空调控制器触摸按键应用应用手册
Touch Key Solution for Air-con Application Note

Rev. 0.01
May 26, 2012

概要

R8C/36T-A 触摸按键解决方案旨在提供一个低成本高集成的单芯片解决方案，该触摸按键解决方案非常适合于带触摸功能的柜式空调或其他高端家电触摸按键的应用。

目标芯片

R8C/36T-A

目录

1. 硬件平台

R8C36T-A 触摸按键评估板是针对于带触摸按键功能的柜式空调器而设计，它支持多达28路触摸按键，59个输入输出口 ，支持多达128K的ROM空间和10K的RAM空间。12路12位AD转换，1路DTC,4路定时器和3路UART。

评估板有以下特点：

- 9 路触摸按键和1路滑条。
- 1 路定时器输出用于蜂鸣器 。
- 2 路AD转换用于温度传感器 。
- 1 路IIC通信用于EEPROM 。
- 1 路定时器用于红外线输入信号检测。
- 7 段双八显示及LED显示。
- 步进电机及负载控制
- 支持E1在线仿真
- 按键复位电路
- 两毫米亚克力板

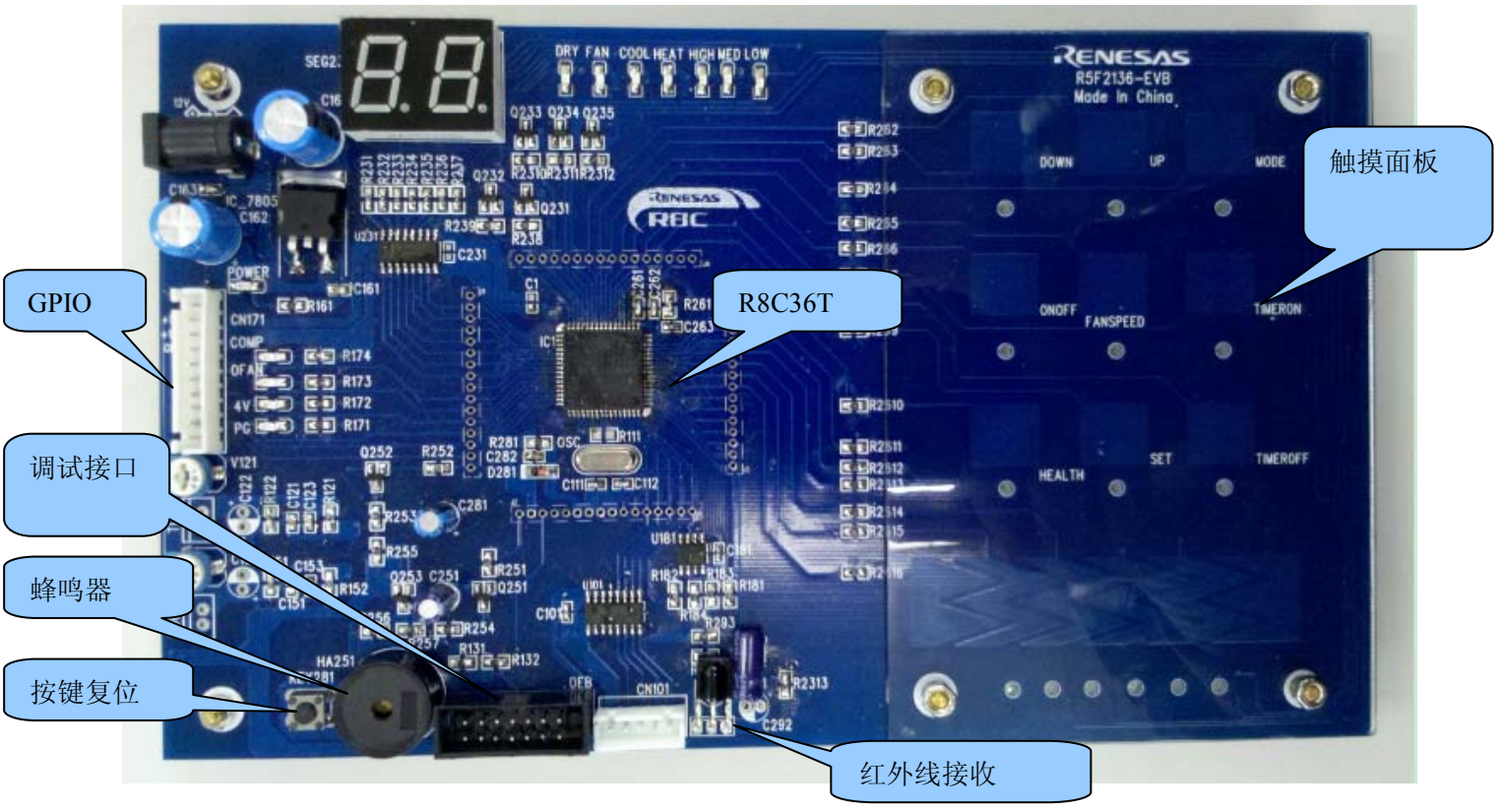


图 1.1 空调触摸按键评估板

2. 开发环境

2.1 High-performance Embedded Workshop

High-performance Embedded Workshop 是一个强大的集成开发环境，它主要用于RENESAS微控器的嵌入式开发，主要特点如下：

- 用户通过可视化界面可以灵活配置编译器、汇编器和链接器的各个选项 。
- 集成了文本编辑器，可以提供客户化的着色功能从而提高代码的可靠性。。
- 可配置的开发环境，允许用于内嵌个性化工具。
- 集成调试器，用户可以在一个应用程序内编译及调试工程。
- 版本控制及支持。

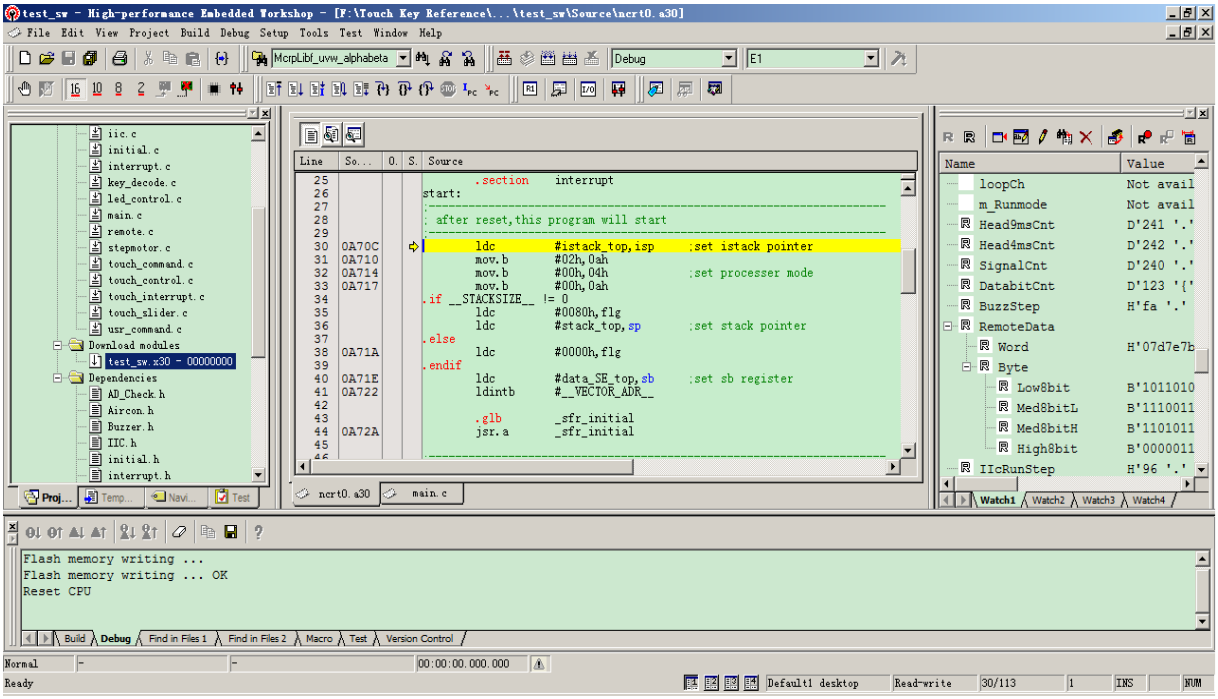
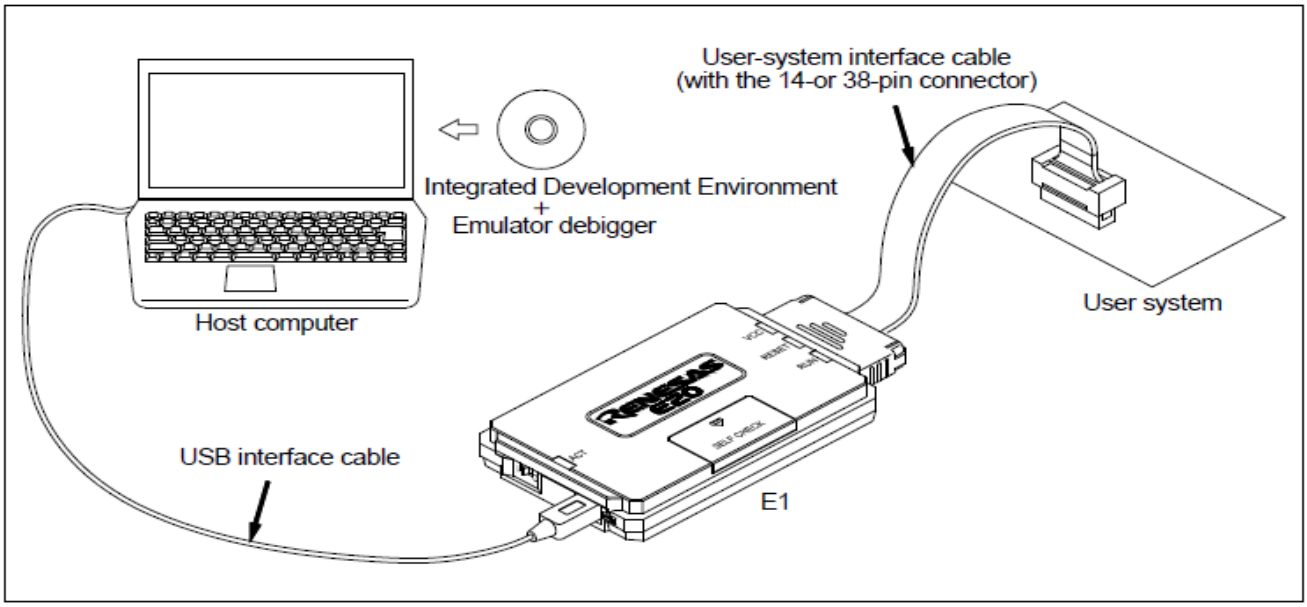


图 2.1: HEW 开发环境

2.2 E1

E1 是用于连接目标板和电脑的仿真器，采用 14Pin 端子，USB 供电。



2.3 Workbench4

触摸按键微控器R8C36T-A通过传感器控制单元(SCU) 感知人体在电极上形成的分布电容，从而达到响应触摸按键的效果。而Renesas Workbench通过目标板和High-performance Embedded Workshop(HEW)的连接，能提供一套可靠地可视化界面进行实时监测，可动态显示各个通道的测量值、参考值及门槛值，给用户调试带来极大地便利。

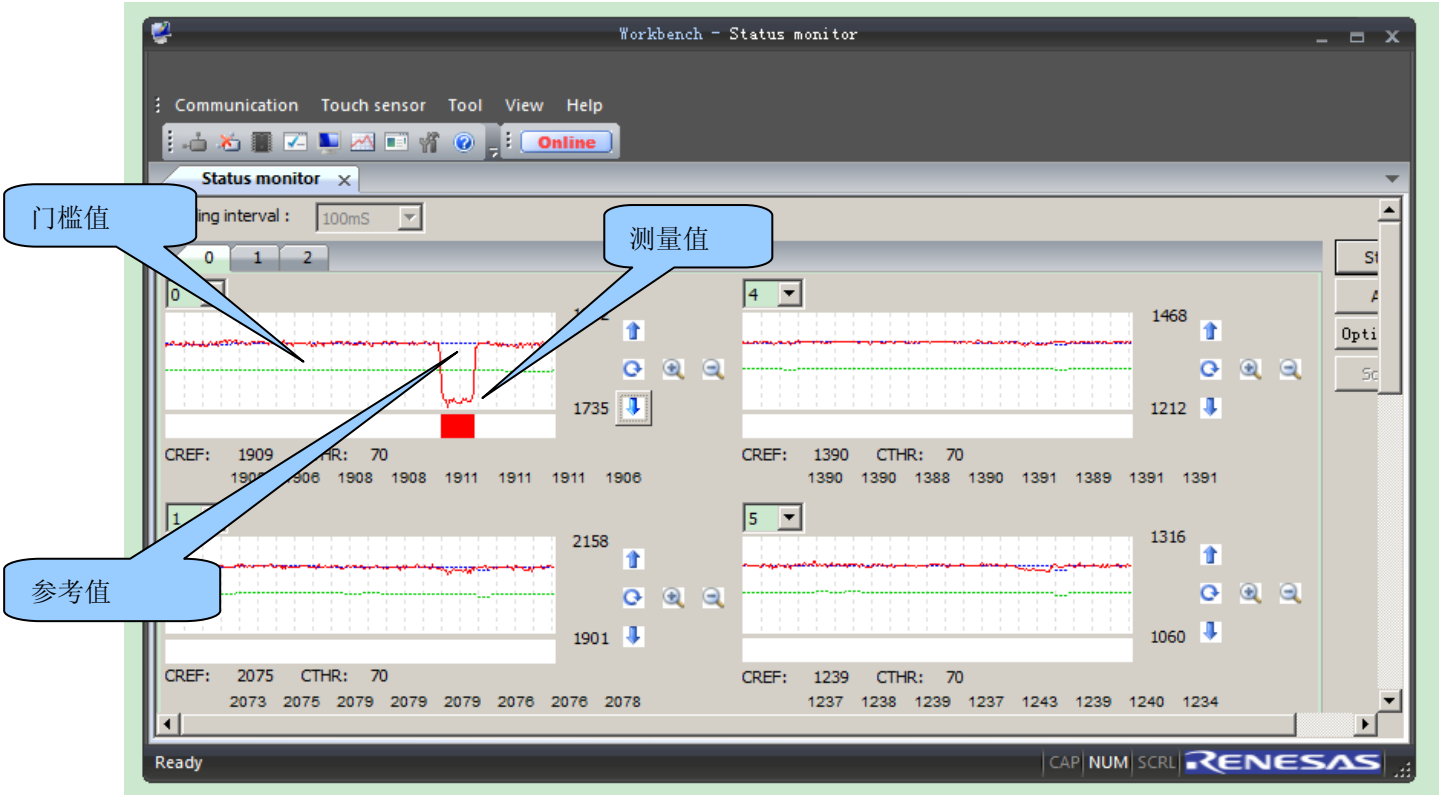
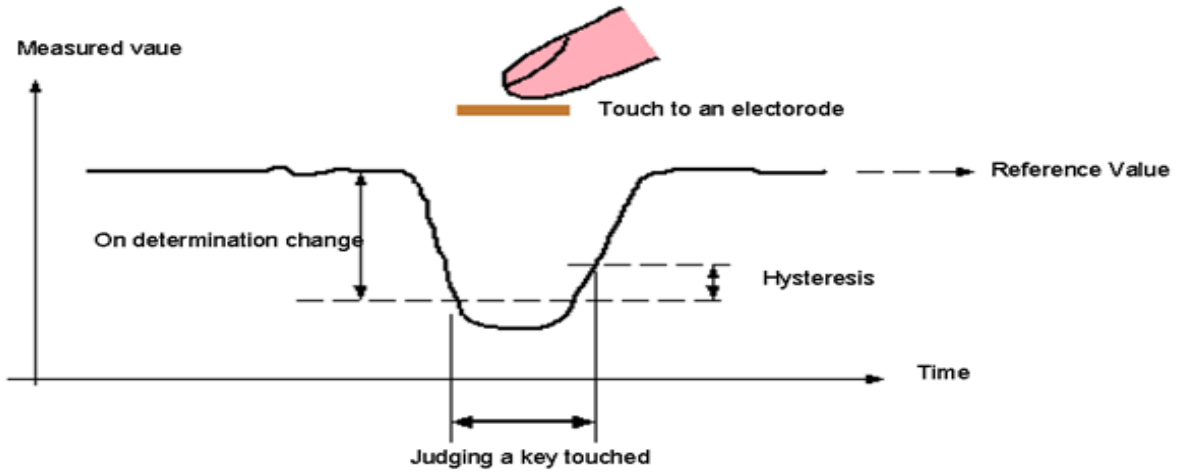


图 2.2: Workbench 用户界面



测量值 ： 传感监测单元 SCU 的测量数据。
门槛值: 进行传感开关判断的阀值。
参考值 ： 测量值的平均值，一般取 128 次平均。

3. 系统控制框图

评估板由 R8C36T-A MCU 部分及触摸面板部分组成，系统框图显示了整个空调控制器的控制系统，R8C36T-A 的资源配置非常适合带触摸功能的空调柜机使用。用户可以通过 E1 仿真器连接到目标板，通过 HEW 进行代码编辑及调试，通过 Workbench 观测和调试触摸按键的效果。

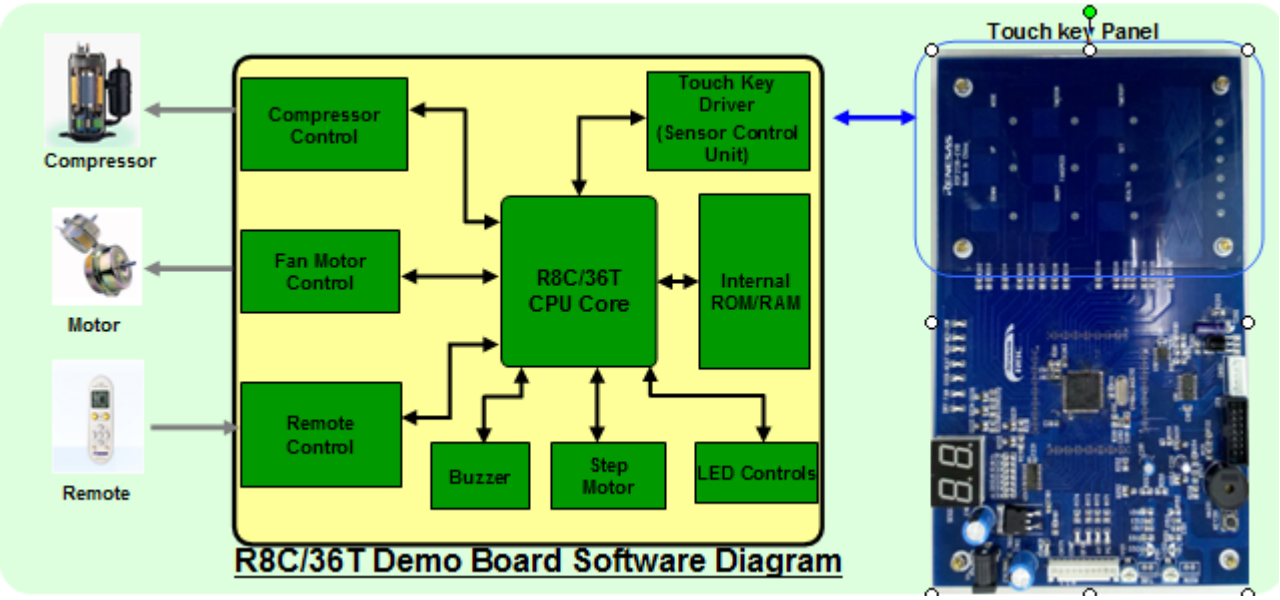


图 3.1: 空调控制系统框图

图 3.2: 触摸按键开发环境框图

4. 触摸按键原理

4.1 概要

触摸传感器芯片 R8C/36T-A 通过检测连接在触摸终端上的电极的分布电容值的变化，来判断触摸按键的开关。如图 4.1, 在电极与地之间存在着分布电容. 因为人体本身也是导体, 当人的手指接近电极, 在手指和电极之间就会产生一个分布电容。从而整个电极到地的电容值也产生了变化，通过检测分布电容值的变化，可以进行触摸与否的判定。

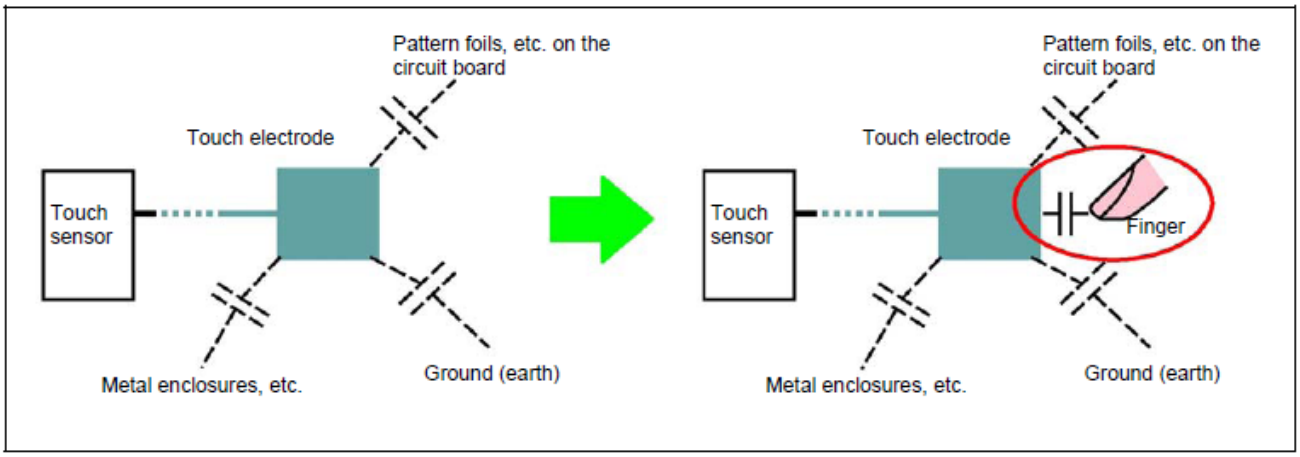


图 4.1 电极分布电容图

4.2 检测电路

触摸按键侦测电路如图4.2所示，

Cr: 分压电容(几pF到几十pF之间)

Rc: 充电放电电阻(几kΩ到几十kΩ之间)

Cc: 充电放电电容(大约0.1 μF)

电容和电阻的精度并没有明确规定，然而，高的偏移值可能导致每个独立的产品都需要进行校正，因此，推荐使用高精度的器件(电阻，精度5%或以上，电容，精度10%或以上).

Cx: 电极的分布电容

Cx值大概在几pF到几十pF之间

而Cx的变化量大约在几pF或者更低。

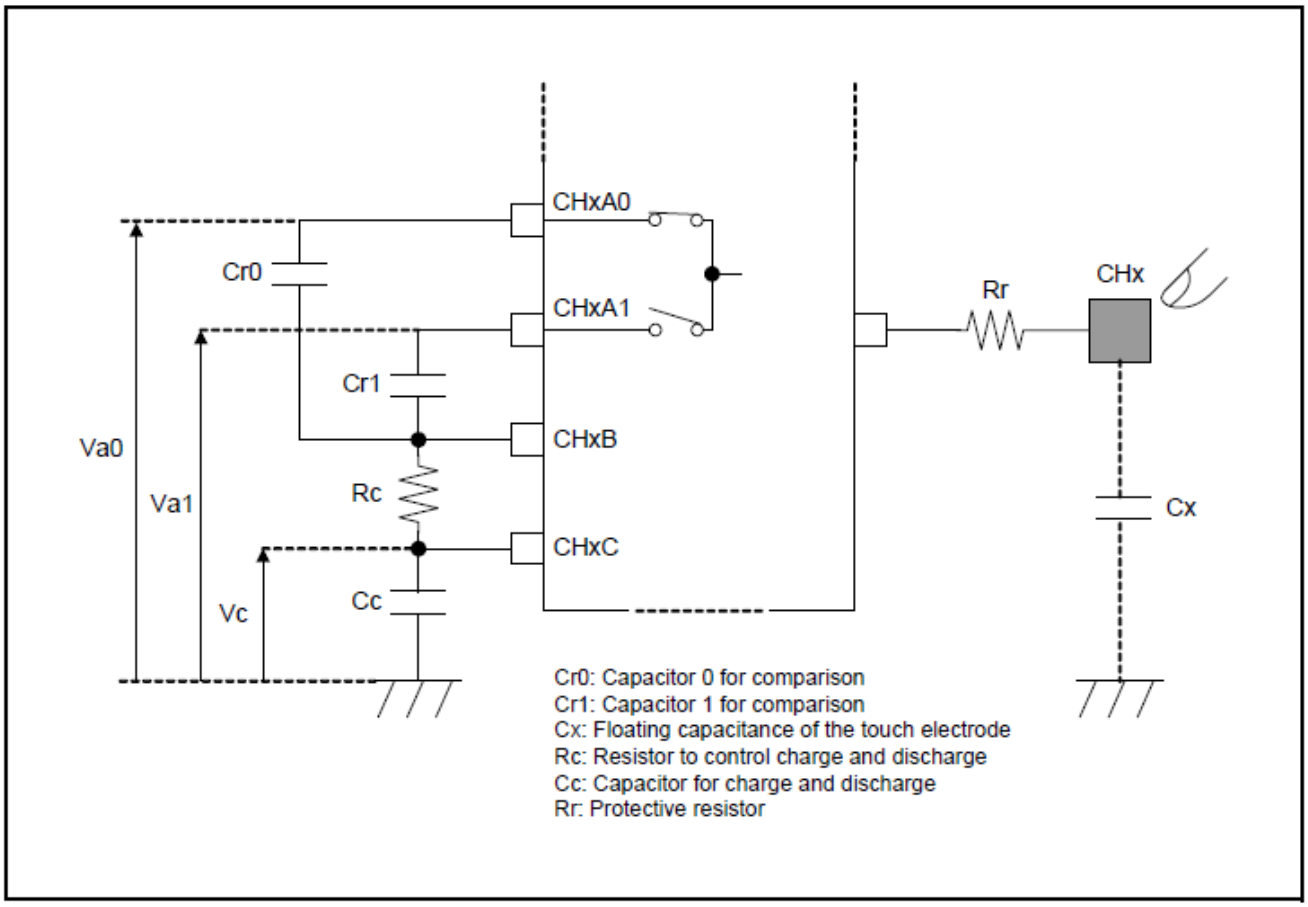


图 4.2 触摸测量电路

4.3 电极分布电容值的测量方法

触摸电极分布电容值通过Cc放电时测量管脚CHxA的电压值获得，测量步骤如下：

(1) 通过管脚CHxC 施加VCC对Cc电容进行充电。

(2) 当对Cc充电完成后，通过把CHxA和CHxB连接到地对Cc进行放电操作

(3) 在对Cc电容进行短时间的放电后，保持管脚CHxA, CHxB和CHxC高阻状态 (Hi-Z)，然后测试CHxA引脚的电压. 此时,如图4.3所示，把CHxA管脚检测的电压标记为Va ，把管脚CHxC上的电压标记为Vc，则，Va电压的表达式如下图所示：

$$Va = \frac{Cr}{Cr + Cx} Vc$$

Va和Vc随时间变化如图5.3所示。

(4)重复第(2)步和第(3)步

(5)通过VLT0特殊功能寄存器设定管脚CHxA的阀值电平(input threshold value control register 0).

通过主计数器累计放电的次数直到Va下降到管脚的阀值电平以下（0.35VCC/0.5VCC/0.7VCC可选），此时，次计数器开始递减计数，主计数器继续累计放电次数直到次计数值的默认值递减为0，

(6)主计数器上的计数值就是所需要的电极分布电容值。

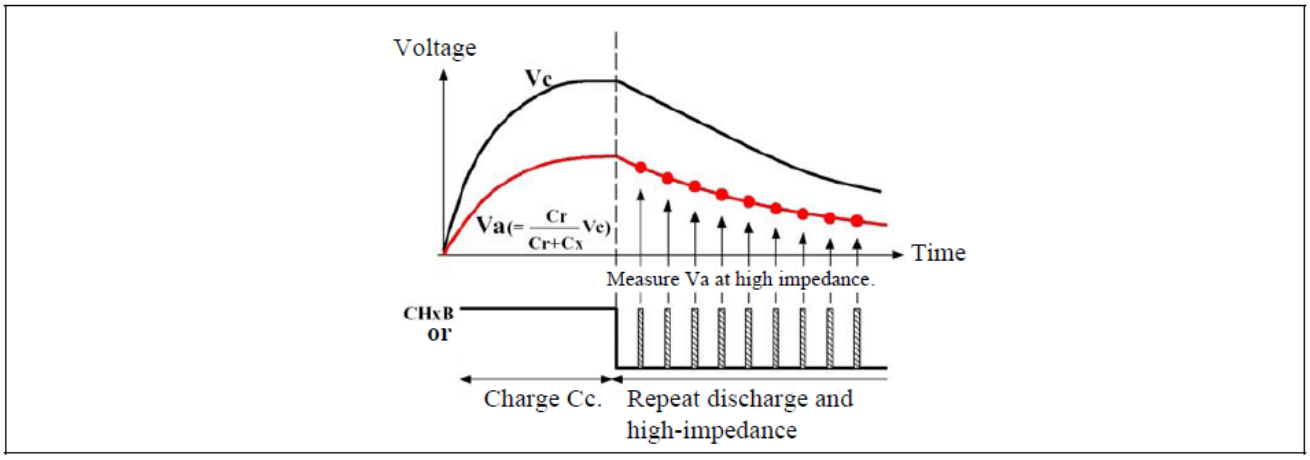


图 4.3 Va 和 Vc 随时间变化如图

5.原理图描述

5.1 原理图

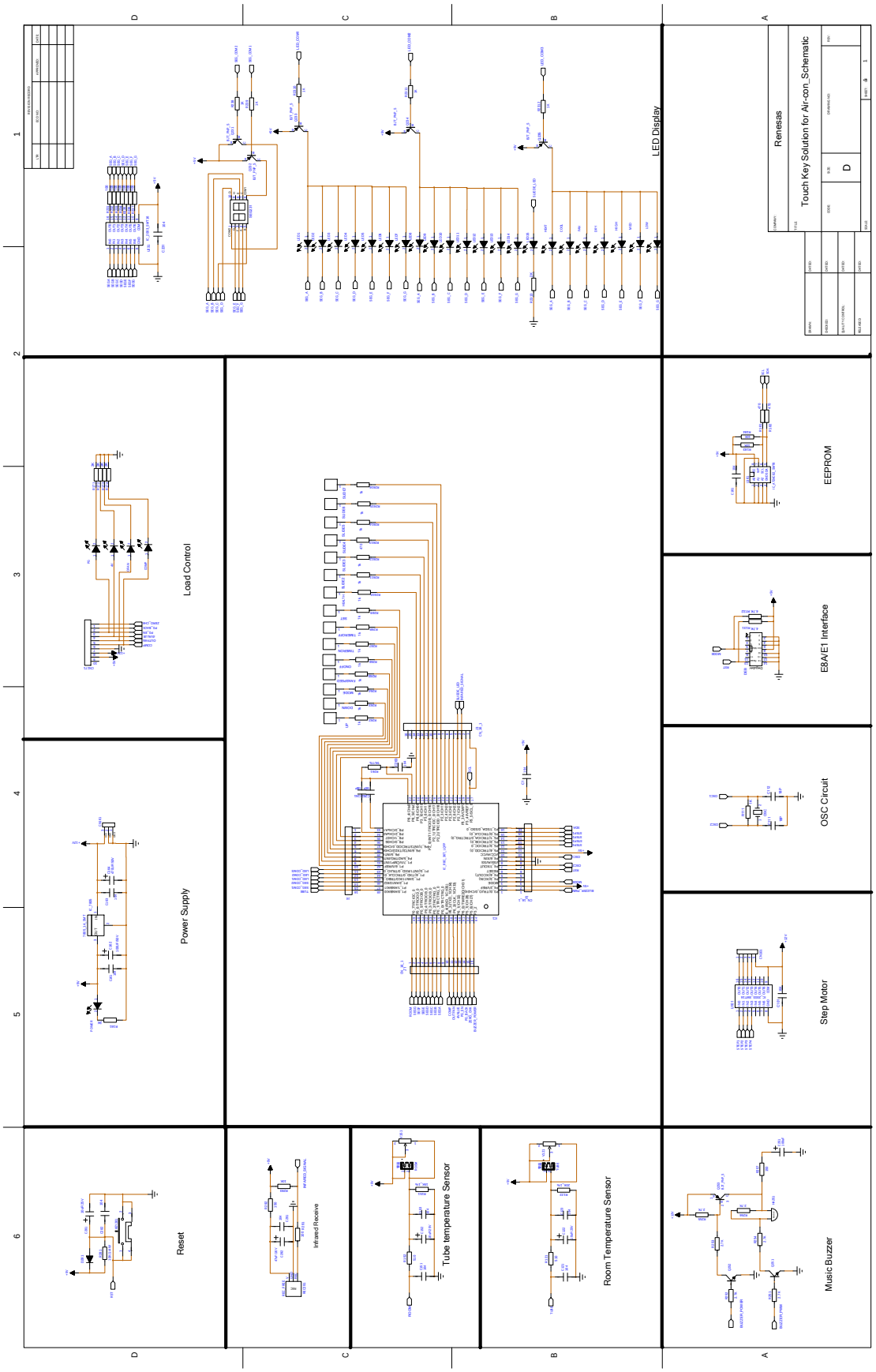


图 5.1 空调触摸按键原理图

5.2 PCB

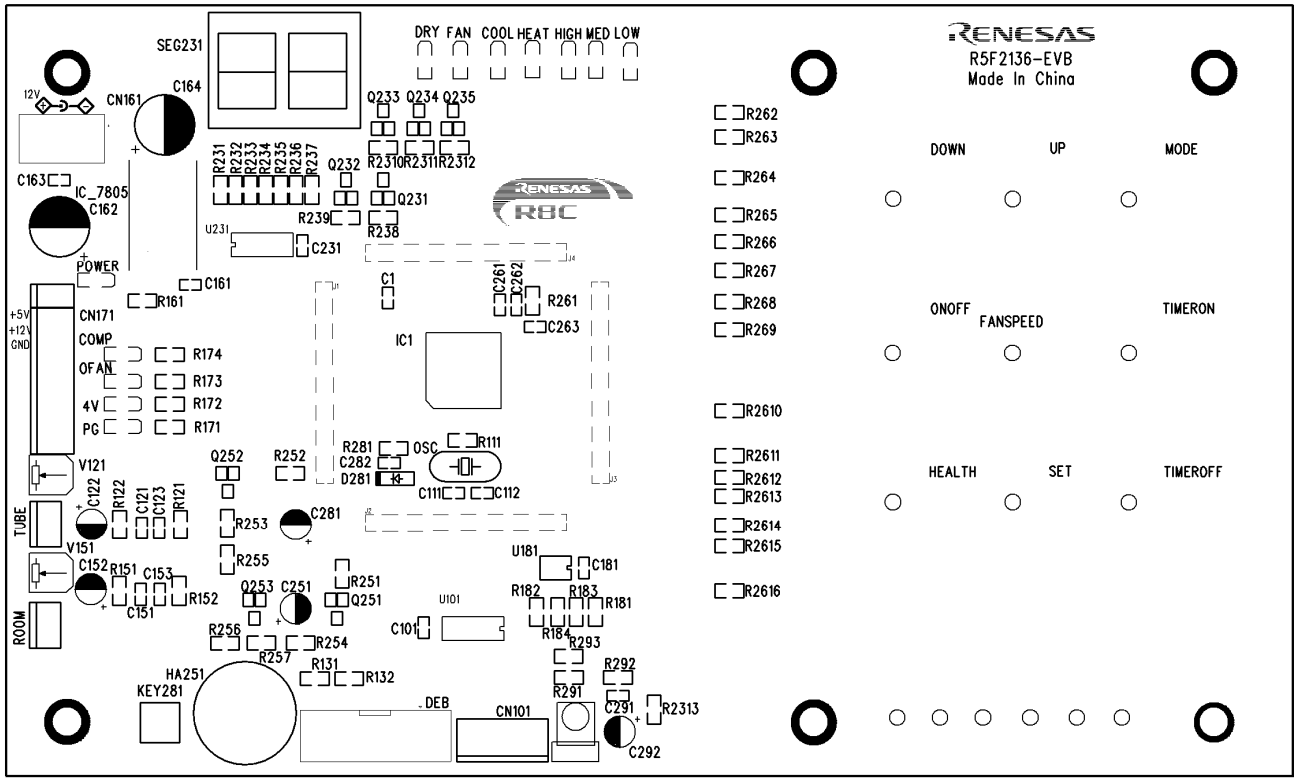


图 5.2 PCB 顶层丝印层

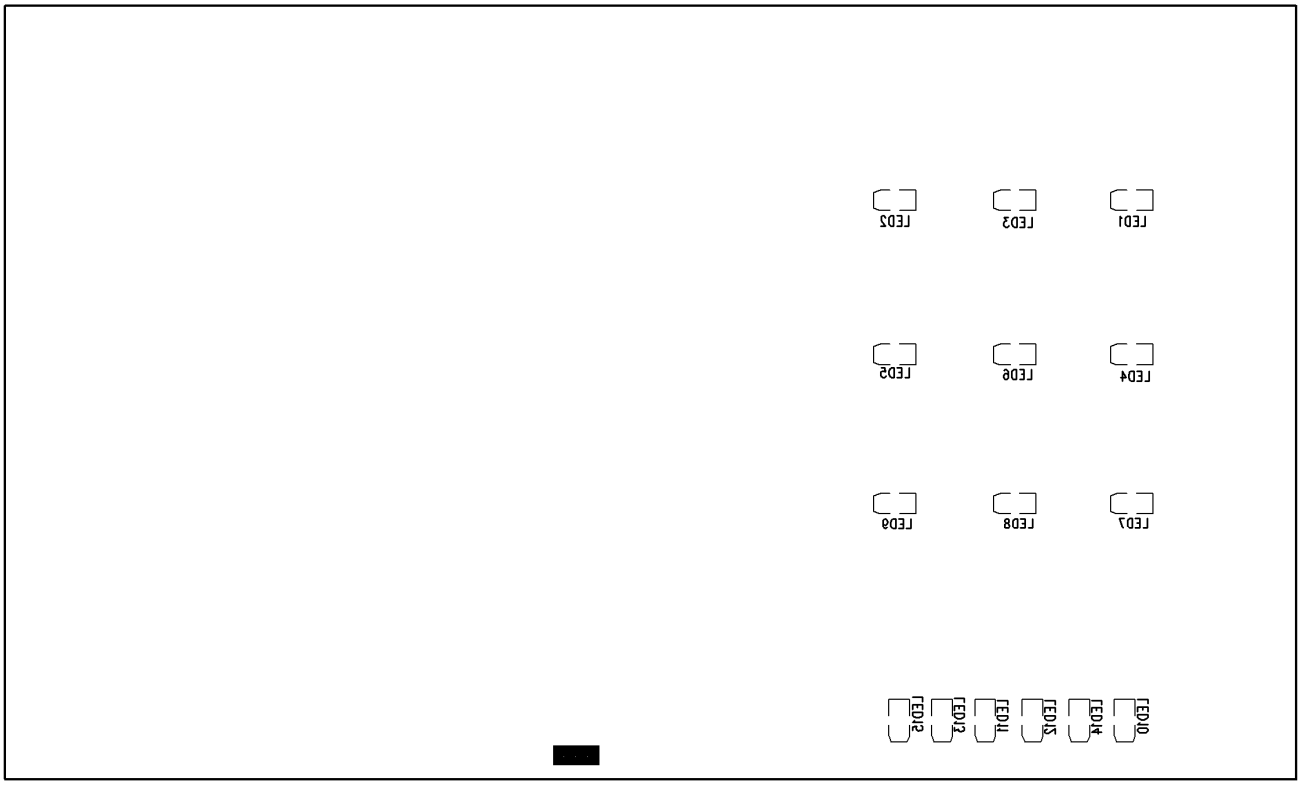
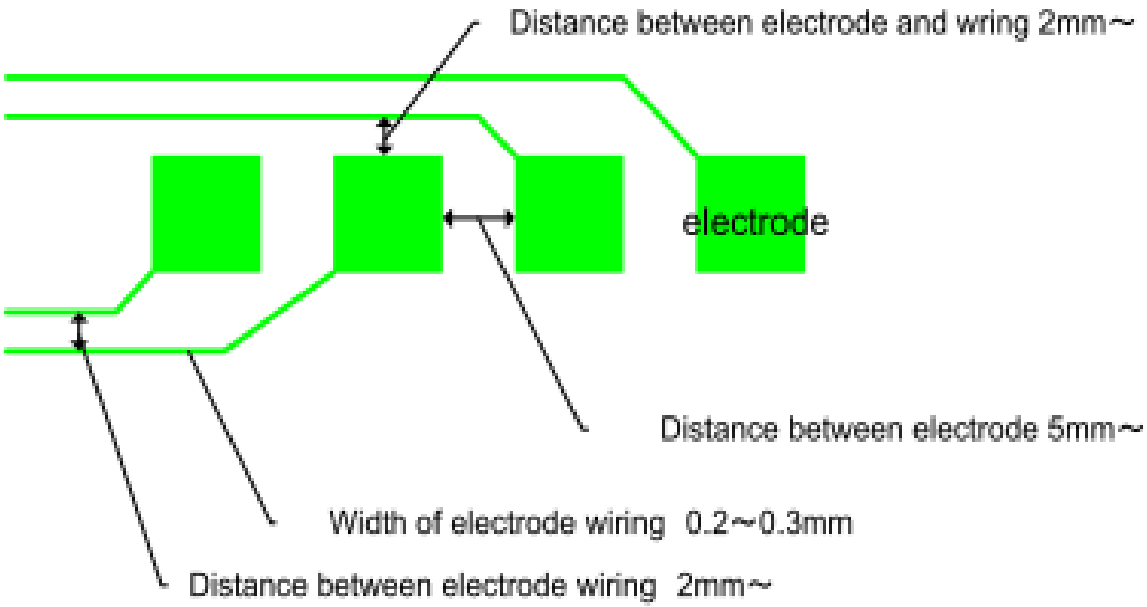


图 5.3 PCB 底层丝印层

6. PCB 设计规则

(1) 布线图



(2)电极导线宽度 : 0.2-0.3mm.
(3)电极与导线、导线与导线距离: 大于 2 mm 。
(4)电极导线长度: 少于 18 cm。
(5)电极间距离: 大于 5 mm。
(6)电极大小: 10x10 mm 到 15x15 mm; 不要太大，形状推荐方形和圆形。
(7)电极材质: 没有特殊限制,电阻(Rr) 如使用高阻材料则需要调整。
(8)铺地处理:电极以及电极导线周围不能铺地。推荐在 Cr, Cc, Rc 和 MCU 背面进行铺地处理。

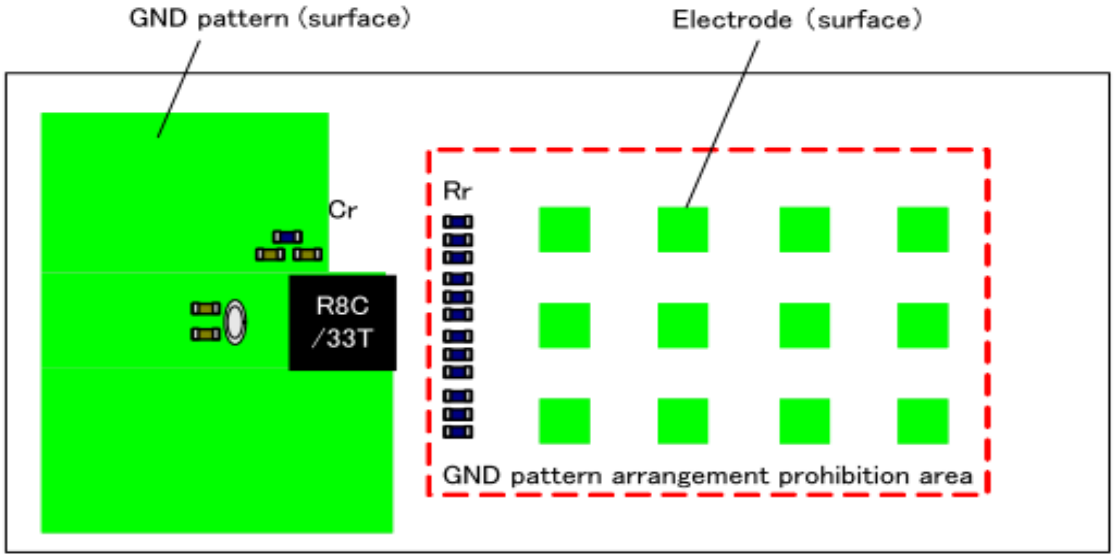


Figure 6.1 触摸按键铺地规则

7. 软件概述

7.1 软件系统框图

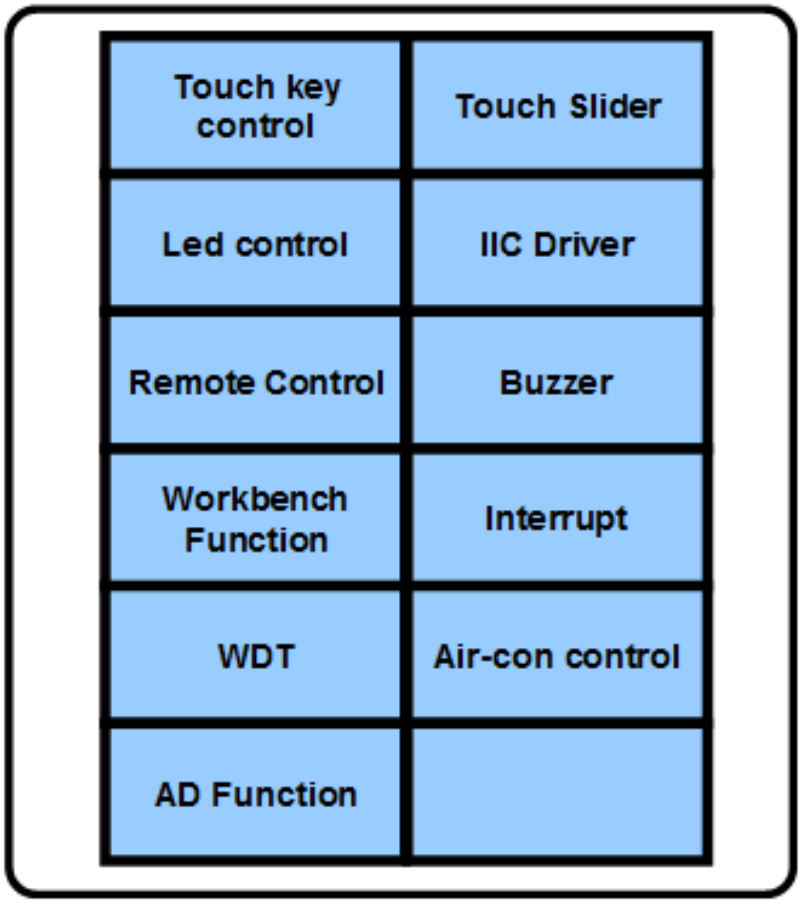


图 7.1 软件系统框图

7.2 软件流程图

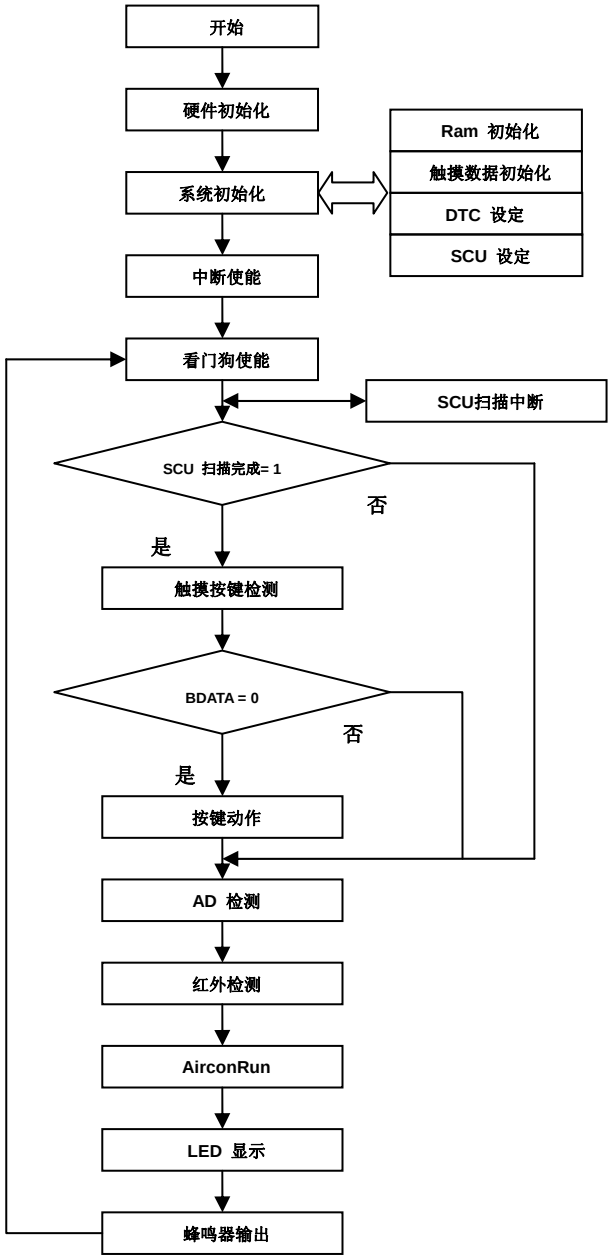


图 7.2 触摸按键方案软件流程图

7.3 触摸按键软件检测方式

7.3.1 触摸按键检测流程图

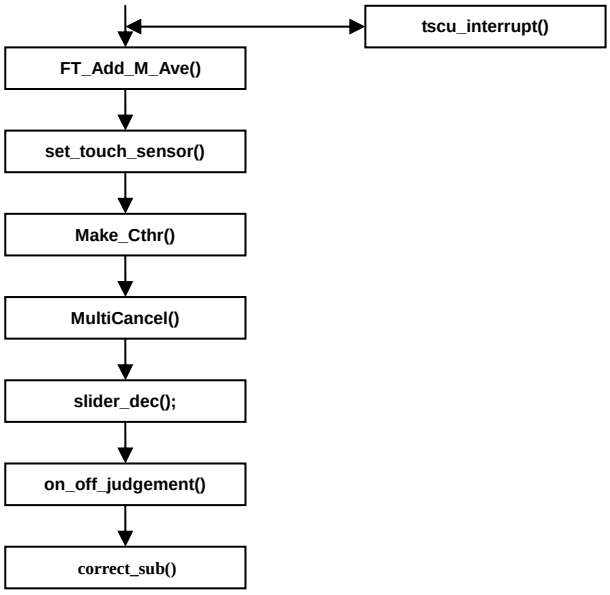


图 7.3 触摸按键检测流程图

7.3.2 触摸按键检测流程

FT_Add_M_Ave(): 该子程序用于计算 Ncount 值；
Make_Cthr()： 该子程序用于计算门槛值提供给 onoff judgement 子程序进行开关的判断；
MultiCancel(): 该子程序用于禁止同一时刻多路按键使能 ；
Slider_dec(): 该子程序用于检测滑条动作；
on_off_judgement(): 该子程序用于判断触摸按键开关；
correct_sub(): 该子程序用于计算参考值；

7.3.3 触摸按键参数和变量

BDATA: 该变量用于存储触摸按键最终开关值；
Ncount: SCU 监测器的检测值；
Dcount: Ncount 值与 Nref 值之差；
Nref[Ch]: Ncount 的参考值 ，是测量值的平均值；
Nhys[Ch]: 触摸按键开关判断的回差值；
Nthr[Ch]: 开关判断的门槛值；
Msa: 按键长按时间；
Mode: 检测模式，值在 4~10 之间；
Acd： 按键去抖次数；
Dci: 校准测量值次数；
Athr: 多按键处理时的门槛值；

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参考文档

R8C/36T-A Group Hardware User's Manual: r01uh0240ej0100_r8c36t-a
Touch Sensor IC Principle of Detection and Adjustment of the External Circuit: rej05b1344_r8cap
Workbench user manual: Workbench4_manual_eng_Rev1.00_.internal_rlease.pdf

Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
0.01	May 26, 2012	—	First edition issued

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. **Handling of Unused Pins**

   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.

   — **The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.**

2. **Processing at Power-on**

   The state of the product is undefined at the moment when power is supplied.

   — **The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.**

   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.

   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. **Prohibition of Access to Reserved Addresses**

   Access to reserved addresses is prohibited.

   — **The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.**

4. **Clock Signals**

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

   — **When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.**

5. **Differences between Products**

   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.

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