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740 族

抗干扰措施-优化 PCB 布线

1. 要点

本篇资料介绍如何进行 PCB 布线的设计以提高单片机的抗干扰特性。同时,对于相同噪音干扰下的两种 PCB 布线(推荐与不推荐)进行了测试,比较它们的抗干扰性能,并且举例说明如何对不推荐的电路板进行改进。

2. 说明

本说明适用于以下条件:

单片机: 740 族单片机

本测试适用于以下条件:

单片机: M37544G2ASP

振荡频率: 4MHz

PCB 类型: 单面板, 无敷铜

3. 推荐的 PCB 布线

以下部分将用实际的例子说明推荐的 PCB 布线和不推荐的 PCB 布线。并列举一些关键点介绍如何通过设计 PCB 布线来减少噪音的干扰。通过这些措施,可以提高产品的抗干扰特性。

3.1 PCB 布线范例

在这一部分中,通过几个范例比较推荐的布线与不推荐的布线的区别。两种电路板的原理图完全相同。单片机周围的电路图如下所示:

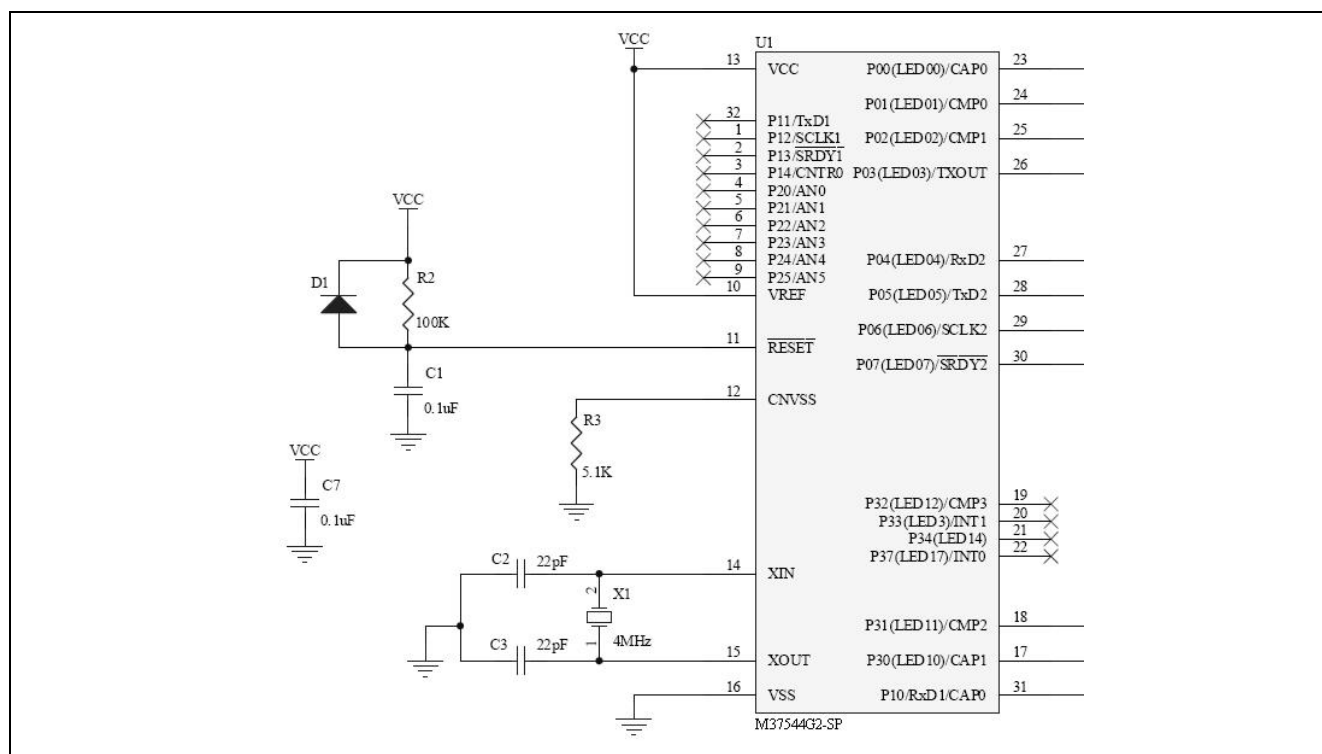


图 1 单片机部分的电路图

图 2 中的 1-5 指出了两种布线的主要不同点。为了获得较好的性能，应按照推荐的方法设计 PCB 布线。具体原因在下一节（3.2 推荐的布线）中详细描述。

使用的 PCB 布线如下所示：

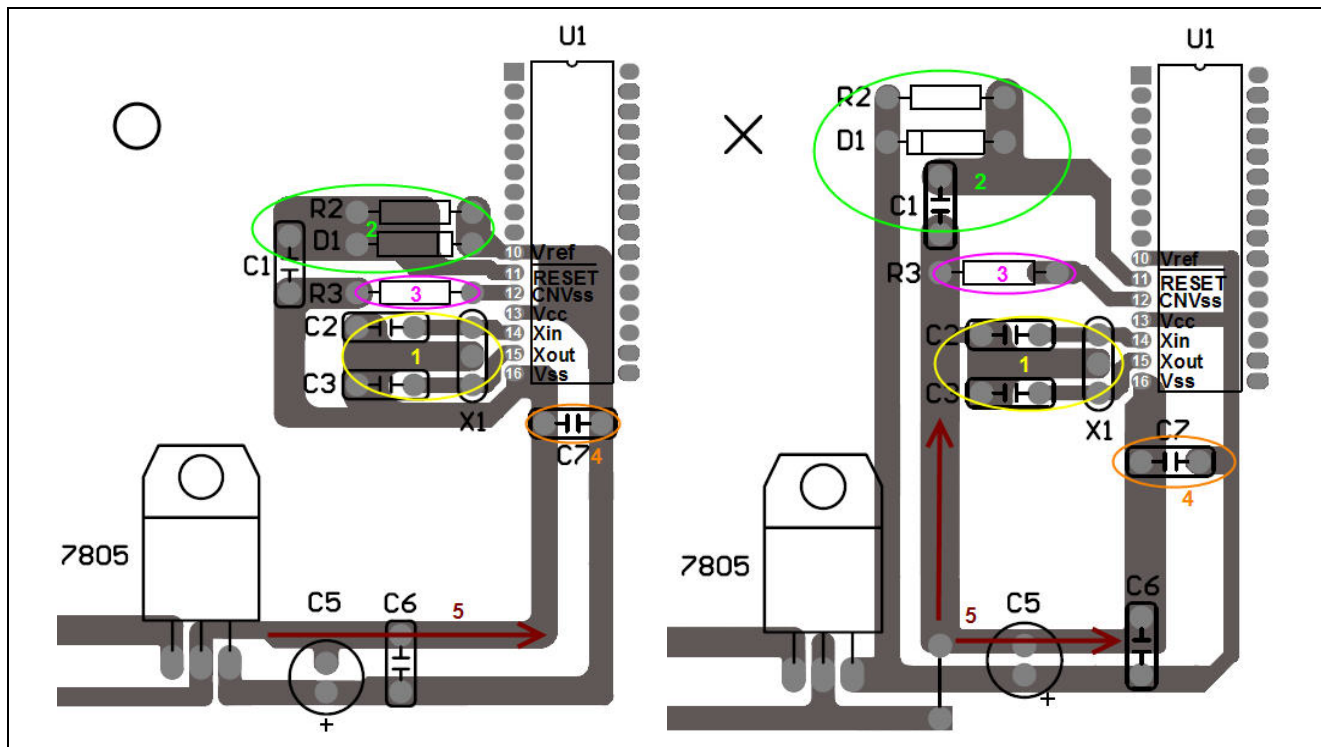


图 2 推荐的布线（左）与不推荐的布线（右）

注：

实验中使用了如上两种 PCB 布线。

器件类型：DIP

PCB 类型：单面板，无敷铜

3.2 推荐的布线

要提高单片机的抗干扰性能，应该遵守以下几个布线原则设计电路板。

3.2.1 时钟电路

为了降低噪声干扰的影响，应该以最短的布线连接振荡器和单片机。同时，将振荡器和单片机的地线与其他地线分离。请参照图 2 中的 Part 1 部分（黄色）。

<理由>：较长的布线会变成接收噪声信号的天线。当有噪声干扰侵入时钟输入/输出管脚，时钟的波形就会发生紊乱，导致误操作和失控。另外，如果噪声使单片机和振荡器的地电平之间产生电位差，正确的时钟就不能输入到单片机。

3.2.2 复位电路

同样，将复位电路尽可能地靠近单片机。请参照图 2 中的 Part 2 部分（绿色）。

<理由>：复位信号将单片机的内部状态初始化。复位信号要求有一定时序，如果短于正常复位脉冲的干扰信号输入到复位管脚，在单片机完成内部初始化之前复位被解除，导致程序失控。缩短复位电路布线长度可以有效地降低噪声干扰的影响。

3.2.3 CNVSS 电路

推荐将 $1\text{k}\Omega \sim 5\text{k}\Omega$ 的电阻串联插入 CNVSS/VPP 管脚和地线之间。尽量缩短 CNVSS/VPP 管脚、电阻和单片机之间的布线。请参照图 2 中的 Part 3 部分（粉色）。

<理由>：如果有噪声侵入 CNVSS/VPP 管脚，单片机工作模式变得不稳定，程序会失控。

3.2.4 去耦电容

在尽可能靠近单片机的位置放置一个去耦电容。单片机的 VCC 管脚到去耦电容的布线长度应该和 VSS 管脚到去耦电容之间的布线长度相等。请参照图 2 中的 Part 4 部分（橙色）。

<理由>：如果单片机到去耦电容布线太长，它会变成接收噪声的天线，造成单片机工作电压不稳定。

3.2.5 接地布线

应该将单片机、振荡器、复位电路和 CNVSS 管脚的接地布线布置到同一条地线支路上，并与其他功能的地线分开。请参照图 2 的 Part 5 部分（棕色）。

<理由>：如果因噪声使两个不同地电平之间产生电位差，程序可能会误操作或失控。

4. 不同布线的抗干扰实验

下面，通过实验来比较噪声对不同布线的影响。实验结果可以证明前面推荐的布线要点。

4.1 实验描述

本实验中使用了两种 PCB 布线。其中一个按照推荐的方法进行设计，另一个则完全相反。单片机周围布线如图 2 所示，两种电路板的外围电路完全相同。实验时向两块电路板的电源中输入相同的噪音干扰，持续 1 分钟。噪音信号的峰值由 100V 提升至 4000V，每次测试升高 100V。

目标板上有两组 Led 指示灯。可以根据这两组灯的闪烁来判断单片机的工作状态。单片机复位后，所有的指示灯会持续点亮 5 秒钟。然后两组指示灯会以“12”为单位，从“00002”闪烁至“11112”，两组指示灯同步闪烁。一组指示灯由主程序循环控制，另一组指示灯由定时器中断控制。

通过观察指示灯，可以判断单片机的状态。

如果在这 1 分钟内单片机可以正常工作，在表中填入“○”。

如果在这 1 分钟内单片机出现异常现象（复位、程序失控或指示灯不同步闪烁），在表中填入“×”。实验环境如下面图表所示。

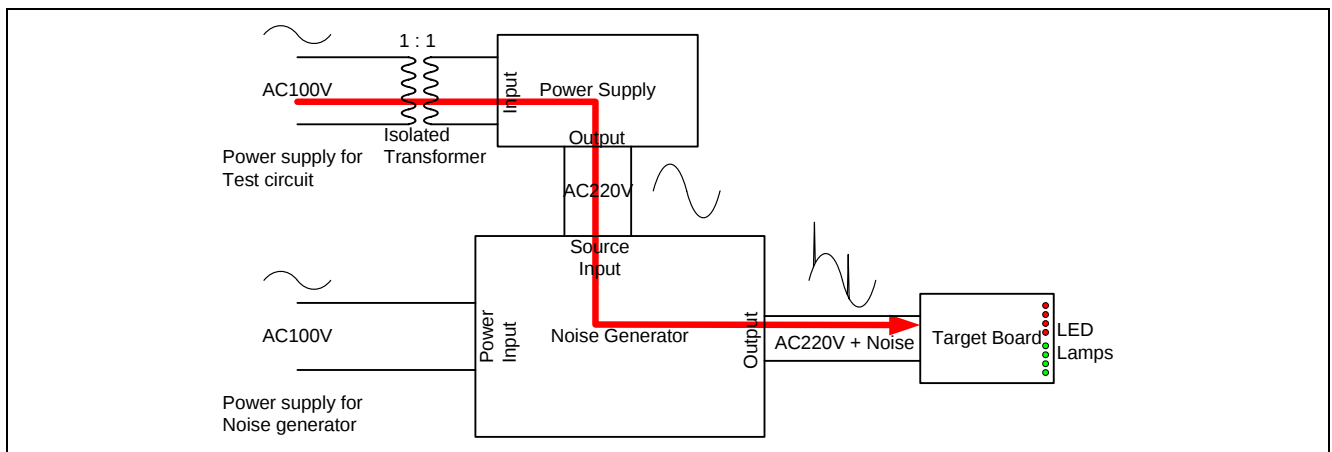


图 3 实验环境框图

4.2 实验条件

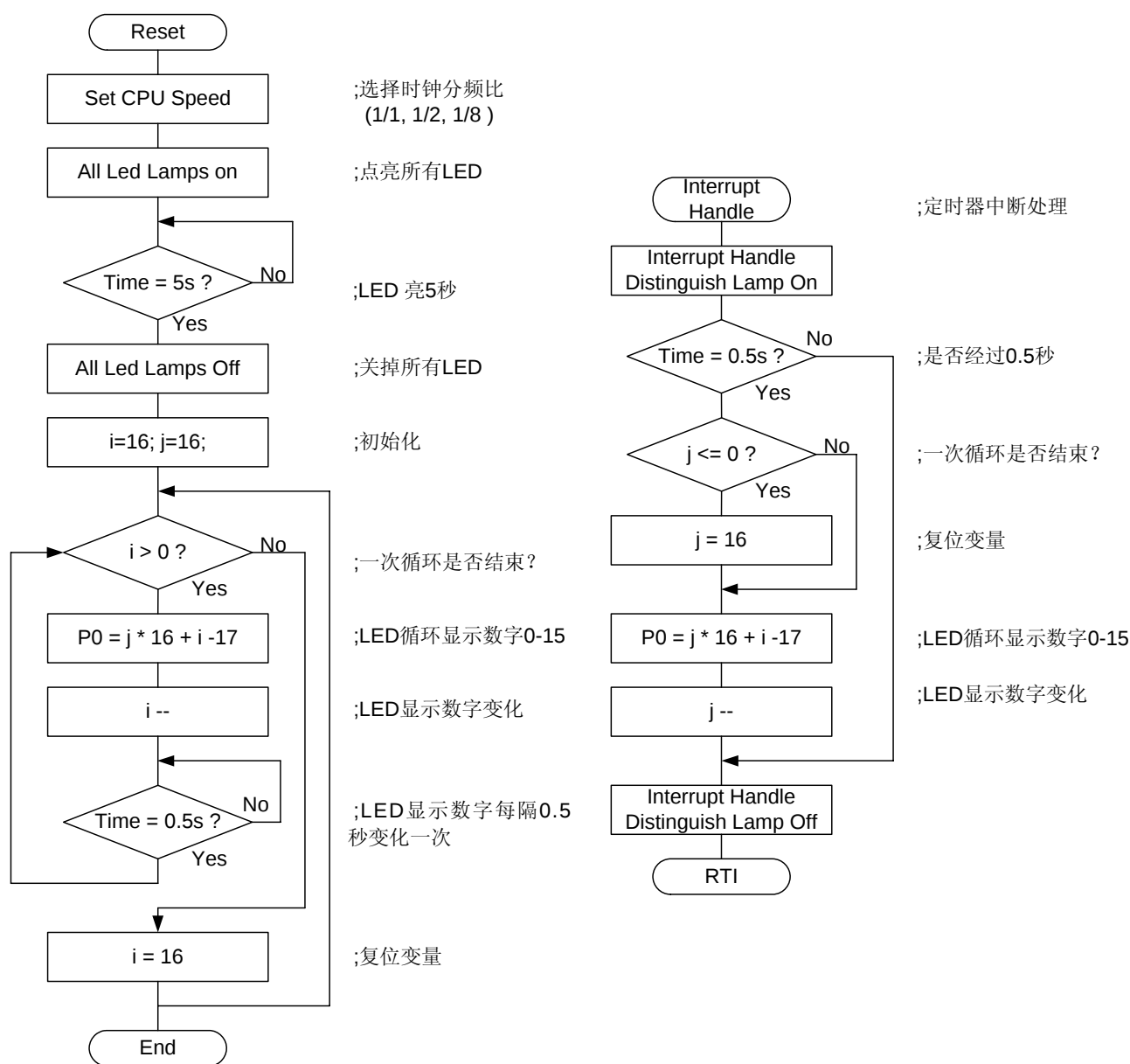
实验工具：

- 电源：CVFT1-200H
- 噪音发生器：NoiseKen INS-4001
- 目标板：推荐布线的电路板与不推荐布线的电路板

实验条件：

- 目标板电源：220V 50Hz
- 单片机类型：M37544G2ASP
- 振荡频率：4MHz
- 单片机速度：采用主时钟的 1/1，1/2，1/8 分频
- 单片机电源：5V
- 单片机去耦电容：0.1uF
- 噪音周期：10ms
- 噪音脉冲宽度：50ns
- 噪音极性：正、负
- 噪音峰值：100V 至 4000V（噪音发生器可输出的最大噪音峰值为 4000V）
- 测试时间：1 分钟

4.3 程序流程图



4.4 实验结果

表 1: 两种 PCB 布线的测试结果

布线 电压 (V) \ 极性	推荐的电路板的测试结果						不推荐的电路板的测试结果					
	+			-			+			-		
4000	×	○	○	×	×	○	×	×	×	×	×	×
3900	×	○	○	×	×	○	×	×	×	×	×	×
3800	×	○	○	×	×	○	×	×	×	×	×	×
3700	○	○	○	×	○	○	×	×	×	×	×	×
3600	○	○	○	×	○	○	×	×	×	×	×	×
3500	○	○	○	×	○	○	×	×	×	×	×	×
3400	○	○	○	○	○	○	×	×	×	×	×	×
3300	○	○	○	○	○	○	×	×	×	×	×	×
3200	○	○	○	○	○	○	×	×	×	×	×	×
3100	○	○	○	○	○	○	×	×	×	×	×	×
3000	○	○	○	○	○	○	×	×	×	×	×	×
2900	○	○	○	○	○	○	×	×	×	×	×	×
2800	○	○	○	○	○	○	×	×	×	×	×	×
2700	○	○	○	○	○	○	×	×	×	×	×	×
2600	○	○	○	○	○	○	×	×	×	×	×	×
2500	○	○	○	○	○	○	×	×	×	×	×	×
2400	○	○	○	○	○	○	×	×	×	×	×	×
2300	○	○	○	○	○	○	×	×	×	×	×	×
2200	○	○	○	○	○	○	×	×	×	×	×	×
2100	○	○	○	○	○	○	×	×	×	×	×	×
2000	○	○	○	○	○	○	×	×	×	×	×	×
1900	○	○	○	○	○	○	×	×	×	×	×	×
1800	○	○	○	○	○	○	×	×	×	×	×	×
1700	○	○	○	○	○	○	×	×	×	×	×	×
1600	○	○	○	○	○	○	×	×	×	×	×	×
1500	○	○	○	○	○	○	×	×	×	×	×	×
1400	○	○	○	○	○	○	×	×	×	×	×	×
1300	○	○	○	○	○	○	×	×	×	×	×	×
1200	○	○	○	○	○	○	×	×	×	×	×	×
1100	○	○	○	○	○	○	×	×	×	×	×	×
1000	○	○	○	○	○	○	×	×	×	×	×	×
900	○	○	○	○	○	○	○	○	○	○	○	○
800	○	○	○	○	○	○	○	○	○	○	○	○
700	○	○	○	○	○	○	○	○	○	○	○	○
600	○	○	○	○	○	○	○	○	○	○	○	○
500	○	○	○	○	○	○	○	○	○	○	○	○
400	○	○	○	○	○	○	○	○	○	○	○	○
300	○	○	○	○	○	○	○	○	○	○	○	○
200	○	○	○	○	○	○	○	○	○	○	○	○
100	○	○	○	○	○	○	○	○	○	○	○	○
电压 (V) \ 单片机速度	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8

注:

电压: 噪音峰值 (较高数值代表较强的抗噪音能力)

极性: 加入到目标板电源中的噪音信号极性

单片机速度: 采用主时钟的 1/1, 1/2, 1/8 分频

○: 单片机正常工作

× (1): 复位无法释放; × (2): 复位->重新启动->复位; × (3): 主循环程序错误或失控

4.5 实验结论

以上实验显示了被测试电路板的抗干扰特性。推荐的电路板可以抵抗约 4000V 的噪音信号干扰（噪音发生器的最大值），不推荐的电路板可以抵抗的噪音干扰要低于 2000V。

由以上实验可以得到如下结论：

根据推荐的布线方法，可以通过设计 PCB 布线提高抗干扰特性。

在同样的运行速度下，用高速的振荡器同时采用大的分频比可以获得更好的抗干扰性能。

注意：

即使使用推荐的布线，也应该使单片机远离高电压噪音。

本测试结果仅被用于比较不同布线的噪音影响，并不代表单片机的性能。

5. 改进不推荐的电路板

经过以上的测试，下面来改进一下不推荐的电路板的部分电路，然后在同样的噪音干扰条件下重新进行测试。在本实验中，对 PCB 电路板做一些临时修改以获得更高的抗干扰性能，但是当开发产品时，应尽可能地按照推荐方法对 PCB 重新设计。

5.1 不推荐的电路板的改进

改进项目如下所示：

振荡器电路：切断原有的连接 VSS 的布线，用一根飞线连接振荡器与单片机的地，缩短振荡器电路的地线长度。请参照图 4 中黄色部分的修改。

复位电路：取下复位电路中的器件，将这些器件焊接在电路板的背面尽可能靠近单片机的地方。请参照图 4 中绿色部分的修改。

CNVSS 电路：取下连接到 CNVSS 管脚的电阻，将它们焊接在电路板的背面靠近单片机的地方，从而缩短地线的长度。请参照图 4 中粉色部分的修改。

VSS 布线：将单片机、振荡器、复位电路和 CNVSS 电路的地线布置在同一条地线支路上。请参照图 4 中棕色部分的修改。

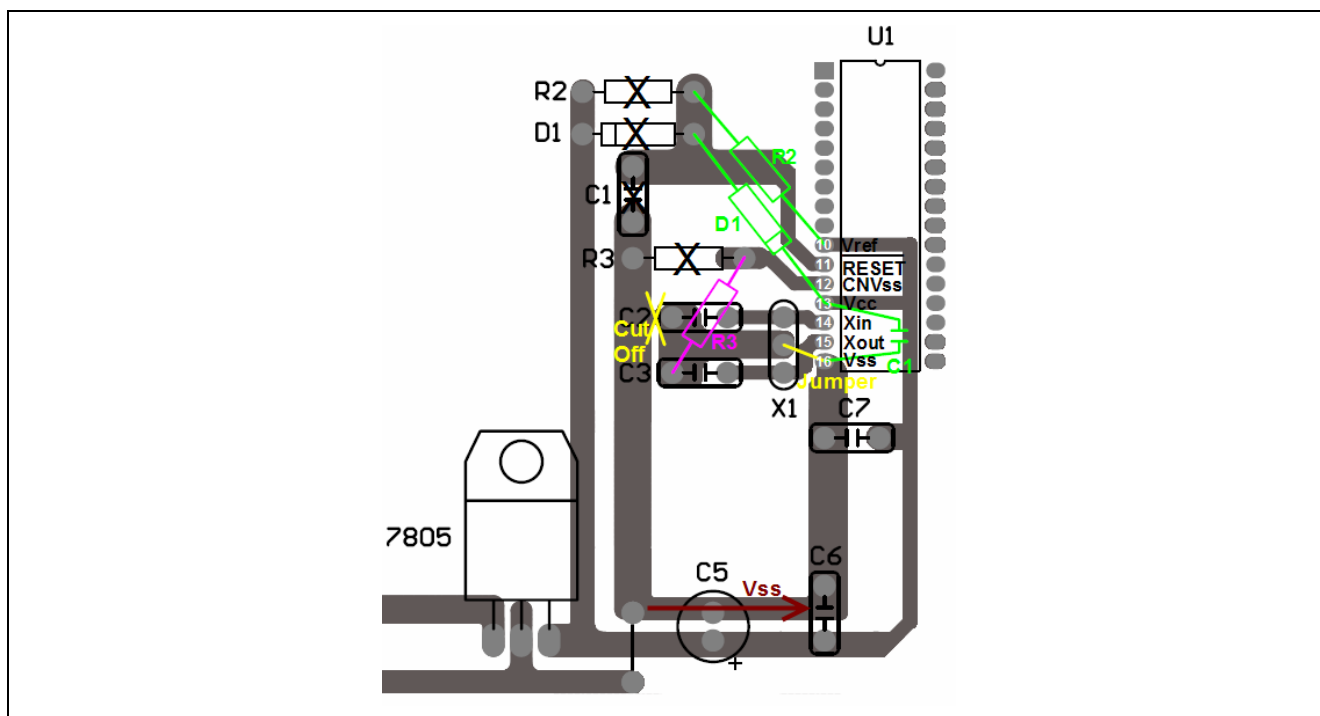


图 4 改进不推荐的电路板

5.2 改进后电路板的测试结果

表 2: 改进前与改进后的比较

不推荐的布线 极性 电压 (V)	改进后						改进前					
	+			-			+			-		
4000	×	○	○	×	×	×	×	×	×	×	×	×
3900	×	○	○	×	×	×	×	×	×	×	×	×
3800	×	○	○	×	×	×	×	×	×	×	×	×
3700	×	○	○	×	×	×	×	×	×	×	×	×
3600	×	○	○	×	×	×	×	×	×	×	×	×
3500	×	○	○	×	×	×	×	×	×	×	×	×
3400	×	○	○	×	×	×	×	×	×	×	×	×
3300	×	○	○	×	○	×	×	×	×	×	×	×
3200	×	○	○	×	○	○	×	×	×	×	×	×
3100	×	○	○	×	○	○	×	×	×	×	×	×
3000	×	○	○	×	○	○	×	×	×	×	×	×
2900	×	○	○	×	○	○	×	×	×	×	×	×
2800	×	○	○	×	○	○	×	×	×	×	×	×
2700	○	○	○	×	○	○	×	×	×	×	×	×
2600	○	○	○	○	○	○	×	×	×	×	×	×
2500	○	○	○	○	○	○	×	×	×	×	×	×
2400	○	○	○	○	○	○	×	×	×	×	×	×
2300	○	○	○	○	○	○	×	×	×	×	×	×
2200	○	○	○	○	○	○	×	×	×	×	×	×
2100	○	○	○	○	○	○	×	×	×	×	×	×
2000	○	○	○	○	○	○	×	×	×	×	×	×
1900	○	○	○	○	○	○	×	×	×	×	×	×
1800	○	○	○	○	○	○	×	×	×	×	×	×
1700	○	○	○	○	○	○	×	×	×	×	×	×
1600	○	○	○	○	○	○	×	×	×	×	×	×
1500	○	○	○	○	○	○	×	×	×	×	×	×
1400	○	○	○	○	○	○	×	×	×	×	×	×
1300	○	○	○	○	○	○	×	×	×	×	×	×
1200	○	○	○	○	○	○	×	×	×	×	×	×
1100	○	○	○	○	○	○	×	×	×	×	×	×
1000	○	○	○	○	○	○	×	×	×	×	×	×
900	○	○	○	○	○	○	○	○	○	○	○	○
800	○	○	○	○	○	○	○	○	○	○	○	○
700	○	○	○	○	○	○	○	○	○	○	○	○
600	○	○	○	○	○	○	○	○	○	○	○	○
500	○	○	○	○	○	○	○	○	○	○	○	○
400	○	○	○	○	○	○	○	○	○	○	○	○
300	○	○	○	○	○	○	○	○	○	○	○	○
200	○	○	○	○	○	○	○	○	○	○	○	○
100	○	○	○	○	○	○	○	○	○	○	○	○
电压 (V) 单片机速度	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8

注:

电压: 噪音峰值 (较高的数值代表较强的抗噪音能力)

极性: 加入到目标板电源中的噪音极性

单片机速度: 采用主时钟的 1/1, 1/2, 1/8 分频

○: 单片机正常工作

× (1): 复位无法释放; × (2): 复位->重新启动->复位; × (3): 主循环程序错误或失控

5.3 PCB 电路板的改进建议

由实验结果可知，将性能不好的电路板修改后，抗干扰性能会得到显著的改进。但是，改进后的性能仍然无法达到推荐的电路板的水平。因此，当开发产品时，应根据推荐的布线方法重新设计 PCB 布线。

在设计 PCB 布线时，有以下几点需要注意：

- 振荡器电路的布线：使用最短距离的布线连接振荡器、电容和单片机。
- 复位电路的布线：将复位电路尽可能靠近单片机。
- CNVSS 布线：在 CNVSS 和地线之间串入电阻，以最短的布线连接 CNVSS 管脚、电阻和地。
- 接地布线：将振荡器的地、复位电路的地和 CNVSS 的地布置于同一地线支路，并将它们与其他地线分离开。

6. 参考文献

硬件手册

7544 群数据手册

(最新版本请从瑞萨科技网页上取得)

技术信息/技术更新

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		页	要点
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1.01	2008.03.17	10	增加咨询邮箱地址，修改硬件手册名称
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