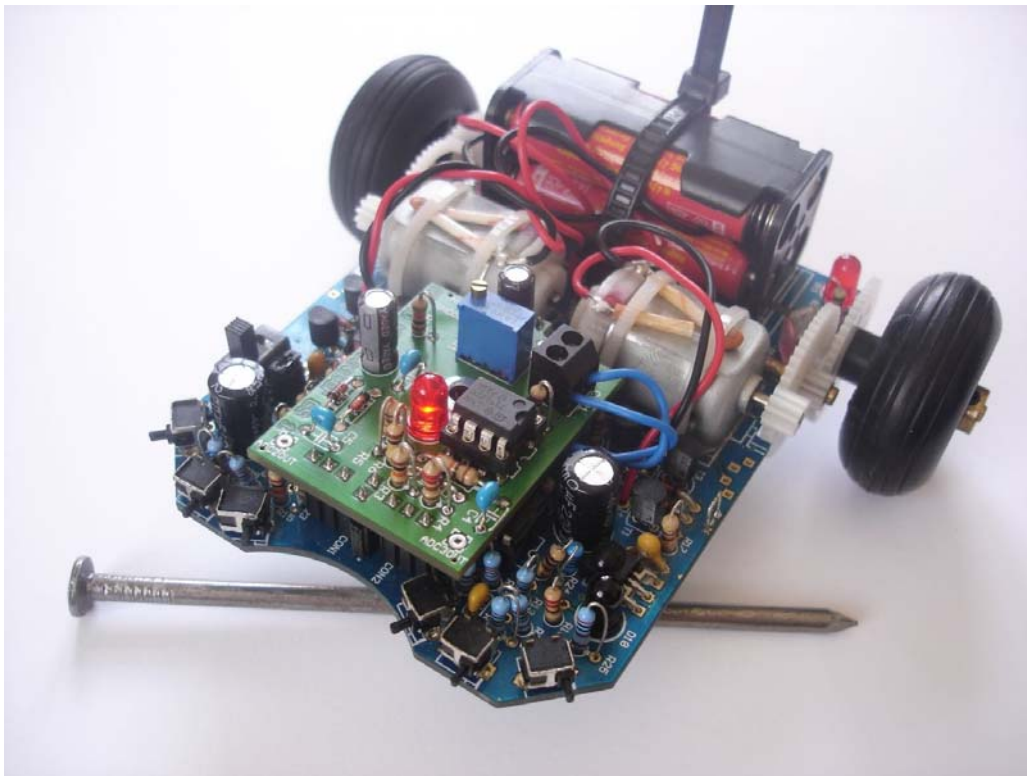


阿木罗 (ASURO) 扩展扫雷模块说明书

AREXX / Robin Gruber 23.3.2009



1 Basic description of the design

基本描述

在ASURO机器人上装扫雷扩展模块，能让机器人底部的半个乒乓球在滑行时探测到金属物体。为避免大篇幅解释有关磁场和交流电的物理理论，接下来几章会详细描述机器人设计和介绍使用说明。

在共振线路中安装运算放大器用来刺激振荡器，共振线路包括一个电容（C）和一个感应器（L）应用在open pot core，磁性地open pot core应用可以将磁场扩展到周边的自由场地，继而受到周围金属物体的影响。

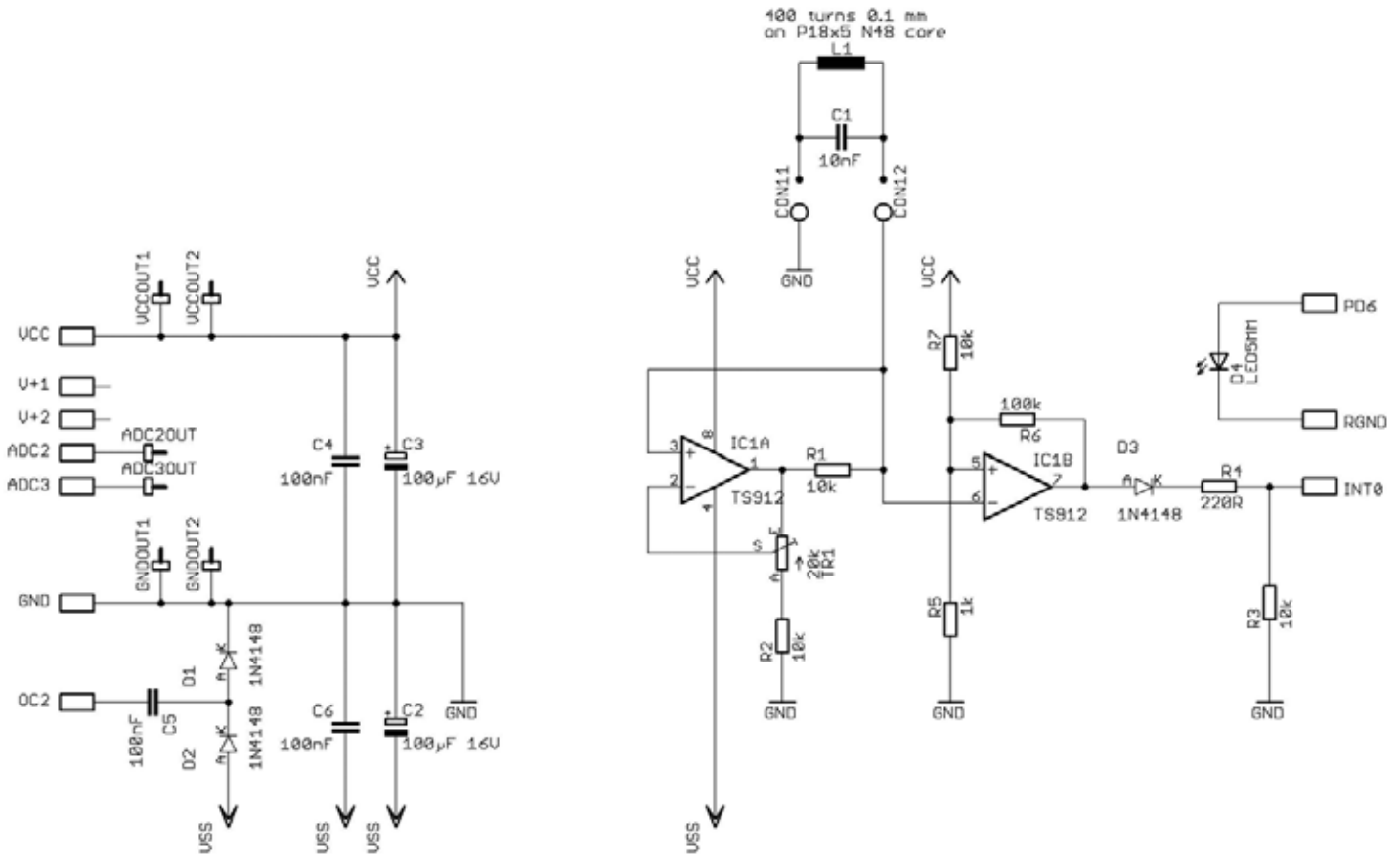


图-1: ASURO扩展扫雷模块电路原理图

Fig. 1 displays the schematic diagram. The resonant circuit applies inductance L1 and capacitor C1. The design allows resonant behaviour by cyclically exchanging the capacitor's electric field-energy and the inductor's magnetic field-energy. The design's transfer frequency depends on the values for the capacitor and for the inductor. Assuming negligible losses the resonator's frequency may be calculated by the following formula:

图片1展示的是扩展扫雷模块机器人的**电路原理图**，共振电路中应用了L1感应器和电容C1。这种设计通过循环交互电容的电子能量场和感应器磁性能量场来产生共振，设计的转换频率由电容和感应器的值来决定。假设忽略损耗的部分，共振频率可以由以下公式来计算：

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

交互电容电子能量场和感应器磁性能量场时是有能量损耗的，并且损耗能量会导致振荡器延续几周，所以要在系统中继续提供能量以补充损耗的部分能量。类似于小孩子的秋千，系统也必须应用正确的短语为线路增加能量。

To achieve this goal the design controls the capacitor's current proportionally to the capacitor's voltage. In this system the active element is the operational amplifier IC1A in a non-inverting amplifier-circuit with resistor R2 and the trimmer-resistor TR1. This circuit will amplify the capacitor's voltage at an adjustable rate of 1 up to 3, which will increase the current into resistor R1 proportionally to the voltage at C1. 为达

到这个目标，线路设计按照电容电压的比例，控制了电容的电流，在此系统中，活跃元件为运算放大器IC1R，用在带有电阻R2和修整电阻TR1的非转换放大器线路中。此线路会在1到3的调节范围内放大电容电压，按照C1中电压的比例，也同样增加了流向电阻R1的电流。The losses in the resonator circuit may vary and to compensate a range of tolerances we will need an adjustable amplifier. The operational amplifier IC1B is used as a comparator and compares the resonator's voltage with a reference-voltage of circa 0.5V (depending on ASURO's battery-voltage). The comparator's result is applied to the extension-pin INT1. 共振线路中的损耗部分可能会有很多变化，所以为了弥补可以接受的范围，我们需要一个可调节放大器。运算放大器IC1B用作比较器，用大约0.5V的参考电压来比较共振电压（由ASURO的电池电压决定）。比较器的结果应用在扩展引脚INT1上。To avoid signal-collisions between the processor-pin and the output of the operational amplifier in non-programmed processor the port is being protected by resistor R4. D4 replaces the previous line-follower LED. The left part of the circuit containing a number of diodes and capacitors generates a negative voltage with respect to the ground level. The design will need a negative voltage as the resonator's voltage swings in a positive and negative range, centred at the ground level. 为避免在处理器引脚和非编程处理器里运算放大器的输出之间发生信号冲突，可以用R4来保护端口，D4代替了之前的循迹LED。线路中左半部分包含一些二极管和电容，在地线上产生负极电压。此设计需要负极电压作为共振电压，摇摆在正极和负极范围，以地线为中心。

Several types of designs are available for metal-detectors. The Asuro-design supports the two following design-types:

很多种设计都使用于金属探测器，ASURO的设计支持以下两种设计类型：

1 The design's amplification-factor and the equivalent energy-input for the resonator is to be controlled at a level, in which electrical losses in the resonator are exactly to be compensated as long as no metal is to be located near the coil. If metal objects are located near the coil the so-called *eddy currents* (for conducting materials) or *demagnetizing losses* (for non-conducting, but ferromagnetic materials) result in extra losses, which will cause the decay of oscillations.

设计的放大因数和共振的等值能量输入由一定的水平控制，在此水平上，只要线圈附近没有金属存在，共振中的电子损耗会完全被弥补。如果线圈附近有物体存在，叫做涡电流，会产生额外损耗，这样将会导致振荡器功能衰退。

2.The design's amplification-factor is to be controlled at a level, in which additional losses by metals in the vicinity of the coil will be compensated and the circuit is to measure the oscillator's frequency. In this mode any conducting materials near the coil result in eddy currents, decreasing the field strength and the inductance and simultaneously raising the oscillator's frequency. Ferromagnetic materials will increase the field strength and the inductance, which lowering the oscillator's frequency. Additionally to detecting metals this design-mode also allows a rather crude determination of the type of detected metal.

设计的放大因数也是由一定水平控制，在此水平上，由线圈附近金属产生的多余损耗会有所弥补，并且线路会测试振荡器的频率。在这种模式下，线圈附近的任何导体材料都会产生涡电流，减少了磁场力和感应力，同时也提高了振荡器的频率。铁磁材料会增加磁场力和感应力，降低振荡器的频率。另外，为检测金属，这种设计模式允许一个更天然的检测金属类型。

2 Constructional details 建构细节

2.1 Manufacturing the coil 制作线圈

In case the coils has been prefabricated completely, including glueing the capacitor and applying the cables as documented in fig. 8, you may skip this chapter. Otherwise you will enjoy the next steps! 如果

线圈已被完全磨擦，并且粘好了电容和装好了电线，如图8所显示的那样，那么大家可以跳过这一章，否则，必须要进行下一步。

First of all we must apply 400 windings (yes, you are reading the correct number!) of very thin isolated copper-wire (diameter 0.1mm) to a coil-carrier. 首先必须要在线圈上缠400圈很细的绝缘铜线(直径为0.1mm)。

The kit supplies a double-sided coil-carrier for two core-halves (see fig. 2).

以下工具是双排线圈携带器，要将它分解成两个空心圈，如图2，



Figure 2: coil-carrier, complete Figure 3: coil-carrier, halved

In order to fit for our purposes we will have to split up the carrier with a saw. A suitable saw is a fine-tooth hacksaw. We will have to remove one chamber by sawing the other chamber in the middle. This procedure results in a singular coil-carrier. Remaining sawing edges may be removed with fine sandpaper (grain size: 240 or 300) or by carefully applying a sharp knife (protect your fingers!). The removed parts will not be needed and may be thrown away.

为了达到分解的目的，需要用锯子来解决问题，合适的锯子是锯齿完好的钢锯，在线圈携带器的中间锯掉其中一个圈就可以了。用砂纸（颗粒尺寸：240或300）磨掉或锋利的小刀小心削掉剩下的边缘部分。锯掉的部分不需要可以扔掉。

In order to apply the coil to the carrier we suggest to place the carrier to a pencil-shaft or (even better for it's conical form) to a suitable paintbrush. In an optimal method we also carefully fix a few centimetres of the isolated copper wire together with the carrier at the pencil's shaft as demonstrated in fig. 4. As an extra fixation you may apply some adhesive tape (cello-tape) to avoid any slipping movements of the wire.

为更好的将线圈缠在携带器上，我建议大家把携带器装在铅笔轴或合适的画笔上。还有一个适用的办法，就是小心地将几厘米绝缘铜线粘在铅笔轴上，如图4。另外，最好是用透明胶将线粘住，防止线会随意滑动。



Figure 4: Winding preparations

After these preparations you start carefully winding up the 400 turns of wire. Of course you avoid reversing the winding direction and you fill the windings neatly, otherwise the 400 windings of wire will fail to fit in the available place. In case the wire should break (there is no room for a repair) or you fail to count correctly you must restart the procedure. No problems are to be expected for winding numbers between 380 up to 420, but do not exceed these tolerances.

最好这些准备工作后，便小心开始绕400圈的铜线。当然，不要弄反缠线的方向，要小心分布线的位置，要不然400圈的线会很难缠好。若是线缠断了或忘记锁缠圈数，必须要重新开始。线圈数的范围在380和420之间是没有问题的，但超出范围是不允许的。

Having completed the windings you are advised to fix the windings with some *nail varnish* or *instant glue*. As soon as the glue has hardened you may carefully remove the cello tape and the pencil or brush.

缠好线后，要在线圈的上涂一些快干胶，等胶水干了要小心撕开透明胶和铅笔或画笔。You may also cut the wire, but do not forget to reserve a few centimetres at both sides. The wire-endings have to be directed into one direction and are not allowed to pass through the hole in the coil-carrier (see fig. 5).

也可以减掉电线，但是别忘了在两边保留几厘米，线的两端必须要指向一个方向，不能穿过线圈携带器中间的孔里。（如图5所示）



Fig. 5: coil-carrier - completed

Having completed the coil-carrier you may fix the structure into the core with some *instant glue*. The wire's endings are to leave the core at the closed core-side through a slit (see fig. 6).

完成线圈后，用快干胶将其粘在磁芯上，线的两端要通过线圈缝隙部分留在外面。（如图6所示）

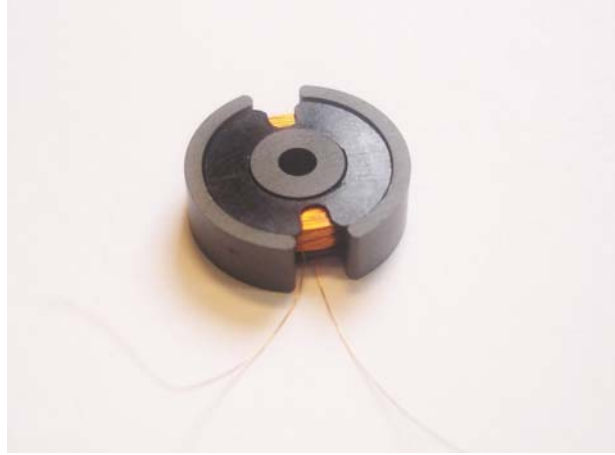


Fig. 6: Coil - fixed in the core

At this stage you are asked to remove the isolation at the wire-endings, starting at a one or two millimetres from the core towards the outside. The optimal tool to remove isolation is a soldering tool with some fresh solder at the soldering tip. Apply the heated top for some time until the isolation has been removed and a thin layer of soldering tin is covering the wire. Warning: the generated smoke may cause injuries to your health and should not be inhaled!

这一步就该去掉线端的绝缘体，从磁芯1到2毫米处开始向外去除绝缘体。最适用于去除绝缘体的工具是焊接头上带有一些新鲜焊料的焊接工具，将热的烙铁头在线上停留在一段时间，知道绝缘体完全去除掉，并在线上留有一层焊锡。警告：产生的烟有害健康，最好不要吸入。

At last you apply some instant glue to the backside of the coil and fix the 10nF-capacitor (imprinted text: 103) in a suitable position to point the wiring connections towards the slit for the coil-windings. Fig. 7 demonstrates a location for the capacitor besides the carrier's hole – just in case we may need the hole for some reason. The published design however does not really require this exact position. 最后在线圈的背面涂上快干胶，在合适的位置粘上10nF的电容，将线连接处指向线圈的缝隙处，如图7，显示了携带器中心孔旁边为电容安装位置，以防要用到中心孔。

Now cut the capacitor's wiring connections to circa 5 mm, wind the tinned copper wire-endings around these wiring connections (maybe using a pair of tweezers) and fix the connection by soldering. 现在将电容的线连接处剪掉大约5毫米，然后将被焊锡过的铜线端缠绕在电容连接处（可以用镊子做这个工作），然后焊接固定连接处。



Fig. 7: Coil with capacitor

Next we proceed with the ready-made cables. The dual cable has been dimensioned at 70 mm, stripped, twined and tinned at the cable-endings. You are asked to solder the cable-endings directly entwined to the capacitor-endings with the endings and pointing in the same direction as shown in fig. 8. Polarity is irrelevant. If you have a multimeter you may now measure the resistance between both cable-endings. The resistance-value is to be circa 30Ω . If the value exceeds 60Ω you should check the proper removal of the isolation layer at the thin copper wires, the soldering quality and any ruptures of the soldering and cables. Should the resistance-value be much lower ($< 10\Omega$) you may check for short circuits at or near the soldering area. Unfortunately you are unable to detect short circuits within the winding area. 接下来要处理已经准备好的电线了，两根电线的规格为70毫米，长条，扭结在一起，线端带有焊锡。然后将线端直接焊接在电容的端部，方向与电容的方向一样，如图8。极性是无关紧要的。用万用表测量两个线端之间的电阻，电阻值应该大约为 30Ω ，如果电阻值超过了 60Ω ，那么就该检查铜线上绝缘体是不是完全去除掉，以及焊接处与电线间是否有断裂。如果电阻值低于 10Ω ，那么就该检查焊接处或焊接处附近是否短路。



Fig. 8: Coil (assembly completed)

2.2 Inserting the coil-assembly 装入组装线圈

To insert the completed coil-assembly into the robot you start by removing the ping-pong ball. Right now you will be grateful if you have glued the ping-pong ball at a minimal number of points instead of an overall glued area of the component.

Proceed by glueing – again using an *instant glue* – the coil at the backside under the ping-pong ball (see fig. 9). 要在机器人中装入完全组装好的线圈，首先要移开乒乓球，移开后将线圈装在乒乓球里面，用快干胶粘好，如图9。

Attention: If ASURO has not been prepared for assembling an extension PC-board you will have to postpone attaching the ping-pong ball until the preparation for the extension board has been completed. 注意：如果ASURO没有准备好安装扩展PCB，那么直到扩展板的准备工作做好才可以连接乒乓球。

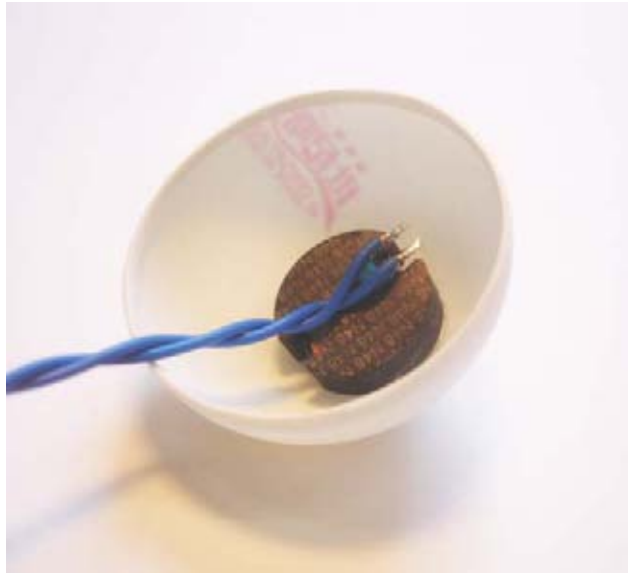


Fig. 9: Coil - attached to the ping-pong ball

2.3 Inserting the extended plug-sockets 装入扩展插件

Before assembling the components to the PC-board you will have to insert the extended plug-sockets. You will have to use a different procedure depending on the status of the ASURO-system. Please check whether the ASURO has been prepared for assembling an extension PC-board or not. 在组装零件到PCB之前，必须要先装入扩展插座，根据ASURO系统的特点要使用不同的组装步骤，并且请检查ASURO是否已经准备好安装扩展PCB。

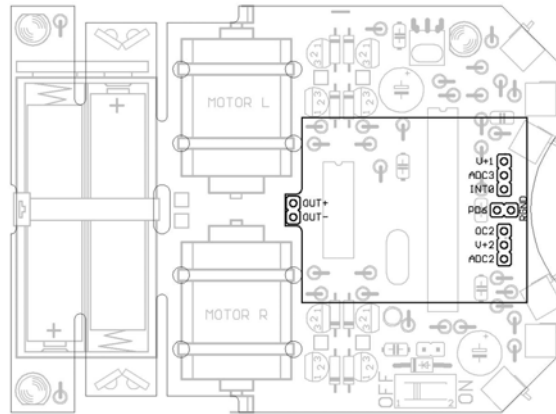
a) ASURO does not provide extended plug-sockets for the extension board

ASURO没有为扩展板提供扩展插件

In this case you will have to remove the components for the line-tracing (the photo-transistors T9 and T10, as well as the LED D11) from the PC-board. These activities require a removal of the *ping-pong ball*. The easiest way to proceed is to heat the components, which are to be removed with a soldering device while simultaneously and carefully pulling the components out of the PC-board's holes. If you are lucky the PCB-holes are free, otherwise the superfluous solder may carefully be removed with a solder sucker and / or a solder wick.

Now the two-and three-poled male and female plug-elements have to be assembled and – additionally to the plugs at the ASURO-board – inserted in the ASURO-PCB as illustrated in fig.

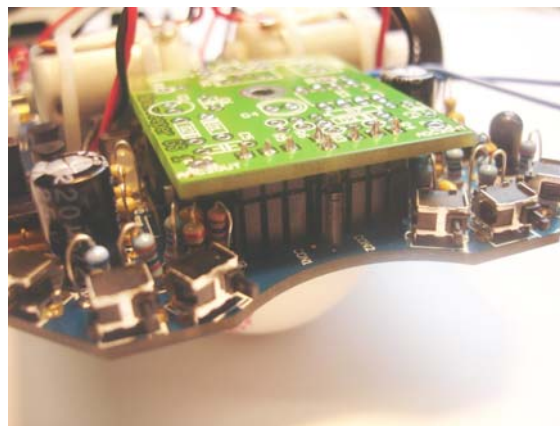
10. In a following step you may *first* insert the extension-board and *at last* proceed by soldering the male and female plug-elements at the extension-board and the ASURO-main PC-board. 在这种情况下，首先要从PCB上移开循迹组件（感光晶体管T9 T10和LED D11），做这些工作必须要先拆掉乒乓球。最简单的办法是用焊接装置加热组件，同时要小心地从PCB孔上拿开这些组件。组装好两根或三根阴性和阴性插入零件后，还要将ASURO板上的插头插入ASURO-PCB上，如图10所示。接下来要先插入扩展板，最后再将阳性和阴性插入零件焊接到扩展板和ASURO主要的PCB上。



b) ASURO already provides extended plug-sockets for the extension board

ASURO已经为扩展板提供了扩展插件

The two-and three-poled plug-elements are to be inserted into the plugs at the ASURO-PC-board (see fig. 10), on top of which you may attach the extension board. The pins will be protruding from the PCB. If all components are well-placed the extended plug-sockets are to be soldered to the extension-board. 将插入零件插进ASURO PCB上的插孔（如图10），在ASURO PCB顶部粘上扩展板，要突出PCB上的针脚。如果扩展插件上的所有的组件都已经组装好了，将其焊接在扩展板上。



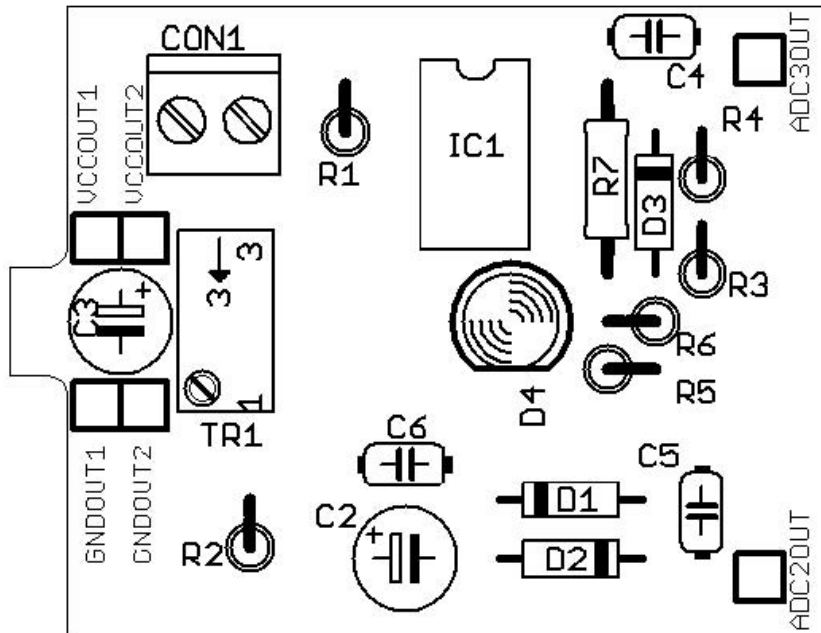
2.4 Placing the ping-pong ball 安置乒乓球

Having soldered the extended plug-sockets to the printed circuit board you have to unplug the extension board and place the component apart for further assembling activities. Now pull the connecting cable of the coil through the hole in the ASURO-PCB and attach the ping-pong ball (together with the included coil) carefully with merely three or four glueing dots at the ASURO-PCB. 在PCB上焊好扩展插件后，先不要在扩展板上插插件和组装零件，方便后面的组装工作更容易。接下来将线圈的连接线从ASURO-PCB中的孔中穿出来，在ASURO-PCB中的三四个粘胶点上将乒乓球（里面带有线圈）小心粘起来。

2.5 Assembling the Printed Circuit Board 组装PCB

After placement of the extended plug-sockets (and eventually the plug-arrays as well) you may remove

the PCB and complete the assembly phase. According to the component placement drawing (see fig. 12) you are advised to proceed the following way: Up to R7 all resistors are to be placed upright – according to the ASURO-standard, which implies bending a U-turn (180°) for one leg of the components. Bend both legs for component R7 at an angle of 90°. 安装好扩展插件后拿开PCB完成组装工序，根据图12中的组件位置并按照以下方式安装：将R7和所有的电阻都竖起来——根据ASURO的规格，也就是说将组件的其中一只脚要弯成U形（180°），将组件R7的两只脚都弯曲90°。



Please insert the components in the following sequence: IC1: Initially merely insert the socket, be careful to apply the correct polarity! D1, D2, D3: 1N4148, be careful to apply the correct polarity! C4, C5, C6: 100nF ceramic R1, R2, R3, R7: 10kΩ 5% (brown, black, orange, gold) R4: 220Ω 5% (red, red, brown, gold) R5: 1kΩ 5% (brown, black, red, gold) R6: 100kΩ 5% (brown, black, yellow, gold) C2, C3: Electrolytic capacitor 100μF, minimal 16V, be careful to apply the correct polarity! TR1: Spindle-trimmer 20k upright D4: LED 5mm rot, be careful to apply the correct polarity! CON1: screw terminal, cable entry must point to the PCB-edge. IC1: Now insert the TS912 into the socket. Maybe you will have to slightly bend the legs. Be careful to apply the correct polarity: the marker at the component must be oriented to the corresponding marker at the socket! 请按以下顺序安装组件：

IC1：首先安装插座，要小心正负极。

D1, D2, D3：1N4148，要小心正负极。

C4, C5, C6：100nF的贴片电容

R1, R2, R3, R7：10kΩ 5%（棕色，黑色，橙色，金色）

R4：220Ω 5%（红色，红色，棕色，金色）

R5：1kΩ 5%（棕色，，黑色，红色，金色）

R6：100kΩ 5%（棕色，黑色，黄色，金色）

C2, C3：电解电容100μF，最小16V，小心正负极。

TR1：微调器，20K，向上

D4: 5mm LED, 小心正负极

CON1: 带螺丝口, 接线部分应朝向PCB边缘

IC1: 在插孔中插入TS912, 可能需要轻微的弯曲一下脚。要小心正负极: 组件上的标志方向必须与插孔上的标志一致。



Note: Initially the terminals VCCOUT1/2, GNDOUT1/2 and ADC2OUT/ADC3OUT will not be needed. Additionally to the fixing-hole at the PCB these terminals may later be used to connect two distance-sensors in a triangulation-sensor-system. This will allow the ASURO to apply an autonomous navigation system and to be searching metallic objects as well.

备注: 起初是不需要VCCOUT1/2, GNDOUT1/2 和ADC2OUT/ADC3OUT这些端口的, 接下来固定PCB孔时, 这些端口在三角感应系统中会用来连接两个远距离的感应器。这样会使ASURO形成自动导航系统, 来搜寻金属物体。

For more details please consult "More Fun with ASURO, Volume II". Instead of attaching the triangulation-sensors directly to the ASURO-PCB you will now have to attach these to the extension-board.

2.6 Startup-procedure

Having attached the ping-pong ball including the coil and having completed the PCB-assembly you may now insert the PCB into the (deactivated!) robot. Please check carefully the isolation of components: none of components at the ASURO-PCB are to short-circuit the metallic areas of the extension-board. The coil-cabling is to be guided from below the PCB to the side of the screw terminal CON1 and may now be attached to the screw terminal. In this case the polarity may be neglected. 粘好乒乓球并完成PCB组装后, 接着将PCB安装到机器人中。请仔细检查组件的绝缘: 确保ASURO-PCB上没有一个组件会使扩展板的金属区域短路。线圈安装在PCB上CON1这一边的底下, 将电线连接到螺丝端口。这种情况下可以忽略正负极。

In order to view the oscillations in the resonator-circuit you may enter the following program (MinesweeperTest1): 若要观察共振线路中的振荡器, 可以进入以下程序(扫雷测试1):

```
#include "asuro.h"
```

```
extern volatile unsigned char count72kHz;
```

```

int main(void)
{
    unsigned char oscillation;

    Init();

    DDRD &= ~(1<<2); // Change Port D Pin 2 to input

    StatusLED(OFF);

    while(1)
    {
        count72kHz=0;

        oscillation = FALSE;

        while (count72kHz<100) {
            // Detect low level

            if ((PIND & (1<<2)) == 0) oscillation = TRUE;
        }

        // If oscillator is running, no metal object is within
        // range, so LED should be off

        if (oscillation) FrontLED(OFF); else FrontLED(ON);
    }

    return 0;
}

```

This program will switch off the LED as soon as the oscillator is working.

此程序可以在振荡器工作时关掉LED。

Depending on the activated detection-method (decay-mode of the oscillations respectively variations of the oscillator-frequency) we will need different calibration methods. At first we will explain the calibration for the decay-mode of the oscillations and this simpler method should always be preferred for testing the system (with the previously referenced program).

根据活跃性探测方法，我们需要不同的测量方法。首先会解释振荡器衰退模式的测量，这种简单点的方法更适合测试这个系统。

If the red LED at the extension board is not activated after switching on the system, please turn the spindle-trimmer clockwise until the LED is activated. The trimmer may be turned ten rotations clockwise, respectively counter-clockwise and will not be damaged if you exceed the operating area. If turning over

ten rotations does not effect the system we will have to proceed with the debugging phase... 如果打开系统后扩展板上的红色LED没有亮，请按顺时针方向旋转微调整器，知道LED发亮，调整器大约要顺时针旋转十圈，如果超过了操作区域也可以逆时针再调回来，是没有任何破坏性的。如果旋转不止十圈还不能影响系统的话，就要考虑进行故障排除程序了。

After a successful calibration please place the robot on top of a definitely non-metallic location (on top of a plastic or wooden box, respectively on a table without nails or screws...) and turn the trimmer counter-clockwise until the LED extinguishes. You may have to repeat the calibration procedure again, as temperature-drifts and changing battery-levels are influencing the operation-point of the system. Careful calibrations will increase the sensitivity of the system but will also reduce the intervals between re-calibrations.

测试成功后，请将机器人放在完全没有金属的位置（塑料或木头箱）上，逆时针旋转调整器，知道LED熄灭。当温度变化和电池水平变化影响系统的操作点时，大家可能要重复测试过程。小心测试会增加系统的灵敏度，但也会降低重复测试之间的间歇差别。

As soon as you near the ping-pong ball with a metallic object (e.g. a screwdriver) the LED should be activated – at least the moment you touch the system.

当乒乓球靠近金属物体（比如螺丝刀）时，LED会发亮。

The sensor will now be sensitive enough to detect even small pieces of aluminium foil at the backside of a paper board. 感应器会非常灵敏，即使是纸板后面的小块铝箔也会探测到。

In order to monitor the frequency-variations you should start by calibrating the sensor in the exact application-mode. In this mode the robot is to be placed in a position for the maximal level of the expected sensor-signal (e.g. very close to the metallic object). Then turn the trimmer counter-clockwise as long as the LED is activated. Now you may use the following program for demonstration purposes (MinesweeperTest2): 若要监测频率变化，首先要测试完全装置模式中的感应器，在此模式中，机器人要放在感应信号水平最强的位置（比如非常靠近金属物体）。然后逆时针旋转调整器，知道LED发亮。可以利用以下程序证明（扫雷测试2）：

```
#include "asuro.h"
#include <stdio.h>

extern volatile unsigned char count72kHz;

int main(void)
{
    unsigned char oldlevel=0, newlevel;
    unsigned int freq;
    int i;
    char s[9];
    Init();

    DDRD &= ~(1<<2); // Change Port D Pin 2 to input
    StatusLED(OFF);
```

```

while(1)
{
    freq=0;
    for (i=0; i<100; i++) {

        count72kHz=0; // This counter is incremented in timer interrupt
        FrontLED(OFF);
        while (count72kHz<72) {

            // Detect level change
            newlevel = PIND & (1<<2);
            if (oldlevel != newlevel) {

                oldlevel = newlevel;
                freq++;
                FrontLED(ON);

            }

        }

        sprintf(s,"%5d\n\r",freq);
        SerWrite(s,7);

    }
    return 0;
}

```

2.7 The debugging procedure 故障排除过程

If the system does not work as expected we will have to start the debugging procedure. Unfortunately we cannot provide as many debugging options as for the basic ASURO-system, and the use of a multimeter may help to debug the system.

如果系统不能正常工作就要进行故障排除过程了，遗憾的是我们不能提供很多故障排除错做，可以万用表比较有利于故障排除。

□ Please start by checking the correct compilation of the test-program. Has the program really been flashed? Proceed by checking the soldering locations and the polarities and values for the components. 请首先检查测试程序的正确编码，然后检查焊接位置、正负极和组件值。

□ Check the connections of the coil-system for correct removing of the isolations and applying the solder? Did you really remove the isolation? At a *deactivated* (!) robot you should be able to monitor a resistance of 30Ω at the terminals for the coil.

检查线圈系统的连接，看绝缘体和所用焊料是否正确去除。对于失效机器人，可以监测连接线圈端口处的30Ω电阻。

At much higher measured resistor-values the cable has not been connected correctly, some isolation at the copper cable has not been removed properly – preventing good conductivity -or the thin copper wire of the coil has been disrupted at the assembly phase. The last problem often occurs in the neighbourhood of the capacitor.

测试的电阻值更高时，电线不能正确连接，铜线上的绝缘体没有去除而影响导体操作，或者线圈的细铜线在组装时被阻断，最后一个问题经常在电容附近出现。

At much lower measured resistor-values you may locate a short circuit at the printed circuit board or in the coil. You are now advised to remove the cable from the screw terminal and to repeat the

measurement of the resistance-value at the screw-terminal. If the resistance is much higher than 30 Ohms you may locate the short circuit area at the coil-module.

测试的电阻值更低时，PCB或线圈上会出现短路，这时便要从螺丝口上移开电线，重复螺丝口上电阻值的测试。如果电阻值高于 30Ω ，可能会在线圈模块上短路。

□ At an activated robot you should be able to monitor an operating voltage in the range 4.5 .. 5.5V between the terminals GNDOUT1 and VCCOUT1. If the operating voltage does not meet these specifications the battery may be empty, the robot may be deactivated, the connections for the battery-compartment may be interrupted or a cold soldering point occurs in the neighbourhood of the rear extended-plugs at the extension-board or the robot itself.

□ 对于有效机器人，可以在端口GNDOUT1 和 VCCOUT1之间监测范围为4.5-5.5V的操作电压。如果操作电压不在此规格内，电池就会耗尽，机器人也可能会失效，电池组件部分的连接也会中断，或者，扩展板或机器人本身后半部分的扩展插件附近出现冷焊接点。

□ The voltage for the operational amplifier may be monitored between pin 4 (minus) (at the bottom left side if the mark at the IC is at the topside) and pin 8 (plus) (at the top rightside). The voltage should be at least 2V higher than the battery voltage.

可以再引脚4（减）（如果IC为顶端部分，它就在左下部分）和引脚8（加）（右上部分）之间监测运算放大器的电压，此电压应该至少比电池电压高2V。