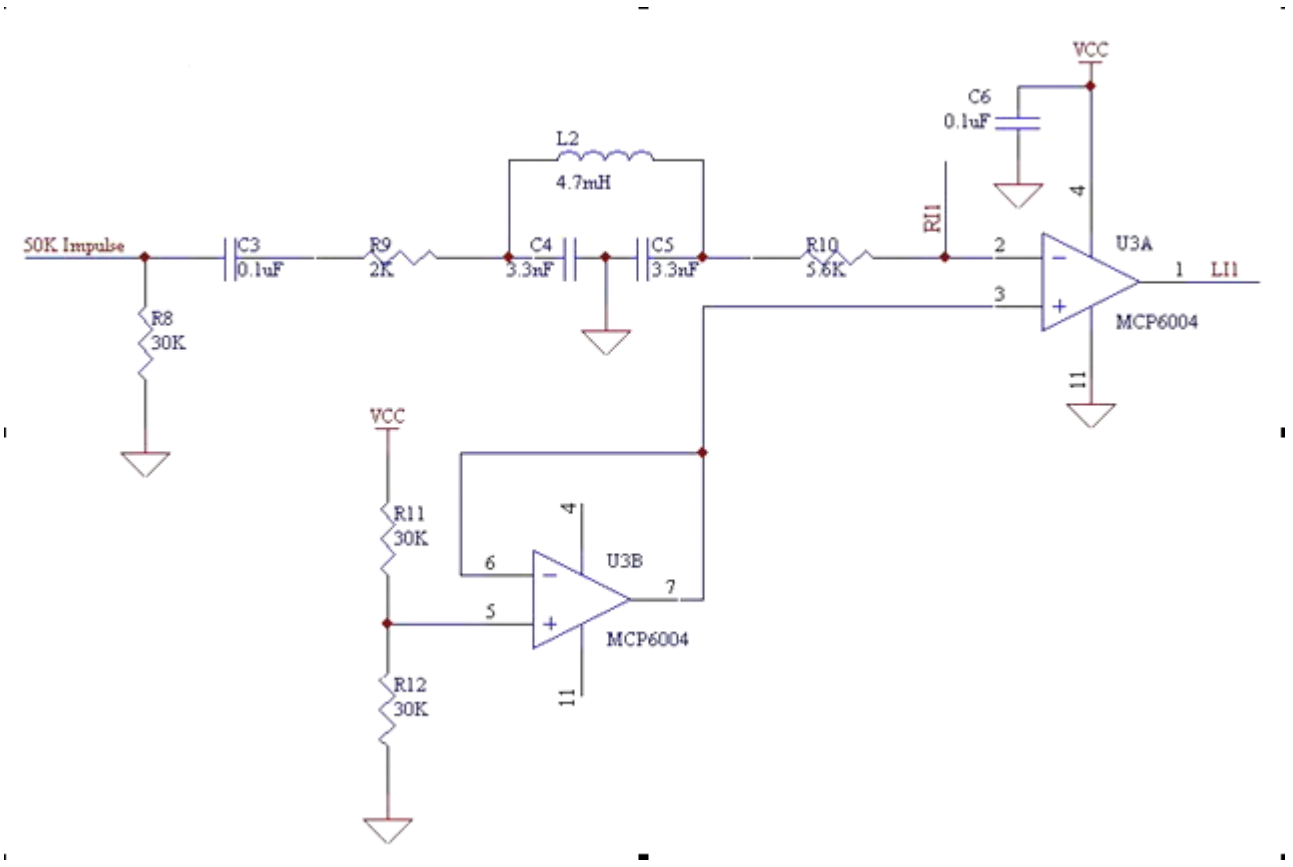


Diagram <5-3> Sine wave generation circuit

As shown above, the circuit is a generation circuit of sine wave of 50KHz and transmits, with the sine wave, RI1 and LI1 to the human body in the way of current for test so as to allow U3 MCP6004 operational amplification to work within the appropriate range of amplification. Square wave of 50KHz, generated by MCU #99 pin, may filter the low-frequency signal through a filter of high-pass filtering circuit, and then reach the waveform generation circuit composed of power conductance L2, capacitor C4 and C5.

With second-order filter composed of the conductance L2, capacitor C4 and C5, it is possible to see the sinusoidal wave form at C4 and C5: at C4, it is possible to see the sine wave of high-frequency component being not fully filtered while as at C5, it is possible to see the sine wave of 50KHz being finally generated.

R10 bears the functions of limiting the output current so as to control the output current within the safe range of the human body (less than 0.5mA). U3B MCP6004 is a follower and provides a stable raising voltage of 2.5V (amplifier's #7 pin) to be routed to MCP6004 #3 pin.

4. Differential detection circuit:

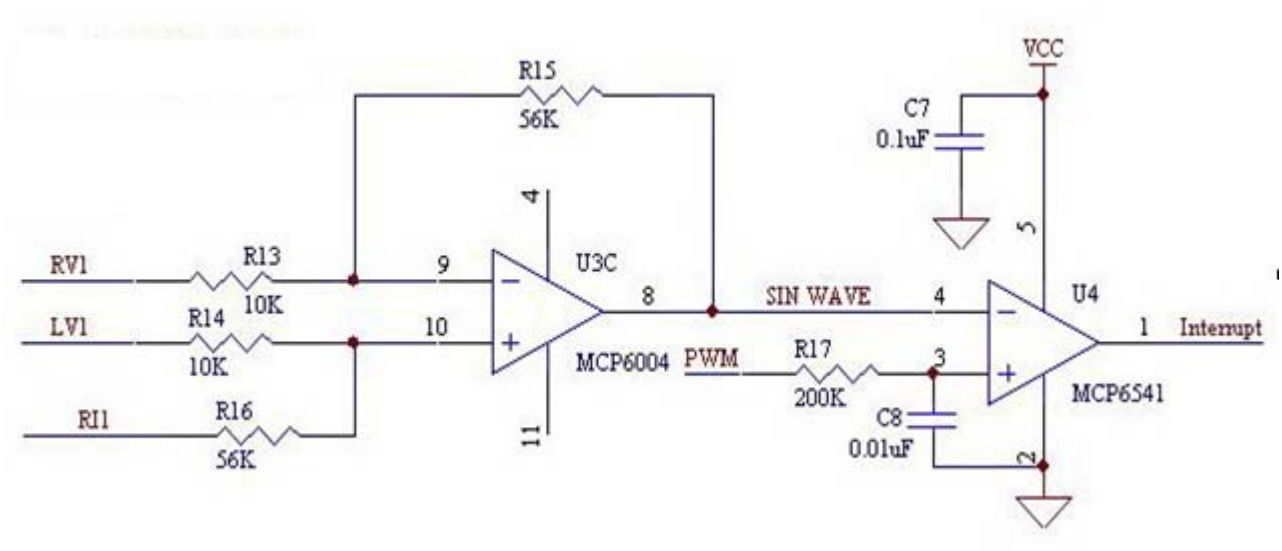


Diagram <5-4> Differential detection circuit

As shown above, the differential detection circuit is designed to allow RI1 and LI1 which is due to produce voltage RV1 and LV1 generated by via U3's operational differential amplification through the human body, to output a differential-value sine wave SIN_WAVE at U3 #8 pin. The differential-value sine wave is compared with PWM generated by MCU #18 pin, ie. To reduce the SIN_WAVE value from the PWM's fixed value (rise minimum voltage or reduce the maximum voltage). If exceeding the value, output VCC voltage or maximum voltage. If beneath the value, output the minimum voltage. The zero voltage may activate MCU's external interruption pin (#23 pin INT1) and enable an interruption. MCU will calculate the voltage value from the span of nearly two interruptions to obtain the resistance value of human body's resistance. The differential of RV1 and LV1 is to eliminate the effect of surface resistance so that the obtained SIN_WAVE value is more accurate.

RV1 and LV1 are both the voltage as the current runs through the human body.
PWM is the square wave of 50KHz triggered by MCU #18 pin.
SIN_WAVE is the differential-value sine wave as generated differential of RV1 and LV1.
Interrupt is the external interruption pin of MCU and triggered on low level.

5. Self- calibration, diode connection, tetrode connection selection circuit:

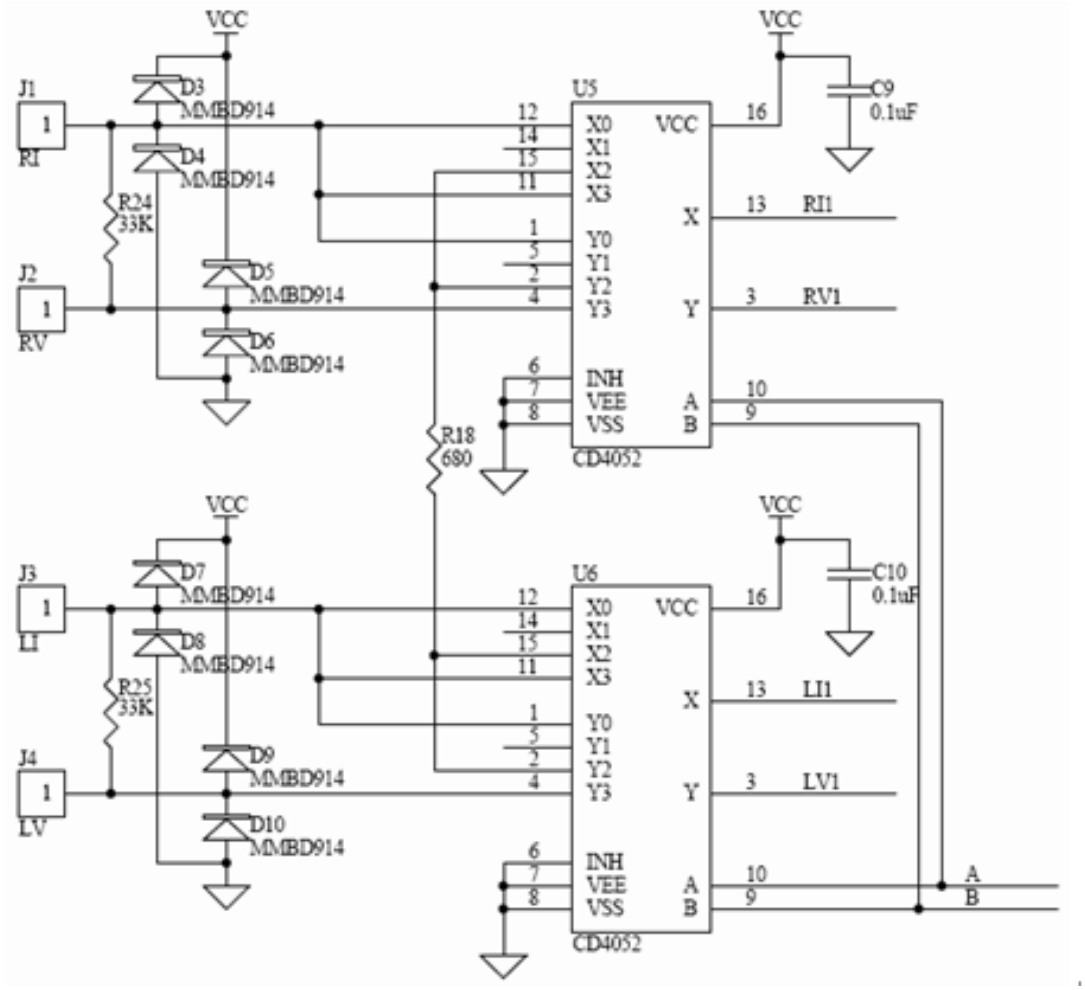


Diagram <5-5> Auto calibration, diode connection, tetrode connection selection circuit

As shown above, RI, RV and LI, LV in the circuit are connected to the external electrode. The ring circuit of the voltage and current is controlled and switchover by 2 analog switches. The ring circuit is equipped with 3 selection channels, ie. auto calibration, diode connection, tetrode connection.
#9 and #10 pins of U6 and U7 selection channel control signal A and B are used to allow CD4052 analog switch to control the output and input terminals so as to select the different functions such as self calibration, diode connection and tetrode connection and the purpose of measuring the resistance across human body and self calibration.

The table below shows the value A and B and their combination of functions:

Input status		Selection channel pin	Function
A	B		
0	0	x0,y0	Diode connection
0	1	x2,y2	Auto calibration
1	1	x3,y3	Tetrode connection

J1-J4's 4 pin electrodes comprise 2 pairs of circuit for test of resistance across human body. With the different switch combination of control pin's A and B, it is possible to allow the AC signal of LI and RI terminals to run into human body via current through the electrode and human body, which may form a loop to enable the output voltage introduced to the differential comparator circuit for resistance across human body.

Diode D3 –D9 are used for clamped purpose to protect the apparatus from static in the human body.

Resistance R24 and R25 are separately in parallel to pairs of current input and voltage output terminals.

6. Crystal oscillator, key and LCD display circuit:

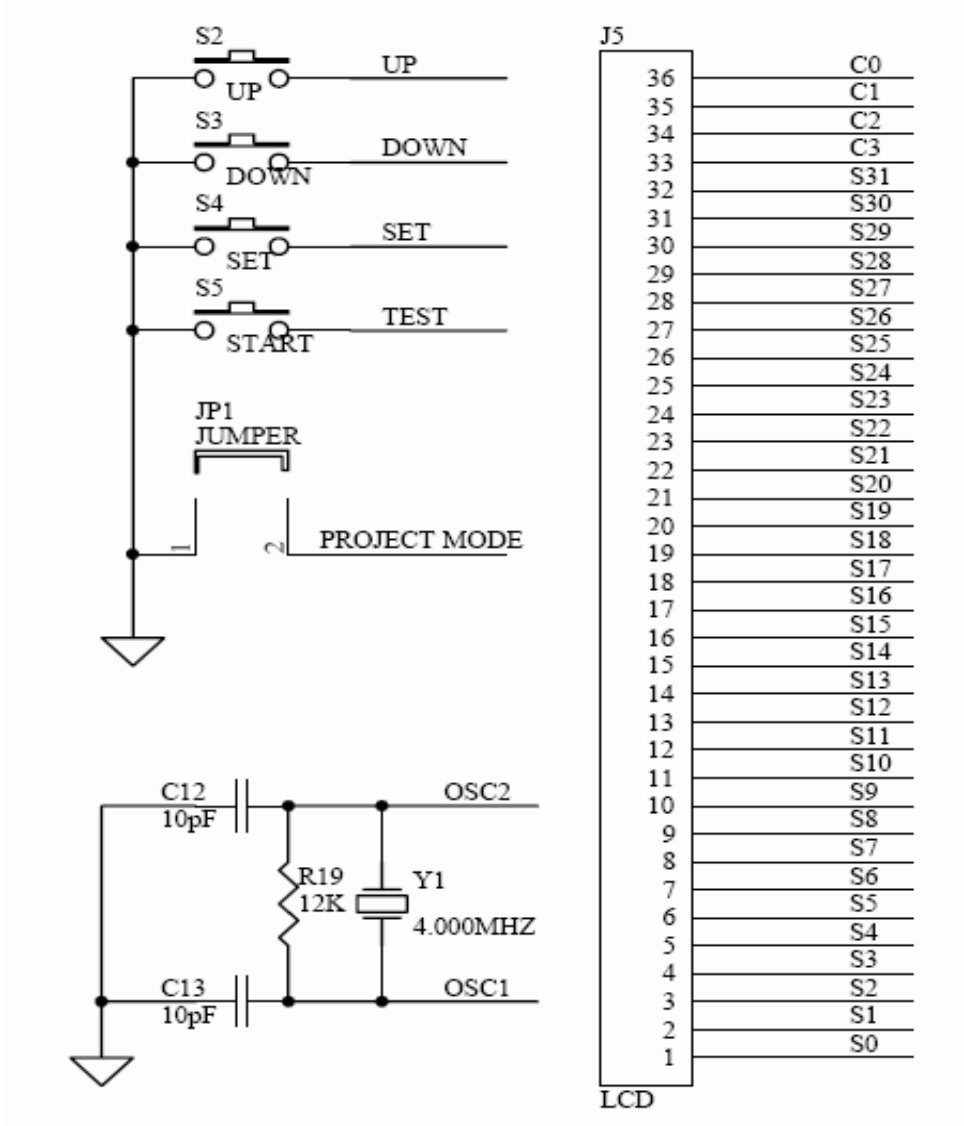


Diagram <5-6> Crystal oscillator, key and LCD display circuit

As shown above, the circuit is the interface circuit related to the output and display:
JP1 is the jumper of project mode: project mode is triggered when JP1 is connected. The jumper, however, is detached before delivery.

S2, S3, S4, S5 keys: they are control keys located on the panel, namely up key, down key, set key, test start key.
LCD interface (J5): the interface, made of carbon film and home-made zebra strip foaming rubber strip, is the circuit to communicate with LCD screen so as to transmit the signal from MCU chip to drive and control LCD screen.

Crystal oscillator circuit: MCU operates on start-oscillation based on the external crystal oscillation. The external crystal oscillator has a frequency of 4.0MHz.

VI. Commissioning method and common troubleshooting

1. Commissioning condition

a) Environemntal temperature: +10℃--+30℃
b) Relative humidity: 30%RH-70%RH
c) Atmospheric pressure: 860hPa-1,060hPa

2. Commissioning equipment

Equipment	Quantity
Oscilloscope	1
Signal generator	1
Resistance box	1
Big and small Phillips screwdriver	1 set
Universal meter	1
Leading wire	Several

3. Content and step of commissioning

3.1 Display commissioning

Load with 2 AAA manganese/alkali dry batteries and press “Power” key, showing the fully illuminated display for about 1sec. On full illumination, the complete contents shall be displayed in the screen without any missing stroke. Presing the “Power” key may maintain the fully illuminated display until release.

In case of any abnormal display shown in the screen, you may progress the maintenance as per the instructions below:

1. After the “Power” key is pressed, the picture in full presentation is not available in LCD screen:

Possible fault	Troubleshooting
Power supply circuit is working well	Check with universal meter if DC-DC power supply ME2100A50P output #2 pin has correct output voltage of +5V. In case of no output, check the appropriate circuit, such as Q1, L1, Q2 and other components.

Crystal oscillator adjacent to MCU is in start-oscillation status	Check the crystal oscillator Y1's pin with oscilloscope for start-oscillation
Zebra strip is in good contact	Take off the cover and unscrew 7 screws located on PCB board as shown in Dia. 1. Check if foaming zebra strips at both sides of LCD screen are placed at the correct locations. If not, locate ther conductance rubber strip correctly.
The chip's displays are welded properly	Check the chip pin for any defective welding.
Display screen is not assembled correctly	There are 4 leading-out pins at the bottom of display screen, which shall be properly identified.
"Power" key is working well	Replace the conductance key film and check the wiring of carbon film key.
Check if main chip misfunctions	Replace the main chip.

2. After the "Power" key is pressed, unexpected pictures are shown in LCD screen, ie. disordered graphics.

Possible fault	Troubleshooting
Check that the display area of display chip are wired correctly	Check with universal meter the pins at display side of the chip and check the pins at drive LCD of the chip for open circuit or short circuit.
Display chip damaged	Replace the main chip.
Zebra strip is in good contact	Take off the cover and unscrew 7 screws located on PCB board as shown. Check if foaming zebra strips at both sides of LCD screen are placed at the correct locations. If not, locate ther conductance rubber strip correctly.

3. When access to project mode, disordered graphics appear in LCD screen:

Possible fault	Troubleshooting
Check that the display area of display chip are wired correctly	Check with universal meter the pins at display side of the chip and check the pins at drive LCD of the chip for open circuit or short circuit.

3.2 Auto shutdown and shutdown commissioing

Auto shutdown: Press the "Power" key for startup. In case no key is pressed on the body fat measuring apparatus for around 60sec., the apparatus will auto shutdown to show the contents in full black background.

Shutdown: Press the "Power" key for startup. After a number of tests, press the "Power" key for shutdown.

In case of any abnormal display shown in the screen, you may progress the maintenance as per the instructions below:

Possible fault	Troubleshooting
Continuous welding of main chip	Check (POWERE ON/OFF) pin.

3.3 Commissioning on functional and accuracy test

Disable two electrodes at both left and right side respectively with leading wires. Connect the electrode of both sides to the resistance box with a leading wire, respectively and set the resistance box to 720Ω. Turn on the power as per the "Operation Manual" to select "Guest", fully selecting the initial values (160.0cm, 60.0kg, 40 years old, male). After about 7sec. since pressing the "Test" key, indicate the body fat rate of 26.9±2.0%, BMI of 23.4 and basal metabolism of 1,416.

With the above settings kept unchanged, carry out 3 tests continusouly and take the average of shown body fat rates. If every test data varies from the average by not more than ±2%, the test is acceptable.

3.4 Commissioning on logging personal data function

As per the "Operation Manual", select the user no.1-9 in sequences under the user number selection mode. With every number, you may set the different height, weight, age, sex, which data will be stored. Recheck the data stored for user no.1-9.

On completion of commissioning, clear the stored data as per the "Operation Manual".

3.5 Alarm commissioning

3.5.1 E1 alarm

Turn on the power as per the "Operation Manual", select "Guest", fully selecting the initial values (160.0cm, 60.0kg, 40 years old, male). Both hands hold the handle as per the "Operation Manual" and press the "Test" key. Release during the test and the measurements will show "E1".

3.5.2 E2 alarm

Disable two electrodes at both left and right side respectively with leading wire. Connect the electrode at both sides to the resistance box with a leading wire, respectively and set the resistance box to 1,200Ω. Turn on the power as per the "Operation Manual" to select "Guest", fully selecting the initial values (160.0cm, 60.0kg, 40 years old, male). Press the "Test" key and the measurements will show "E2".

3.5.3 E3 and E4 alarm

Turn on the power as per the "Operation Manual" to select "Guest", inputtig the following parameters: 100.0cm, 91.0kg, 40 years old, male. Both hands hold the handle as per the "Operation Manual" and press the "Test" key. Release during the test and the measurements will show "E3" and "E4".

3.5.4 Undervoltage alarm

Take off 2 AAA manganese/alkali dry batteries and use signal generator to produce a DC signal of 2.35V/100mA. The negative pole of the DC signal is connected to –BK and the positive one to +R. Press the "Power" key for startup, showing  , which is acceptable.

3.6 Withstand test

It is required to withstand DC test voltage for 1min. without breaththrough or flashover.

DC500V appears between the electrical part and housing (A-a2);

AC1,500V appears between the application part and housing (B-d).

4. Project mode

The body fat measuring apparatus is equipped with project mode, designed to connect U2's #16 pin and #17 pin (ie. JP1's two contacts to be connected with soldering tin) before entry into project mode. Project mode the commissioning mode only available in the company and soldering tin at JP1 shall be removed before delivery. There are following functions available under project mode:

4.1 PWM differential value and standard resistance value

Turn on the "power"to select the personal no."Guest". Press the "Set" key until only "0" appears in the screen. Press the "Set" key under the status, showing the PWM differential value at the lef bottom corner of the screen and standard resistance value at the right top corner of the screen. Later, press the "Set" key to return to "0" indication status. Under "0" indication status, keep pressing the "Set" key to exit the project mode.

Measure the standard resistance value in 3 continuous tests, showing the resistance value of 680Ω±10Ω.

Measure the standard resistance value in 3 continuous tests, showing PWM differential value of 110±8.

Part of causes contributing to big deviation of PWM value and troubleshooting are shown below:

Causes contributing to big deviation of PWM value	Troubleshooting
L2 conductance defective welding or broken	Replace L2 conductance
Operational amplification short circuit and defective welding	Reweld the appropriate pin on operational amplification, such as U3's 2 pins.
Waveform generation circuit discrete device welding	Check R9 and R16 for incorrect welding, or for defective welding, etc. Replace capacitor C8, C4, etc.

4.2 3V voltage and 5V voltage measurements

Press the "Power" key for startup and select the personal no. "2". Press the "Set" key until only two numerical values are shown in the screen. Internal test values of battery voltage (X battery) are shown at the left top corner of the screen and internal test values of 5V voltage (X5V) are shown at the right top corner of the screen. Press the "Set" key to exit the project mode.

Actual values and internal values are converted in the formula below:

Y battery = (3×X battery) /1024;

Y5V = (5×X5V) /1024;

In which, Y5V = 5±0.05.

5. Waveform measurement

Measurement mode:

Connect the grounding terminal of oscilloscope to –BK terminal. Turn on the “power”to select the personal no.“Guest”. Press the “Set” key until only “0” appears in the screen. Start the test by pressing the “Set” key. During test, measure the waveform at TP1, TP2, TP3, TP4 respectively with test terminal of oscilloscope.

There are 4 locations to test the waveform, namely TP1, TP2, TP3, TP4. with the measurement of waveform at 4 locations, it is able to understand whether the system is working well.

Waveform at TP1: PWM waveform of 50KHz, with amplitude of 5V;

Waveform at TP2: DC waveform of 5V±0.05V, without obvious burrs;

Waveform at TP3: DC waveform of 2.5V±0.05V, without obvious burrs;

Waveform at TP4: sinusoidal waveform of 50KHz, with amplitude changing with change of external measurement resistance.

6. Troubleshooting

6.1 No display or missing stroke in the screen

Cause: It may be attributed to such cases as the screen is assembled in reverse, zebra strip is not in good contact, display chip may have defective welding of pin, ceramic resonant device may have defective welding;

Solution: Reverse the screen, ensure the zebra strip in good contact with the screen, appropriately weld teh pin of display area, appropriately weld the pin of ceramic resonant device.

6.2 Measurements of body fat rate deviates beyond ±2%

Cause: Welding may possibly cause damage or defective welding to the device;

Solution: After acess to project mode, test each parameter in project mode and log each parameter. Measure the waveform at TP1, TP3, TP4 with oscilloscope to confirm where the problem occurs.

6.3 With full illumination background after startup, it works ineffectively by pressing any key and the apparatus is able to auto shutdown in 60sec.

Cause: Measuring circuit may possibly have damaged or defective welding of device.

Solution: Re-weld some devices in detection circuit. In case the problem still exists, Measure the waveform at TP1, TP3, TP4 with oscilloscope to confirm where the problem occurs.

6.4 PWM differential value and standard resistance measurements beyond the specified threshold or in unstable condition

Cause: 4.7μF, 47μF filter capacitor may be not appropriately welded. 4.7mH inductance parameters may not meet the specified limits;

＊ Solution: Re-weld 4.7μF, 47μF filter capacitor and replace 4.7mH inductance.

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