

RL78/G11

R01AN3905EC0101

Rev.1.01

High-end Gas Cooker

Oct. 08, 2018

Introduction

This user's manual describes a Renesas ultra-low-power microcontroller RL78/G11 application for a high-end gas stove, through the internal timer array unit, buzzer output control circuit, A/D converter and other functions.

Target Device

RL78/G11

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1. Outline of System Function

1.1 Introduction of High-end Gas Cooker

Nowadays, gas cooker has been popularized in every household, and this also has a high demand on the control and safety of gas stove. The introduction of the high-end gas stove in this user's manual is optimized for handling and safety.

The high-end gas stove uses a 9V battery as power supply. Lightly press the micro switch to start the ignition. The high voltage pulse ignition allows faster gas ignition, and the gas detecting device can effectively alarm to avoid gas leakage and improve the safety; the flame temperature detection (thermocouple temperature feedback) can get the flame temperature in real time to avoid flameout; the anti-dry protection device can avoid occurrence of danger and waste of gas effectively.

1.2 Introduction of Control System

The high-end gas cooker consists of micro switch, high voltage pulse ignition, gas detection, anti-dry protection, flame temperature detection (thermocouple temperature feedback), alarm and electronic circuit with RL78/G11 MCU as its core. For schematic diagram of control system, see Figure 1.1.

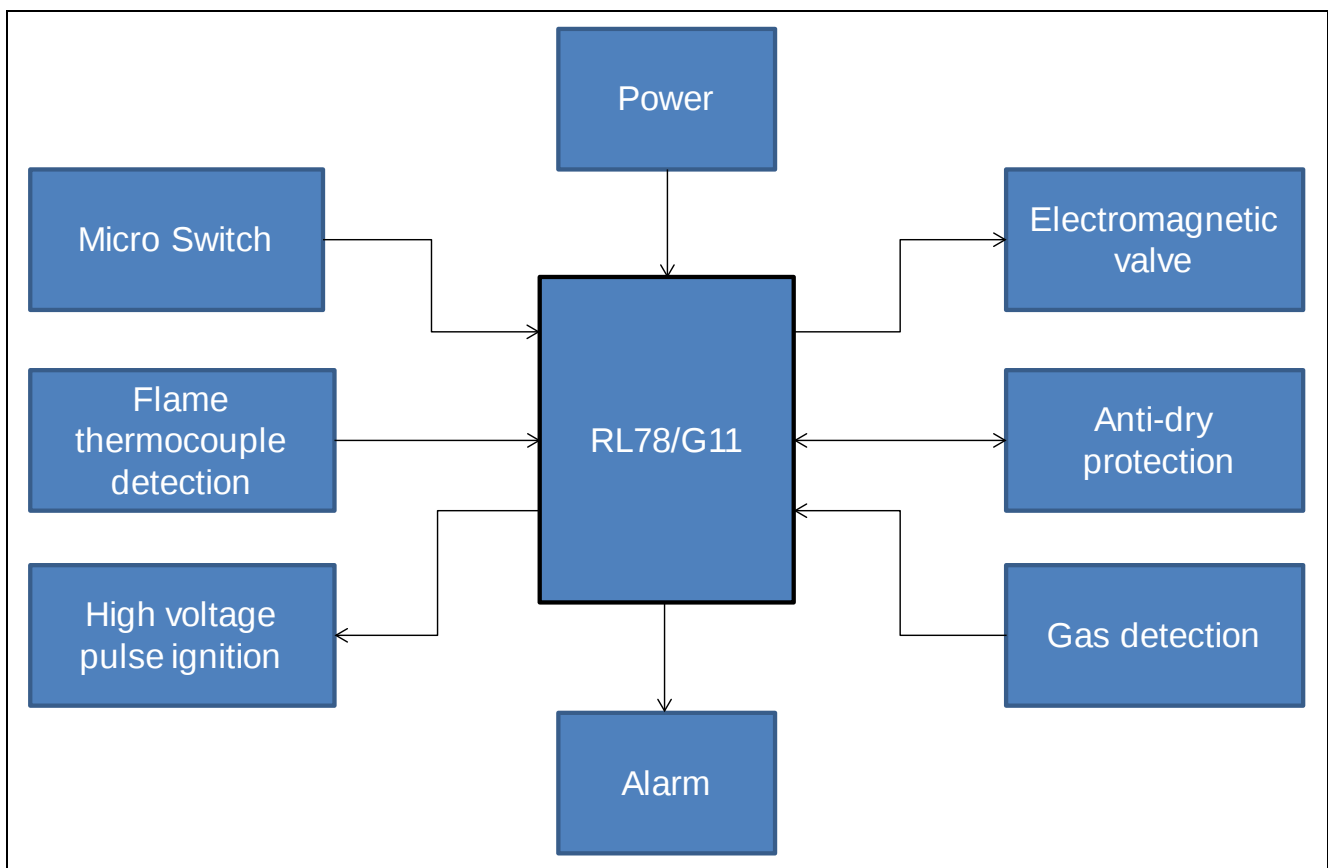


Figure 1.1 Schematic Diagram of Control System

1.3 Introduction of Operation

- (1) The gas detection timer starts automatically after the power is turned on.
- (2) When time (10 ms) is up, it begins to detect gas concentration, and if the concentration is too high, the buzzer will sound.
- (3) When it is not in burning state, if micro switch is pressed, it will start ignition process (4); otherwise, it returns to (2); But when it is in burning state, micro switch signals would be blocked, and it enters (5).
- (4) The electromagnetic valve is opened and the high voltage pulse ignition starts. Then the flame temperature is detected, and if the flame temperature is too low, that means ignition failure, then the ignition failure process starts, otherwise, it enters (5).
- (5) The flame temperature is detected. If the flame temperature is too low, it can prevent accidental flameout, that is, the electromagnetic valve will be closed and the alarm sounds.
- (6) The temperature of the pot bottom is detected. If the temperature is too high, it will start the anti-dry protection, that is, the electromagnetic valve will be closed and the anti-dry protection alarm sounds.
- (7) Repeat (2) ~ (6).

2. Introduction of Hardware

2.1 Introduction of PCB

The demo board of the high-end gas cooker is shown in Figure 2.1.

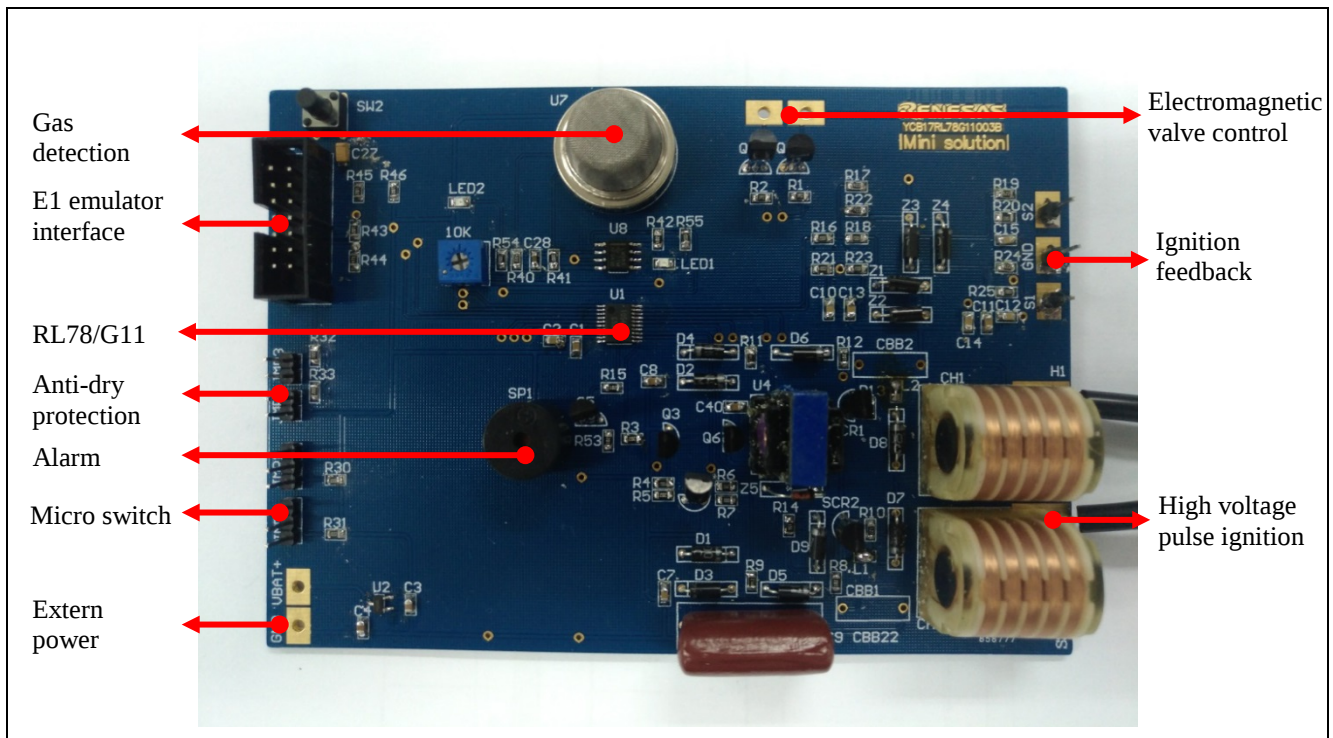


Figure 2.1 Demo Board of High-end Gas Cooker

2.2 Hardware Block Diagram

The hardware block diagram of the high-end gas cooker lighting is shown in Figure 2.2.

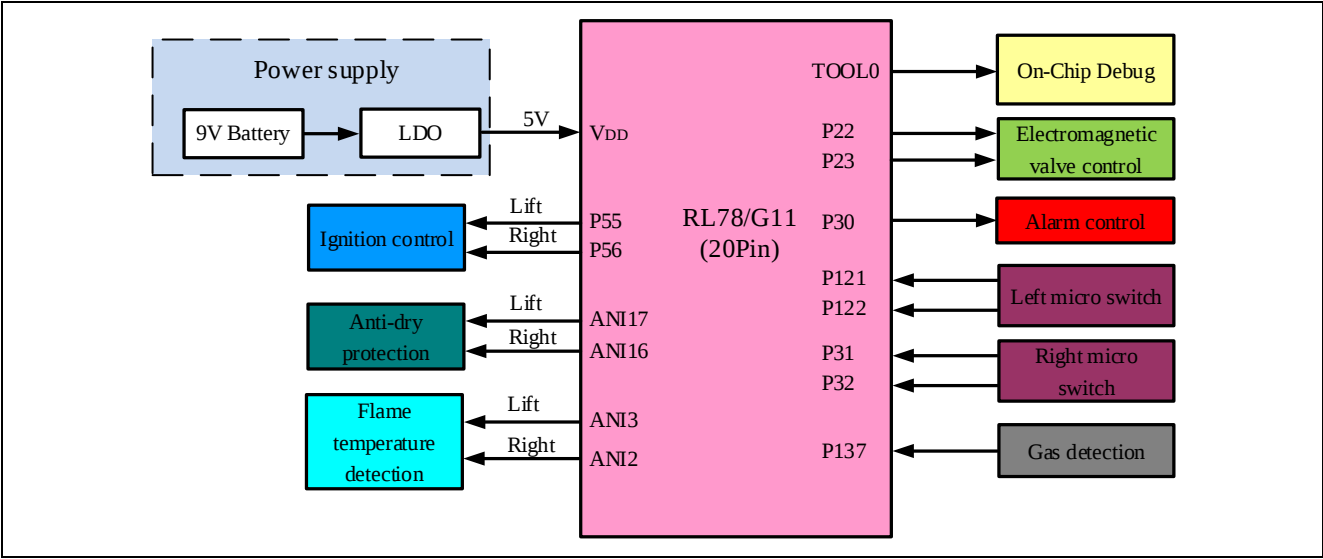


Figure 2.2 High-end Gas Cooker Hardware Block Diagram

2.3 Main MCU

The demo board of the high-end gas cooker uses RL78/G11 (R5F1056AASP main MCU. The Flash ROM size of RL78/G11 is 16 KB and the RAM size is 1.5 KB. The used peripheral functions of RL78/G11 and their applications are shown in Table 2.1.

Table 2.1 The Used Peripheral Functions and Their Applications

Peripheral functions	Usage
TAU	10ms timer, plus oscillation
Buzzer output controller	Alarm controller
ANI16, ANI17	Anti-dry protection
ANI0, ANI1	Flame temperature detection
P22, P23	Electromagnetic valve control
P122, P121, P31, P33	Micro switch
P54	Oscillation circuit control
P55, P56	Ignition control
P137	Gas detection

The interface control circuit of RL78/G11 is shown in Figure 2.3.

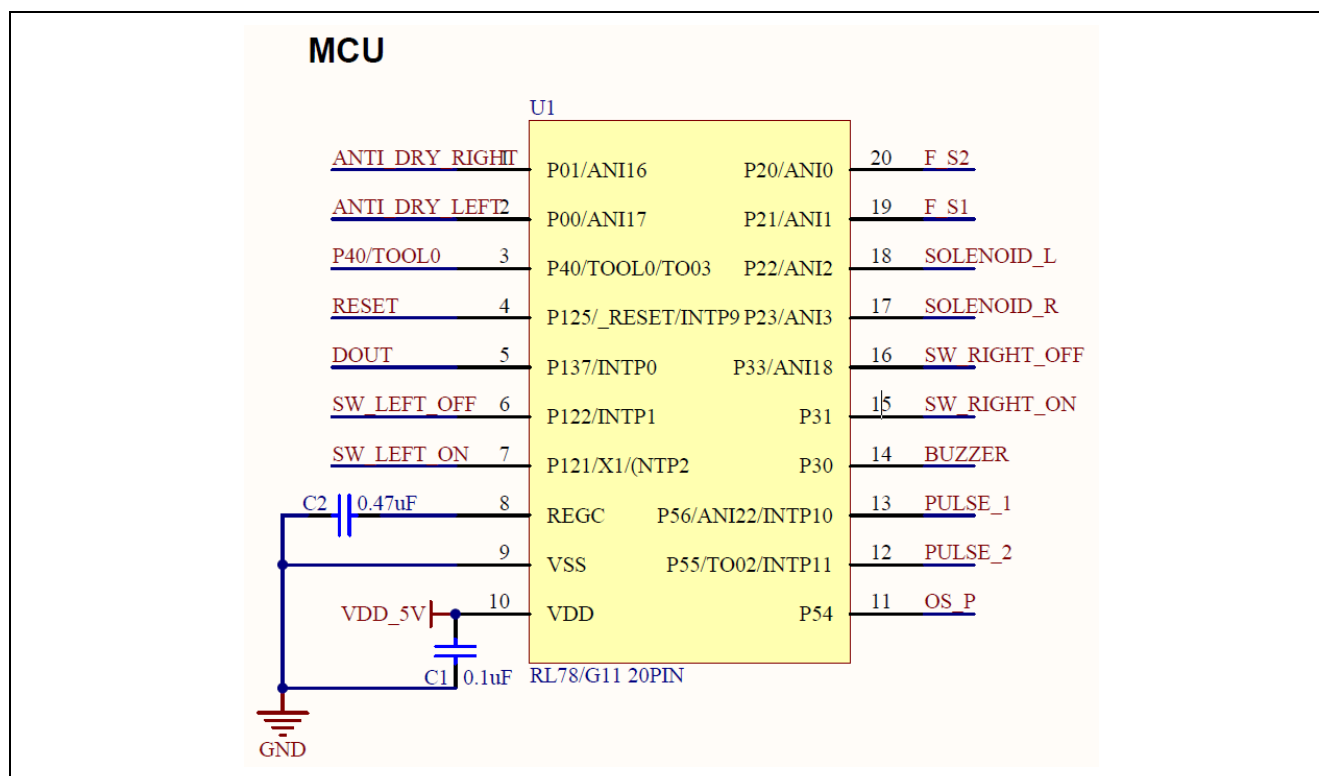


Figure 2.3 Interface Control Circuit of RL78/G11

2.4 Power Supply Circuit

The power section needs to connect with external 9V DC, then gets stable 5V for power supply through ME6209A50. The power supply circuit is shown in Figure 2.4.

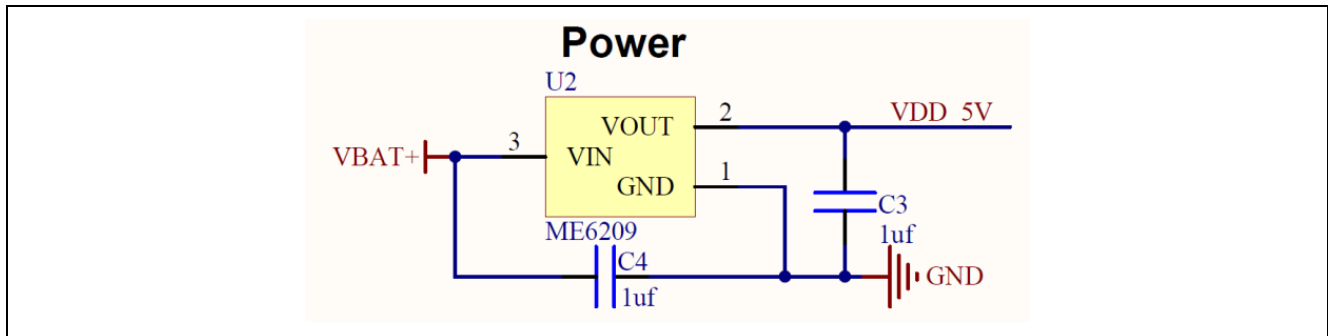


Figure 2.4 Power Supply Circuit

2.5 High Voltage Pulse Ignition Circuit

The high voltage pulse ignition circuit is composed of an oscillating circuit and a high-voltage circuit. The high voltage pulse ignition circuit is shown in Figure 2.5.

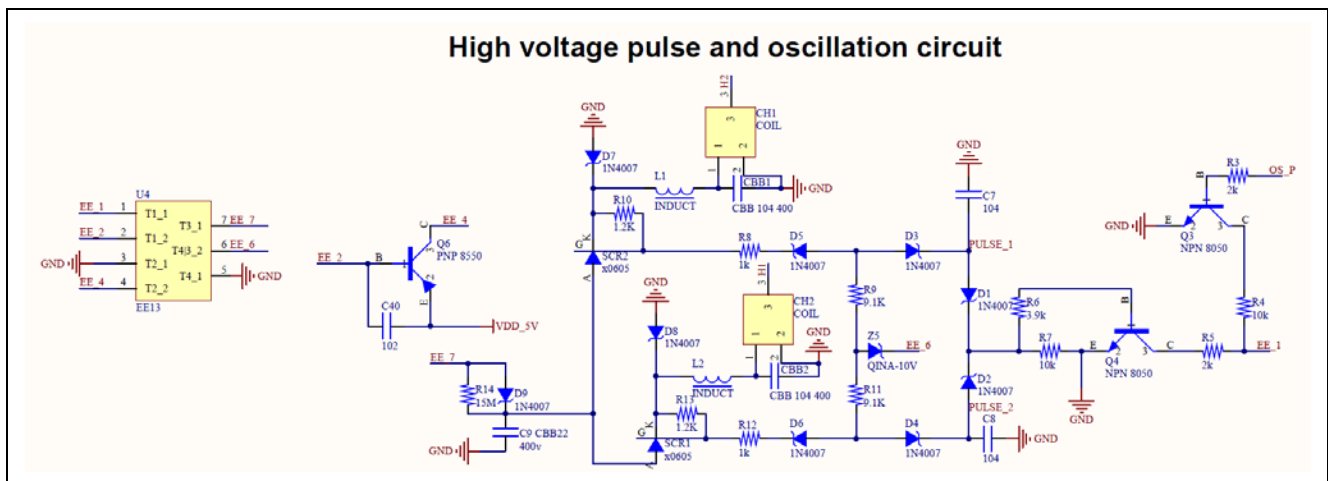


Figure 2.5 High Voltage Pulse Ignition Circuit

2.6 Micro Switch Circuit

The high voltage pulse ignition starts/stops according to the pin status of the micro switch.

The micro switch circuit is shown in Figure 2.6.

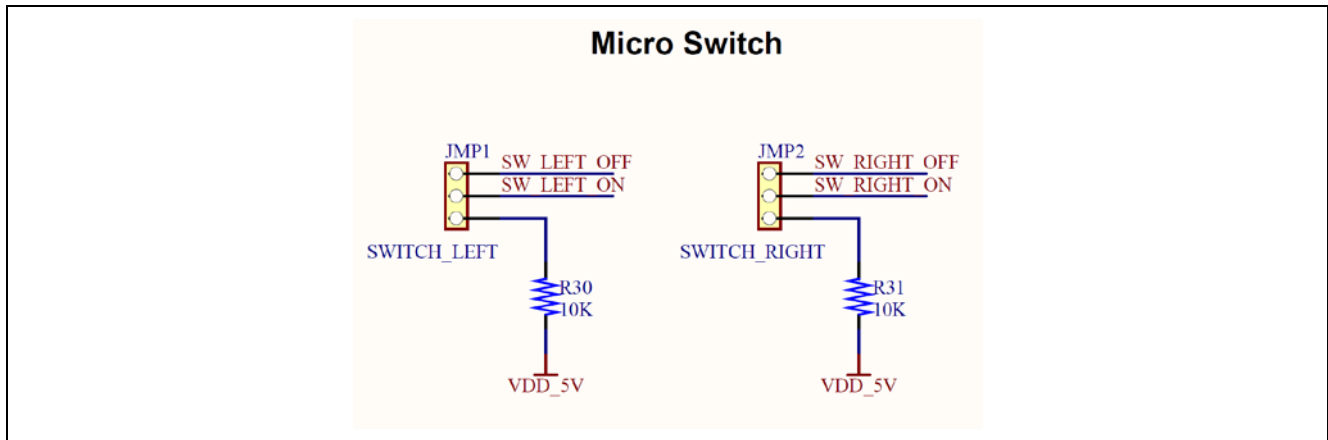


Figure 2.6 Micro Switch Circuit

2.7 Flame Temperature Detection Circuit

After the high voltage pulse ignition begins, it starts to detect the voltage signal of thermocouple feedback. Then it will judge whether the ignition is successful by voltage signal. If the ignition is successful, it will continue to detect flame temperature; but if the ignition fails, the alarm will be turned on to alert people.

The flame temperature detection circuit is shown in Figure 2.7.

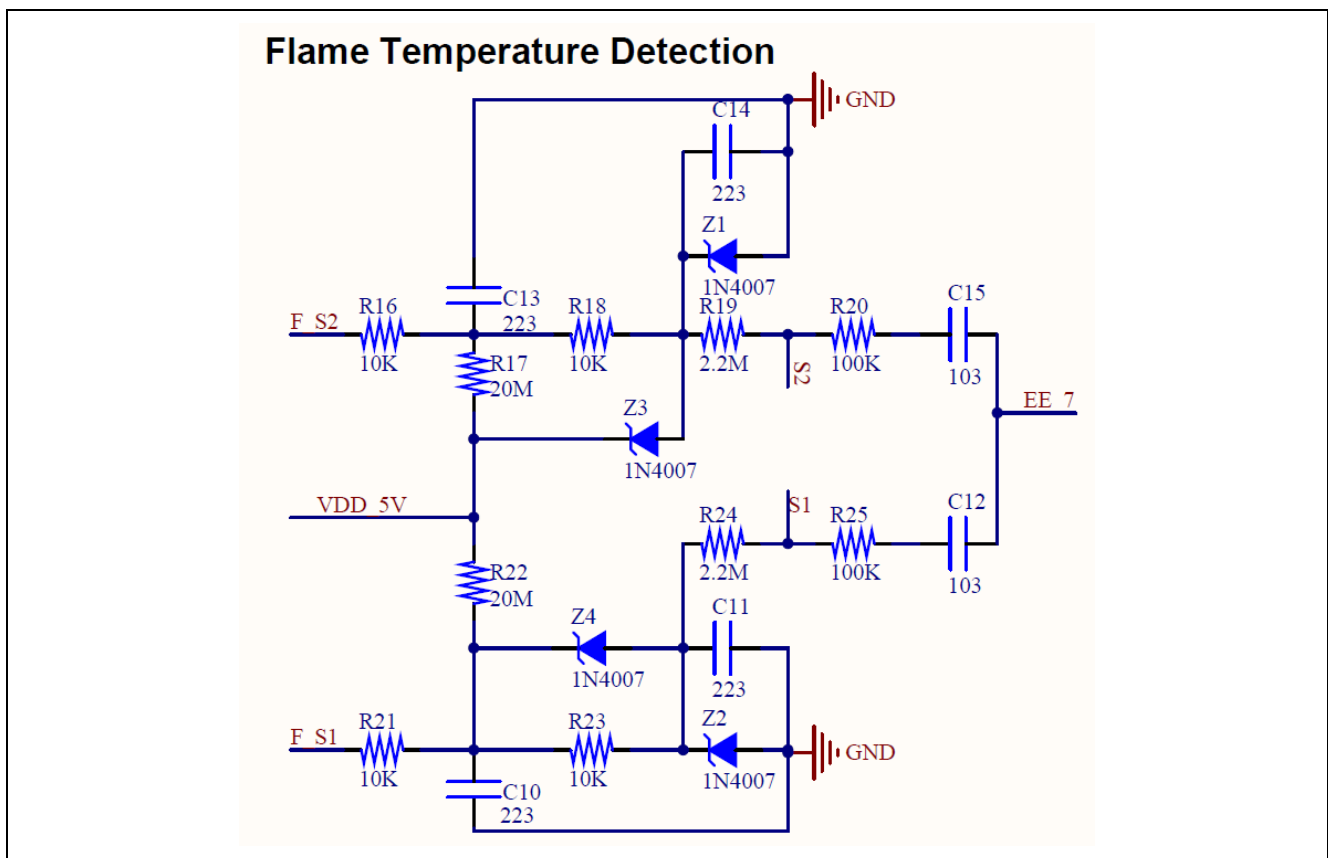


Figure 2.7 Flame Temperature Detection Circuit

2.8 Gas Detection Circuit

The high-end gas cooker's gas detection circuit is composed of a MQ-4 gas detection sensor and a LM393B voltage comparator. When the concentration of natural gas exceeds the standard, the DOUT pin outputs a low level, at the same time the LED1 (alarm lamp) lights up, then it will disable ignition and close the electromagnetic valve and give an alarm tone.

The gas detection circuit is shown in Figure 2.8.

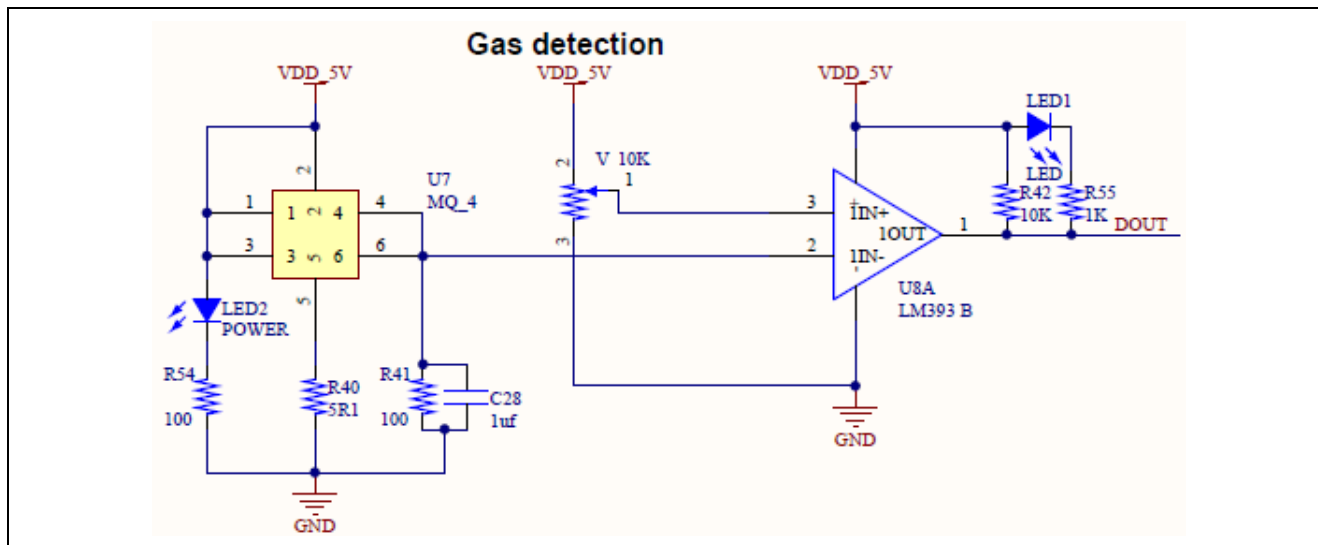


Figure 2.8 Gas Detection Circuit

2.9 Anti-dry Protection Circuit

The high-end gas stove uses a thermal resistance temperature sensor as anti-dry protection device. The outer layer of the sensor is a heat insulation layer, so that the flame temperature interference can be avoided; the top is a temperature measuring layer which can cling to the bottom of the pot when the pot is put on the stove, so as to detect the pot temperature in real time and judge whether the pot is in boil-dry state. If the pot is in boil-dry state, gas supply will be stopped and the alarm buzzer will sound.

The anti-dry protection circuit is shown in Figure 2.9.

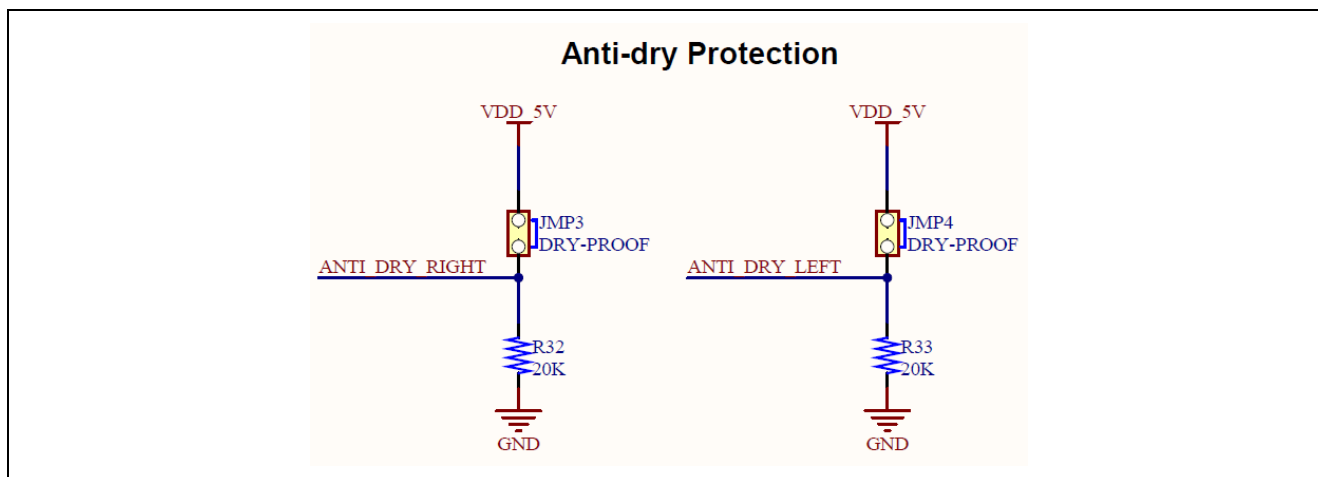


Figure 2.9 Anti-dry Protection Circuit

2.10 Electromagnetic Valve Control Circuit

The high-end gas cooker will start the ignition after receiving the switch response. At this time, the gas control valve will be opened.

The electromagnetic valve control circuit is shown in Figure 2.10.

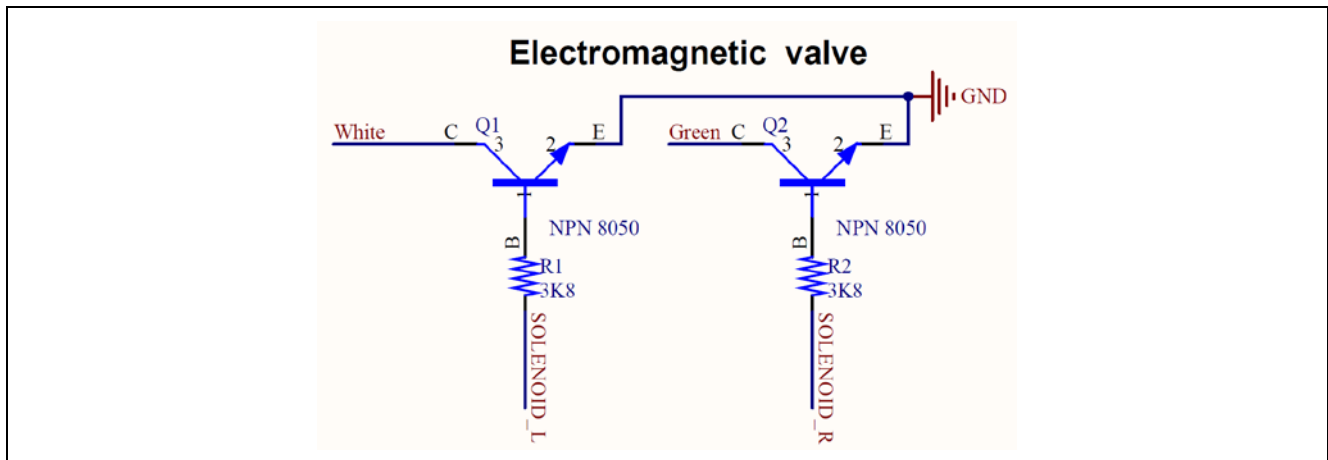


Figure 2.10 Electromagnetic Valve Control Circuit

2.11 Buzzer Output Controller Circuit

The high-end gas cooker has alarm function. If ignition failure lasts for a long time, gas leakage or boil-dry will occur and the buzzer will sound.

The buzzer output controller circuit is shown in Figure 2.11.

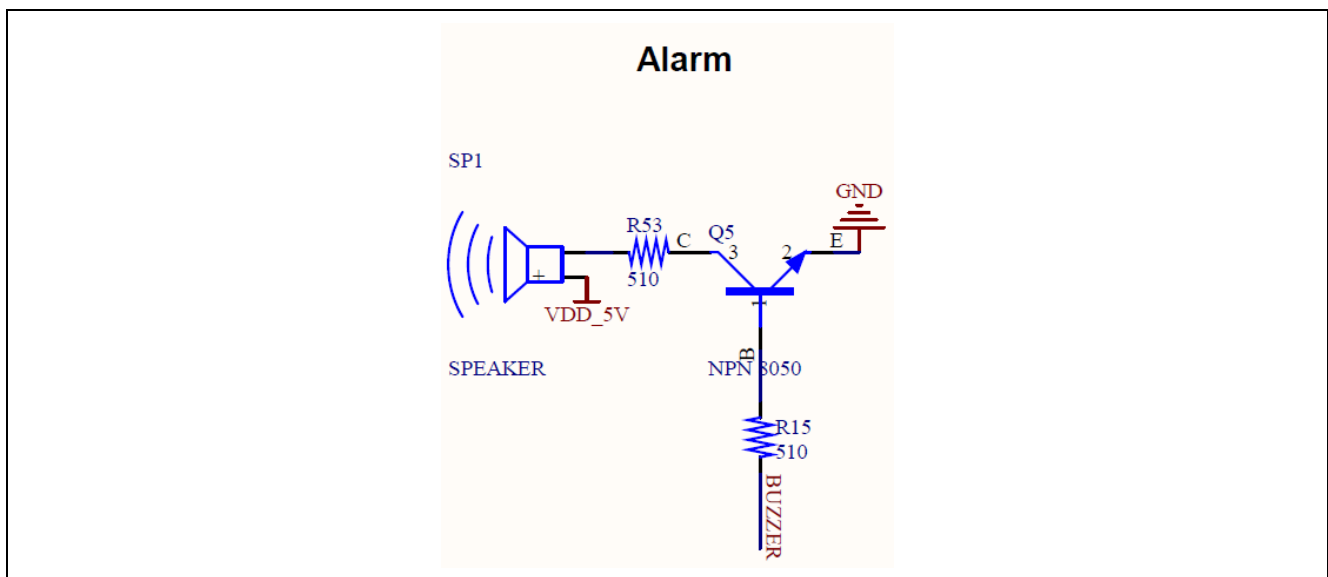


Figure 2.11 Buzzer Output Controller Circuit

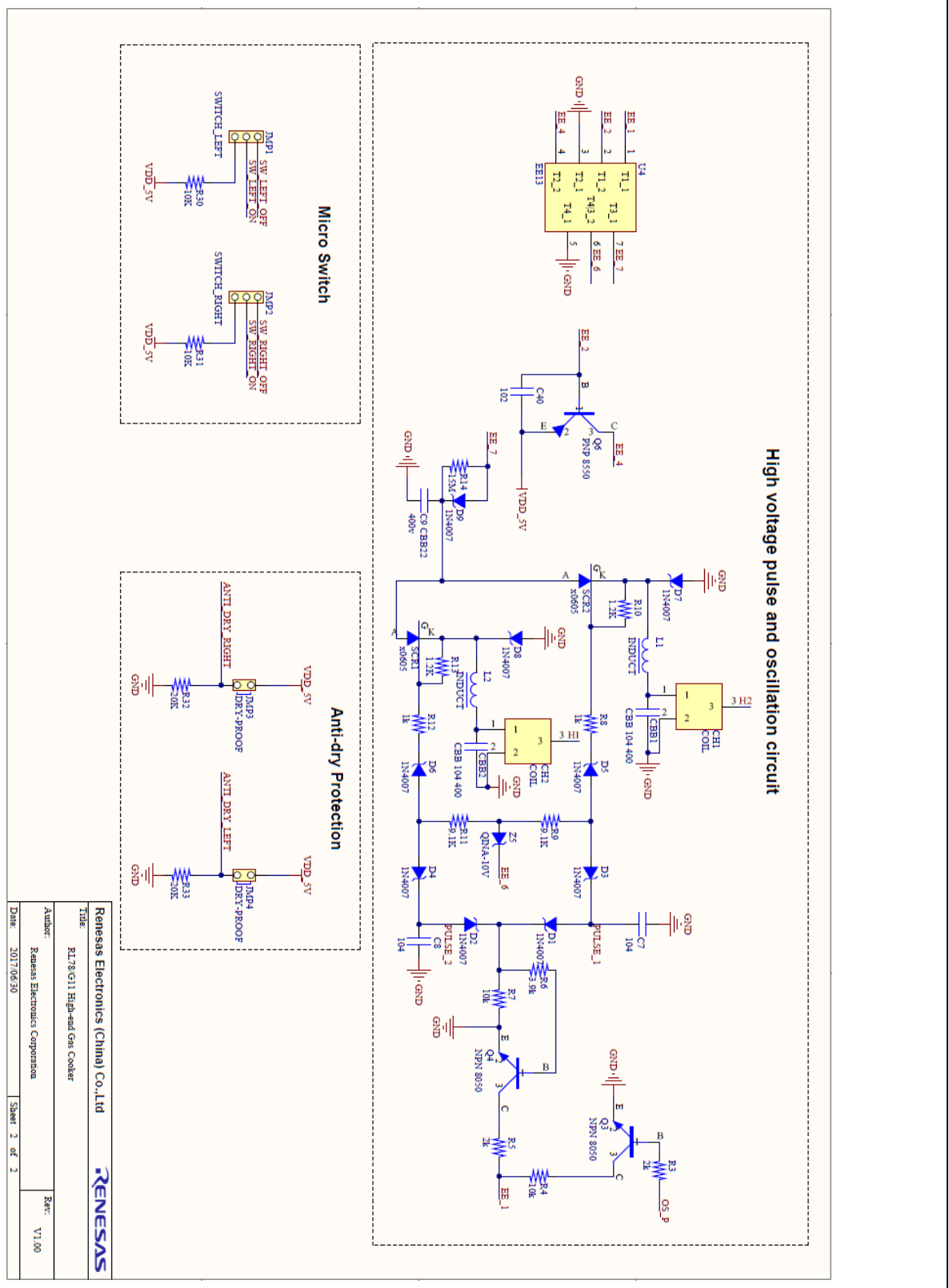


Figure 3.2 Schematic (2/2)

3.2 PCB

The PCB of the high-end gas stove lighting is shown in Figure 3.3.

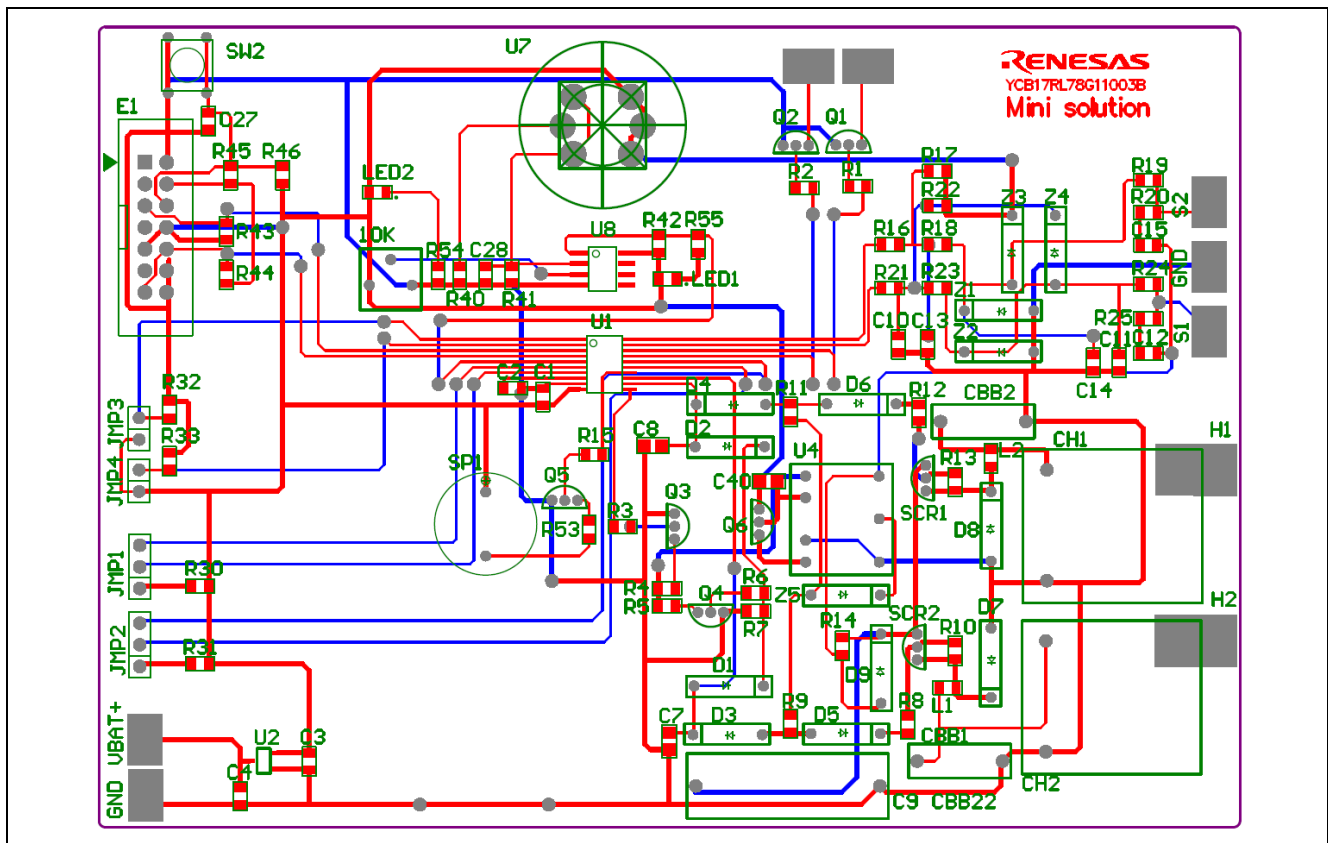


Figure 3.3 PCB

3.3 Bill of Materials

The bill of materials of the high-end gas stove is shown in Table 3.1 and Table 3.2.

Table 3.1 Bill of Materials

Designator	Quantity	Part Name	Manufacturer	Description
VR1	1	—	—	Adjustable resistance (10K)
C1, C7, C8	1	GRM21BR71E104KA01L	Murata	Capacitor (0.1uF, 16VDC, ±10%, 0805)
C2	1	GRM188R71C474KA88D	Murata	Capacitor (0.47uF, 16VDC, ±10%, 0805)
C3, C4, C28	2	GRM21BR71A105KA01L	Murata	Capacitor (1uF, 10VDC, ±10%, 0805)
C10, C11, C13, C14	4	GCM188R71H223KA37J	Murata	Capacitor (0.022uF, 50VDC, ±10%, 0603)
C12, C15	2	GRM216R71H103KA01J	Murata	Capacitor (0.01uF, 50VDC, ±10%, 0805)
C27	1	GRM188R61A106KE69D	Murata	Capacitor (10uF, 10VDC, ±10%, 0603)
C40	1	GRM216R71H152KA01D	Murata	Capacitor (0.001uF, 50VDC, ±10%, 0603)
C9 CBB22	1	CBB22 400V682	—	Capacitor (680000P, 400VDC)
CBB1, CBB2	2	104k 400	—	Capacitor (0.1uF, 400VDC)
CH1, CH2	2	—	—	High pressure bag (28UH, 400UH)
D1, D2, D3, D4, D5, D6, D7, D8, D9, Z1, Z2, Z3, Z4	13	1N4007	TOSHIBA	General Rectifier 50V 1A SMA/DO-214AC
E1	1	2514-6002	3M Limited	Header 7x2, 14-Pin, 2.54mm
JMP1, JMP2	1	146850	TE Connectivity	CON 3X1, 2.54mm
JMP3, JMP4	2	146850	TE Connectivity	CON 2X1, 2.54mm
L1, L2	2	—	—	Magnetic beads
LED1	1	XZMDK54W-1	SunLED	Action LED (green, 0805)
LED2	1	XZMG54W-1	SunLED	Action LED (green, 0805)
Q1, Q2, Q3, Q4, Q5	5	MMSS8050	Micro Commercial Co	TRANS NPN 25V 1.5A SOT-23
Q6	1	MMSS8550	Micro Commercial Co	TRANS PNP 25V 1.5A SOT-23
R1, R2	2	ERJ6ENF3831V	Panasonic	Resistor (3.8KΩ, ±1% 0805)
R3, R5	2	ERJ6GEYJ202V	Panasonic	Resistor (2KΩ, ±5% 0805)
R4, R7, R16, R18, R21, R23, R30, R31, R42	9	ERJ6GEYJ103V	Panasonic	Resistor (10KΩ, ±5% 0805)
R6	1	ERJ6GEYJ392V	Panasonic	Resistor (3.9KΩ, ±5% 0805)
R8, R12, R43, R45, R46, R55	6	ERJ6GEYJ102V	Panasonic	Resistor (1KΩ, ±5% 0805)
R9, R11	2	ERJ6GEYJ912V	Panasonic	Resistor (9.1KΩ, ±1% 0805)
R10, R13	1	ERJ6GEYJ122V	Panasonic	Resistor (1.2KΩ, ±1% 0805)
R14	1	ERJ6GEYJ154V	Panasonic	Resistor (15MΩ, ±5% 0805)
R15, R53	2	ERJ6GEYJ511V	Panasonic	Resistor (510Ω, ±5% 0603)
R17, R19, R20, R22, R24, R25	6	ERJ6GEYJ204V	Panasonic	Resistor (20MΩ, ±5% 0805)
R32, R33	2	ERJ6GEYJ203V	Panasonic	Resistor (20KΩ, ±5% 0805)
R40	1	ERJ6GEYJ5R1V	Panasonic	Resistor (5.1Ω, ±5% 0805)
R41, R54	2	ERJ6GEYJ101V	Panasonic	Resistor (100Ω, ±5% 0805)
R44	1	ERJ6GEYJ471V	Panasonic	Resistor (470Ω, ±5% 0805)
SCR1, SCR2	2	X0605	ST	SCR(VDRM>600V, VGT=0.8V, IGT<20mA)

Table 3.2 Bill of Materials

Designator	Quantity	Part Name	Manufacturer	Description
SP1	1	AT-1224-TWT-5V-2-R	PUI Audio,Inc.	AUDIO MAGNETIC XDCR 3-7V TH
SW2	1	1825910-6	TE Connectivity	Push Switch (6x6mm DIP)
U1	1	R5F1056AASP	Renesas	MCU RL78/G11 20PIN (LSSOP-20)
U2	1	ME6209	Micro One	Low Power Consumption LDO
U4	1	EE13	—	Transformer
U7	1	MQ-4	SparkFun Electronics	Gas Detection
U8	1	LM393 B	TI	Dual voltage comparator
Z5	1	—	—	Zener diode(10V)

4. Introduction of Software

4.1 Integrated Development Environment

The integrated development environments of the high-end gas stove are shown in Table 4.1 and Table 4.2.

Table 4.1 Integrated Development Environments (CS+ for CC)

Item	Contents
Integrated development environment	CS+ for CC V5.00.00 (Renesas Electronics Corporation)
C complier	CC-RL V1.04 (Renesas Electronics Corporation)
Debugger	E1 (Renesas Electronics Corporation)

Table 4.2 Integrated Development Environments (e2studio)

Item	Contents
Integrated development environment	e ² studio V5.2.0.020 (Renesas Electronics Corporation)
C complier	CC-RL V1.04 (Renesas Electronics Corporation)
Debugger	E1 (Renesas Electronics Corporation)

4.2 List of Option Byte Setting

The option byte setting of the high-end gas stove is shown in Table 4.3.

Table 4.3 Option Byte Setting

Address	Setting	Description
000C0H/010C0H	11101110B	Watchdog timer operation is stopped (count is stopped after reset)
000C1H/010C1H	11111111B	LVD: closed
000C2H/010C2H	11100000B	HOCO: 24 MHz, operation voltage range: 4.0 V~5.5 V
000C3H/010C3H	10000100B	On-chip debugging is enabled.

4.3 Flow Chart

4.3.1 Flow Chart of Firmware Main Program

The flow chart of firmware main program is shown in Figure 4.1.

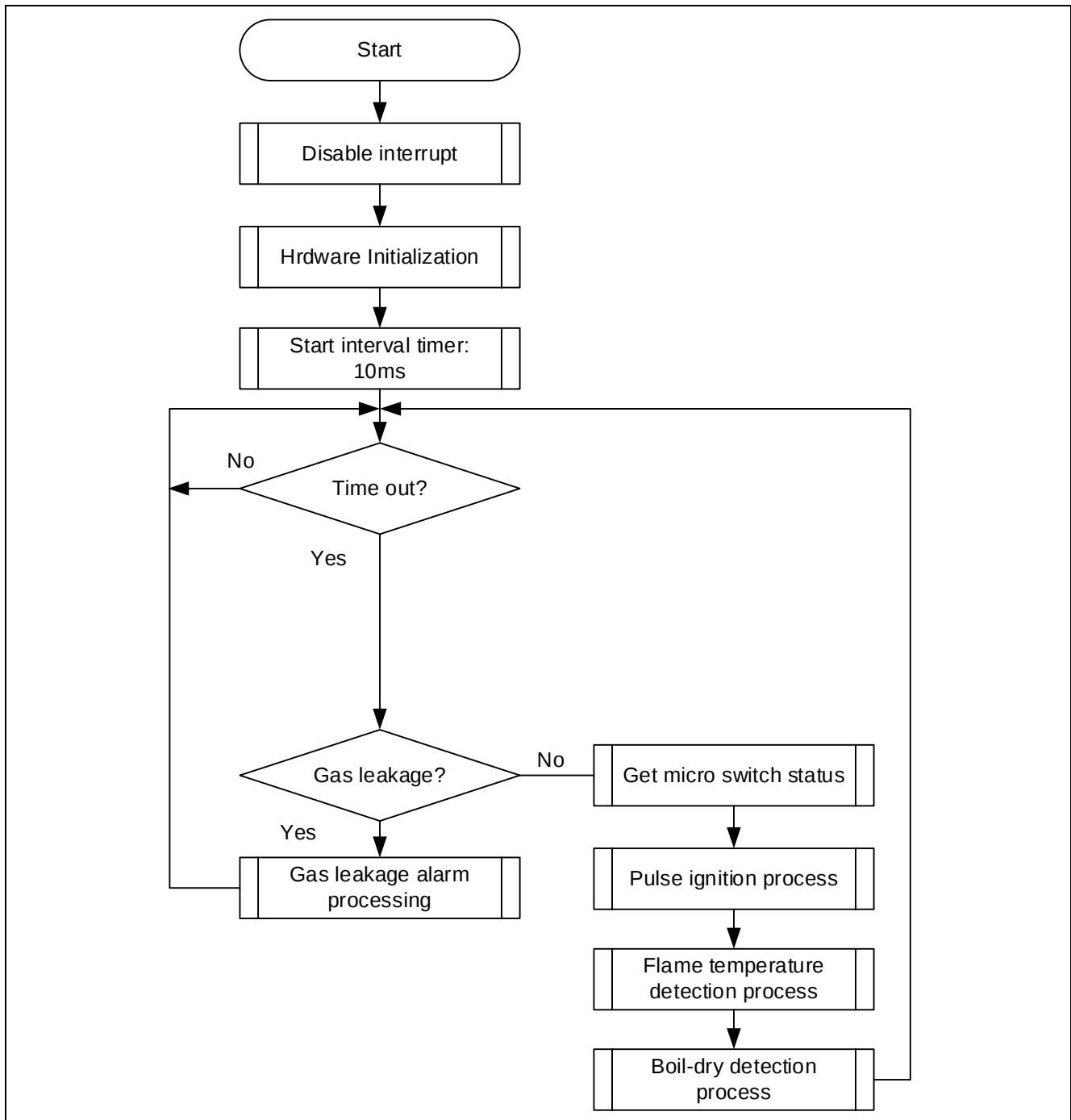


Figure 4.1 Flow Chart of Firmware Main Program

5. Sample Code

The sample code is available on the Renesas Electronics Website.

6. Reference Documents

User's Manual

RL78/G11 User's Manual: Hardware (R01UH0637E)

RL78 Family User's Manual: Software (R01US0015E)

The latest versions of the documents are available on the Renesas Electronics Website.

Technical Updates/Technical News

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep. 15, 2017	-	First edition issued
1.01	Oct. 08, 2018	7, 16	Change MCU name from R5F1056A to R5F1056AASP

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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1. Handling of Unused Pins

Handle unused pins in accordance 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 a product with a different part number, confirm that the change will not lead to problems.

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