RL78/G11

TDS Water Quality Tester

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Introduction

Human health, in both developing and developed countries throughout the world, depends on the quality of available drinking water. So, water quality test is necessary during our daily life. This user's manual describes a Renesas microcontroller RL78/G11 application for a TDS (Total Dissolved Solids) water quality tester. It can be used to check the performance of water filter, to ensure that the drinking water is at the right conductivity level, also it can measure EC (Electrical Conductivity) level for other applications.

Target Device

RL78/G11

Contents

1. Outline of System Function

1.1 Introduction of TDS Measurement

There are various methods and technologies used to measure and evaluate the water quality. While the water electrical conductivity (EC) level is a key indicator of overall water purity.

The total dissolved solids (TDS) measurement is a procedure to test the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg / L), also referred to as parts per million (ppm). It is based on the electrical conductivity (EC) of water. Pure water has virtually zero conductivity. Conductivity is usually about 100 times the total cations or anions expressed as equivalents. TDS is calculated by converting the EC by a factor of 0.5 to 1.0 times the EC.

1.2 Introduction of Operation

(1) Turn the meter (indicate the TDS water quality tester) on by pressing the button "ON/OFF".

(2) Immerse the meter into the testing water up to the maximum immersion level.

(3) Stir the water with the meter to dislodge any air bubbles lightly.

(4) Wait until the display become stability. Once the reading stabilizes, press "Hold" button to hold the reading out of water.

(5) The temperature will be displayed when button "Temp" is pressed. The default unit of temperature is Celsius.

(6) Continue to press the "Temp" button to switch the unit from Celsius (°C) to Fahrenheit (°F).

The state transition diagram is shown in Figure 1.1.

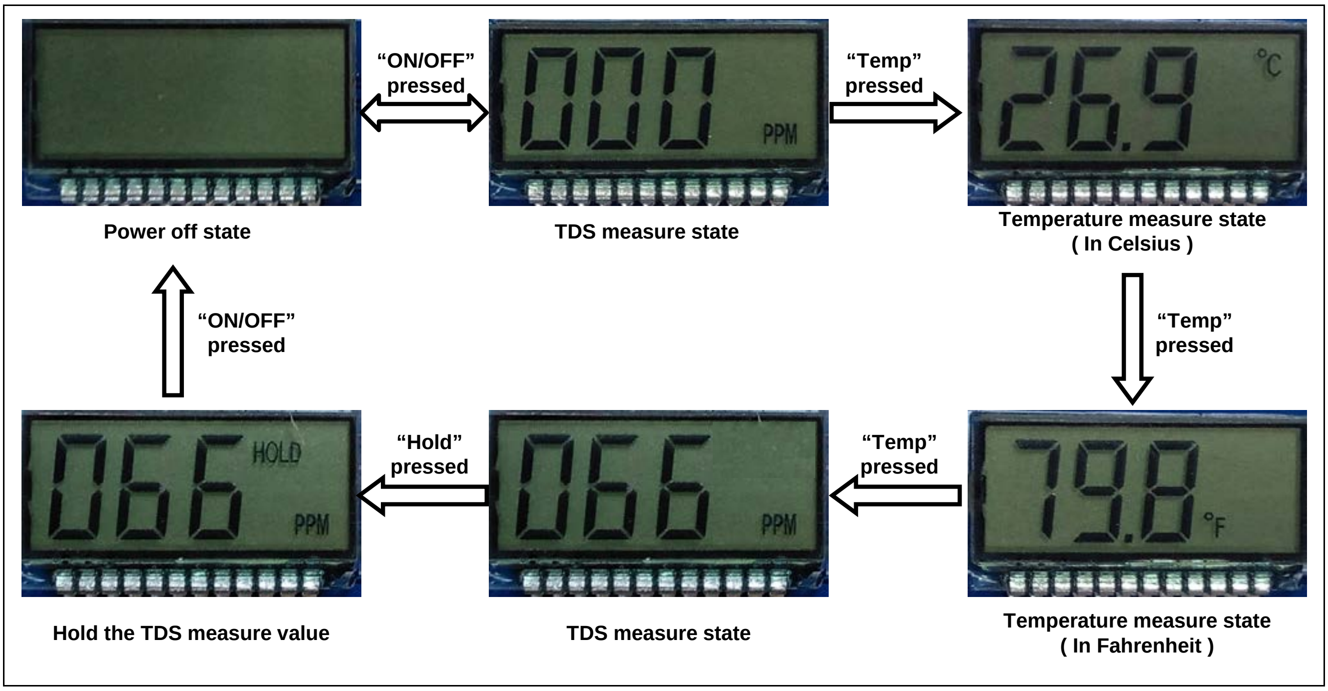


Figure 1.1 State Transition Diagram

2. Introduction of Hardware

2.1 Introduction of PCB

The top view of the water quality tester is shown in Figure 2.1.

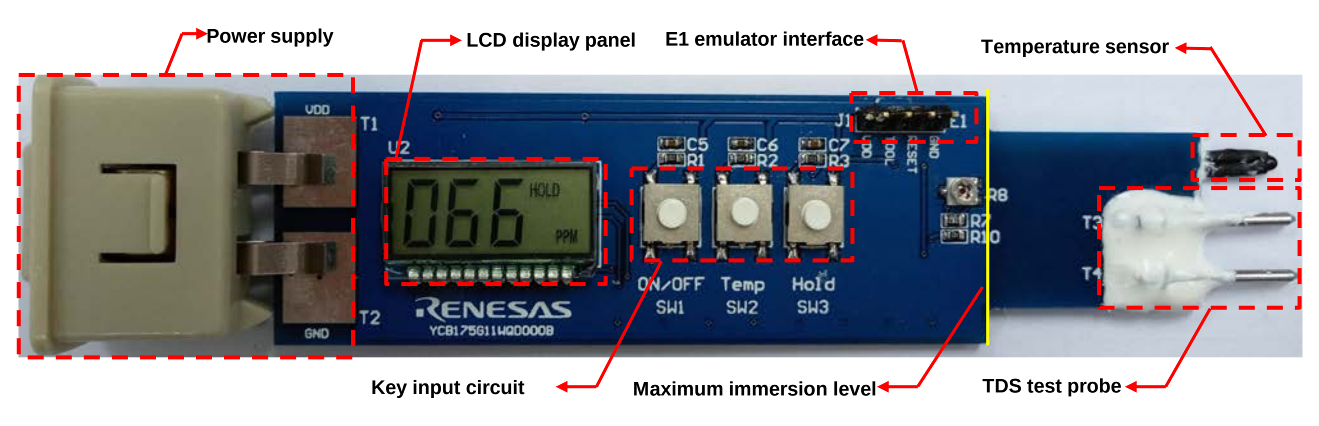


Figure 2.1 Top View of Water Quality Tester

The bottom view of the water quality tester is shown in Figure 2.2.

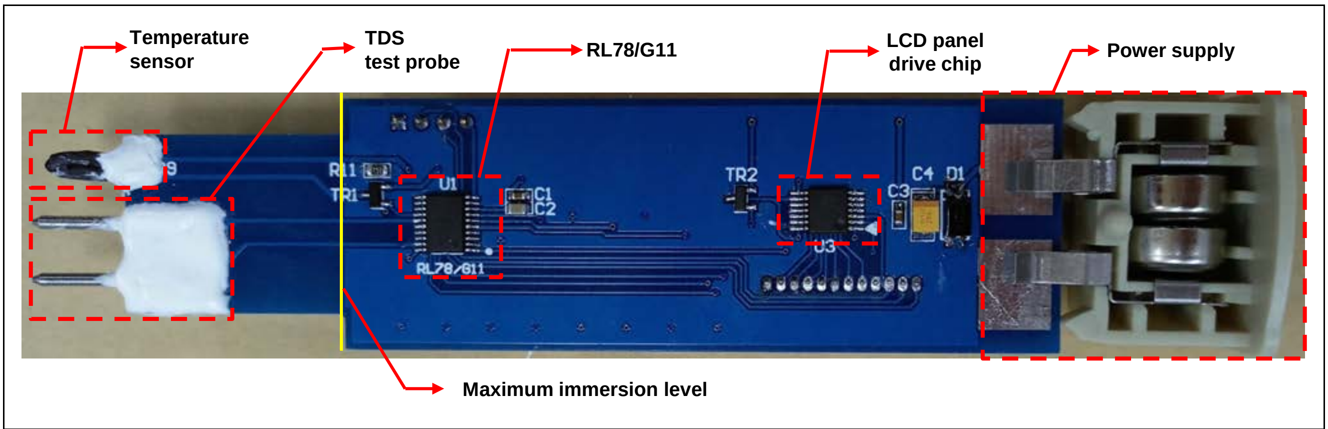


Figure 2.2 Bottom View of Water Quality Tester

2.2 Hardware Block Diagram

The hardware block diagram of the water quality tester is shown in Figure 2.3.

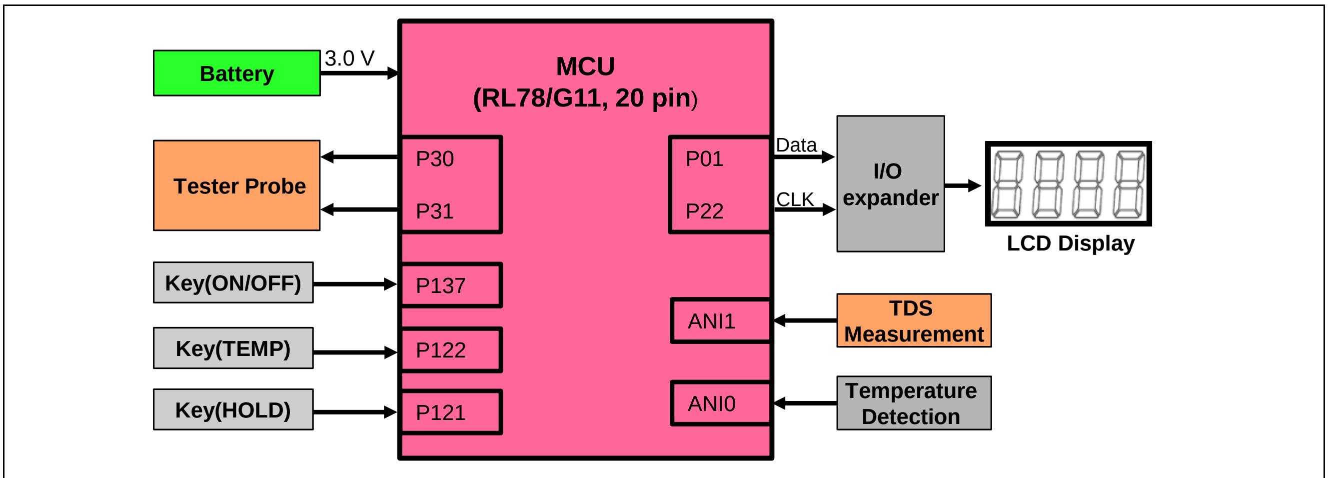


Figure 2.3 Water Quality Tester Hardware Block Diagram

2.3 Main MCU

The demo board of the water quality tester uses RL78/G11 (R5F1056) as main MCU. The Flash ROM size of RL78/G11 is 16 KB and the RAM size is 1.5 KB. The used peripheral functions in this application are shown in Table 2.1.

Table 2.1 The Used Peripheral Functions and Their Applications

Peripheral Functions	Usage
P01	Data input port of I/O expander
P23	Clock input port of I/O expander
P22	Power control of I/O expander
P137/P122/P121	Key input
ANI0	Temperature measurement
ANI1	TDS measurement
P30/P31	Drive wave output port for TDS measurement
P54/P55/P56/P33	For LCD display
TAU00	680 μs interval time used for TDS measurement
TAU01	3 ms interval time used for LCD drive wave output

2.4 Power Supply Circuit

The power uses 2 × 1.5 V batteries (LR44) as power supply. Diode D1 is used for battery reverse mounted protection.

The power supply circuit is shown in Figure 2.4.

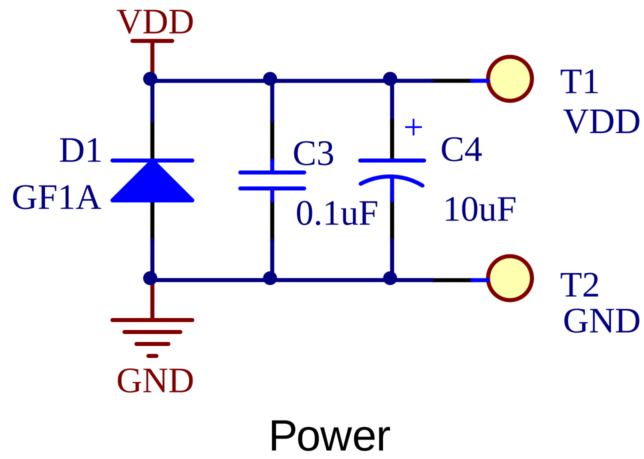
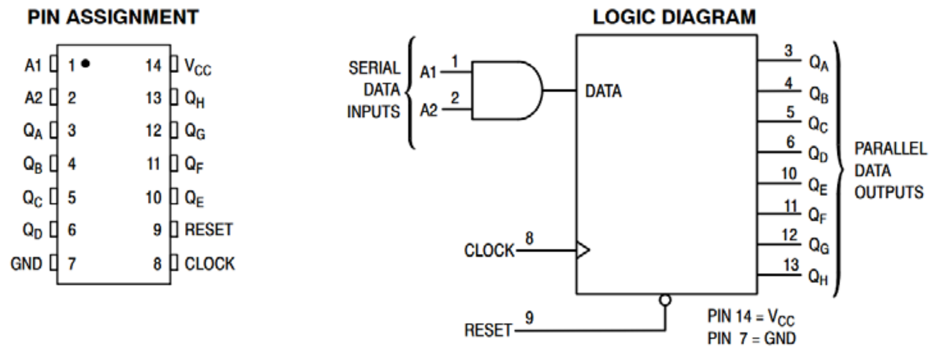


Figure 2.4 Power Supply Circuit

2.5 LCD Display Panel Interface Circuit

There is not enough GPIO used for LCD panel display for RL78/G11 (20 pin) product. So an 8-bit serial-input/parallel-output shift register chip MC74HC164 is selected to drive LCD panel display.

The pin assignment and function table of MC74HC164 is shown in Figure 2.5.



FUNCTION TABLE

Inputs				Outputs			
Reset	Clock	A1	A2	Q_A	Q_B	…	Q_H
L	X	X	X	L	L	…	L
H	↓	X	X	No Change			
H	↑	H	D	D	Q_{An}	…	Q_{Gn}
H	↑	D	H	D	Q_{An}	…	Q_{Gn}

D = data input
Q_{An} – Q_{Gn} = data shifted from the preceding stage on a rising edge at the clock input.

Figure 2.5 Pin Assignment and Function Table

The LCD display panel interface circuit is shown in Figure 2.6.

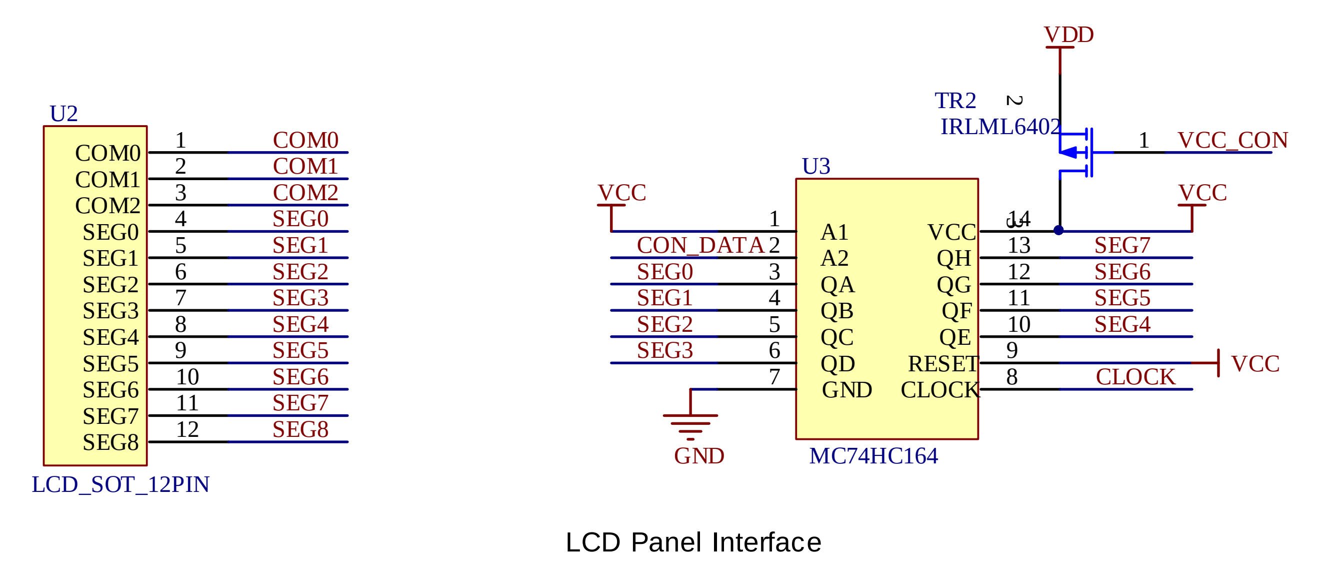


Figure 2.6 LCD Display Panel Interface Circuit

2.6 Key Input Circuit

The key input circuit is used to power on/off the meter, switch LCD display mode, and hold/release LCD display content.

The key input interface circuit is shown in Figure 2.7.

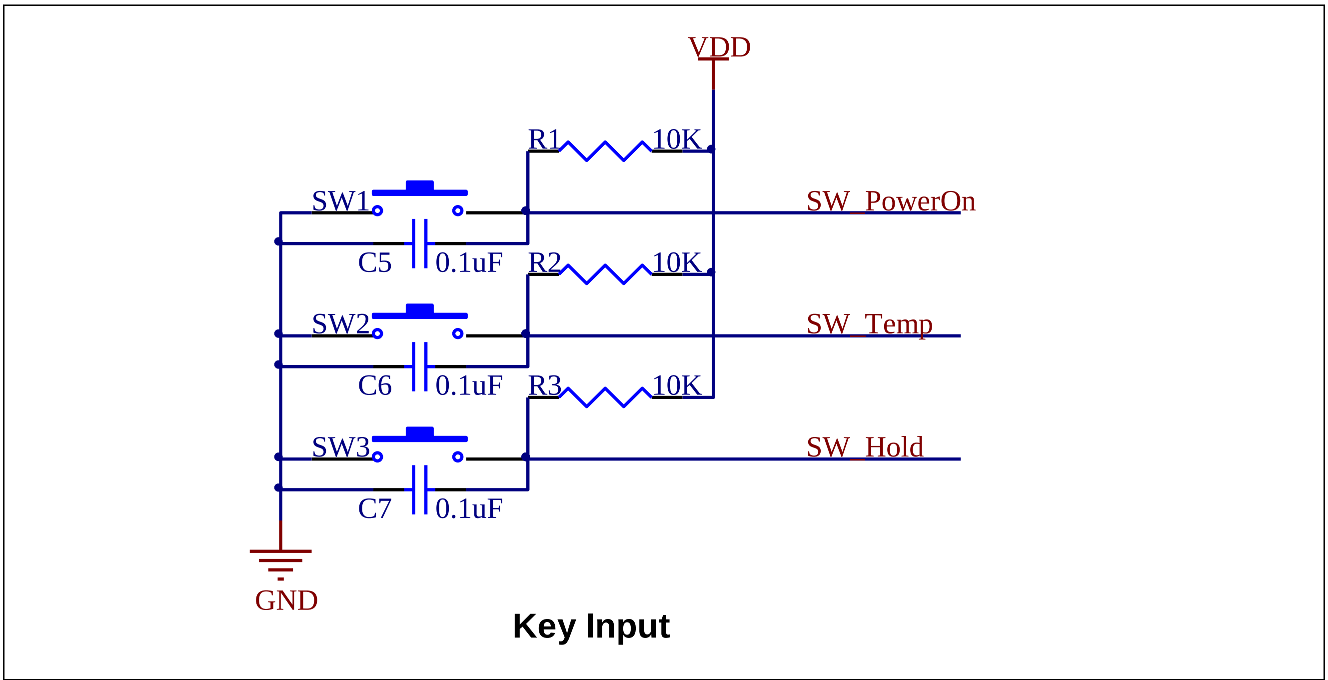


Figure 2.7 Key Input Circuit

2.7 TDS and Temperature Measurement Circuit

The TDS measurement is to test the electrical conductivity of the water by passing a small current through it. And temperature measurement is to test the value of NTC resistor, then calculate the current environment temperature.

The TDS and temperature measurement circuit is shown in Figure 2.8.

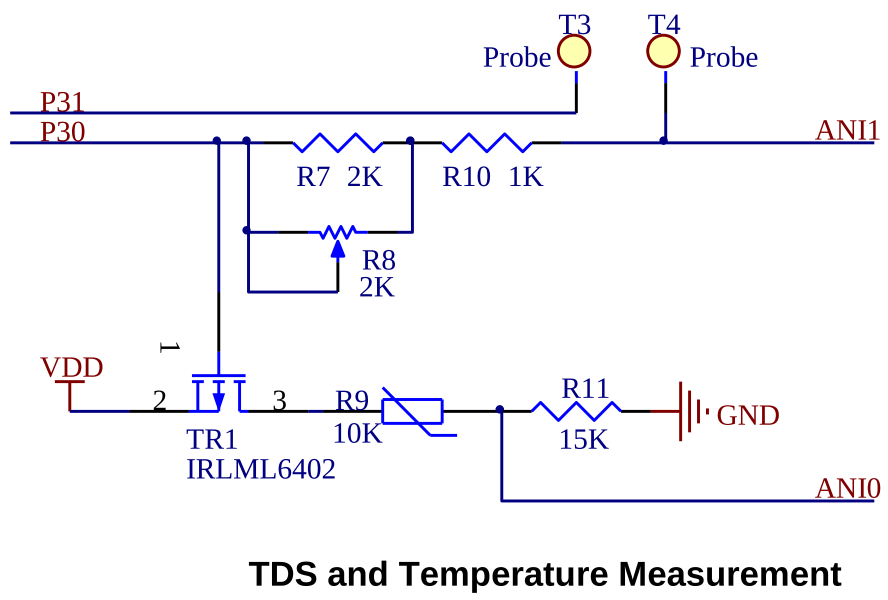


Figure 2.8 TDS and Temperature Measurement Circuit

3. Schematic, PCB and Bill of Materials

3.1 Schematic

The schematic of the TDS water quality tester is shown in Figure 3.1.

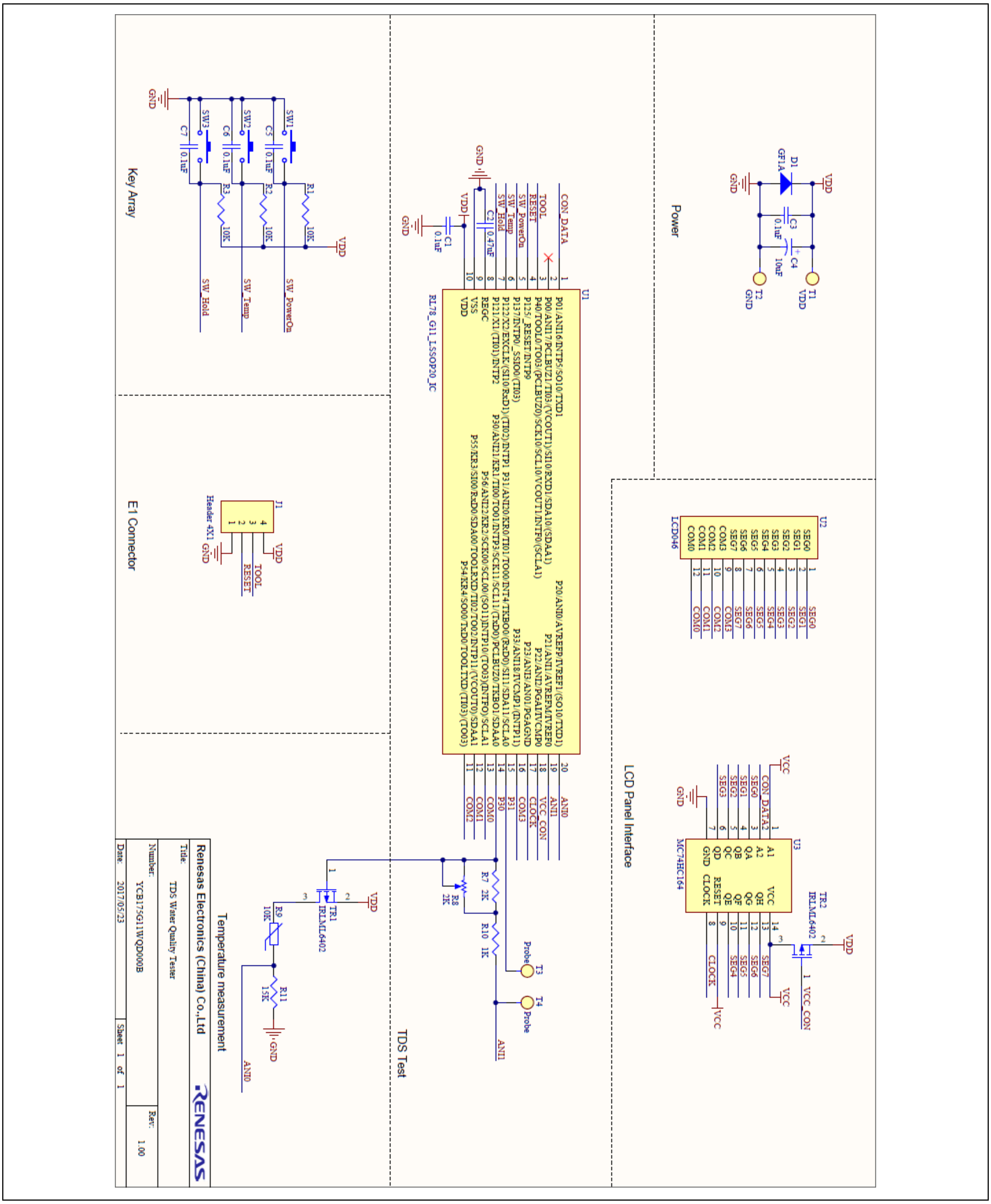


Figure 3.1 Schematic

3.2 PCB

The PCB of the TDS water quality tester is shown in Figure 3.2.

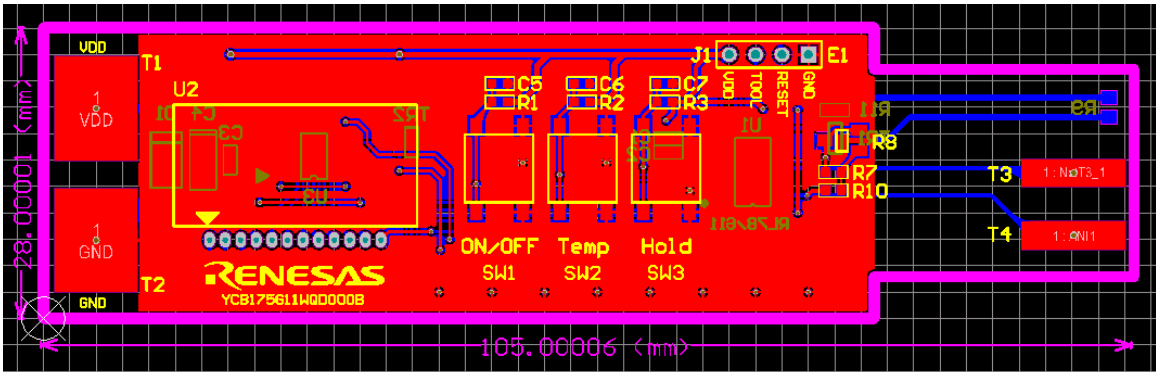


Figure 3.2 PCB

3.3 Bill of Materials

The bill of materials of the TDS water quality tester is shown in Table 3.1.

Table 3.1 Bill of Materials

Designator	Quantity	Part Name	Manufacturer	Description
C1, C3, C5, C6, C7	5	GRM188R71C104KA0	Murata	Capacitor (0.1uF,16VDC, ±10%
C2	1	GRM188R71E474KA12D	Murata	Capacitor (0.47 uF, 25 VDC, ±10%, 0603)
C4	1	T491B106M016AT	Kemet	Tantalum Capacitor (10uF, B3528-21)
D1	1	GF1A-E3/67A	Vishay	Diode (50 VDC, 1 A, DO214BA)
R1, R2, R3	3	ERJU03F1002V	Panasonic	Resistor (10KΩ, ±1%, 0603)
R7	1	ERJU03F1002V	Panasonic	Resistor (2KΩ, ±1%, 0603)
R8	1	TC33X-2-202G	Bourns Inc.	Trimmer 2 K, 0.1 W
R9	1	B57891M0103K000	EPCOS	NTC thermister (10 K, ±10%)
R10	1	ERJU03F2001V	Panasonic	Resistor (1KΩ, ±1%, 0603)
R11	1	ERA3AEB153V	Panasonic	Resistor (15 K, ±0.1%, 0603)
SW1, SW2, SW3	3	B3S-1100P	OMRON	Push Switch (6 * 6mm SMT)
TR1,TR2	2	IRLML6402TRPBF	Infineon	P-channel mosfet (SOT-23)
U1	1	R5F1056AASP	Renesas Electronics	20-pin plastic LSSOP
U2	1	-	-	LCD Panel (Customed)
U3	1	MC74HC164	ON Semiconductor	IC shift register 8-bit 14-TSSOP
J1	1	61300411121	Wurth Electronics Inc.	CONN Header 4x1, 2.54 mm
T3, T4	2	-	-	Test Probe

4. Introduction of Software

4.1 Integrated Development Environment

The integrated development environment of the TDS water quality tester is shown in Table 4.1.

Table 4.1 Integrated Development Environment

Item	Contents
Integrated development environment	a. CS+ for CC V5.00.00 (Renesas Electronics Corporation) b. e2 studio for version 5.3.0 (Renesas Electronics Corporation)
C compiler	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 TDS water quality tester is shown in Table 4.2.

Table 4.2 Option Byte Setting

Address	Setting	Description
000C0H/010C0H	11101111B	Watchdog timer operation is stopped (count is stopped after reset)
000C1H/010C1H	11111111B	LVD: closed
000C2H/010C2H	10101010B	HOCO: 8 MHz, operation voltage range: 1.8 V~3.6 V
000C3H/010C3H	10000101B	On-chip debugging is enabled.

4.3 Flow Chart

4.3.1 Flow Chart of Main Program

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

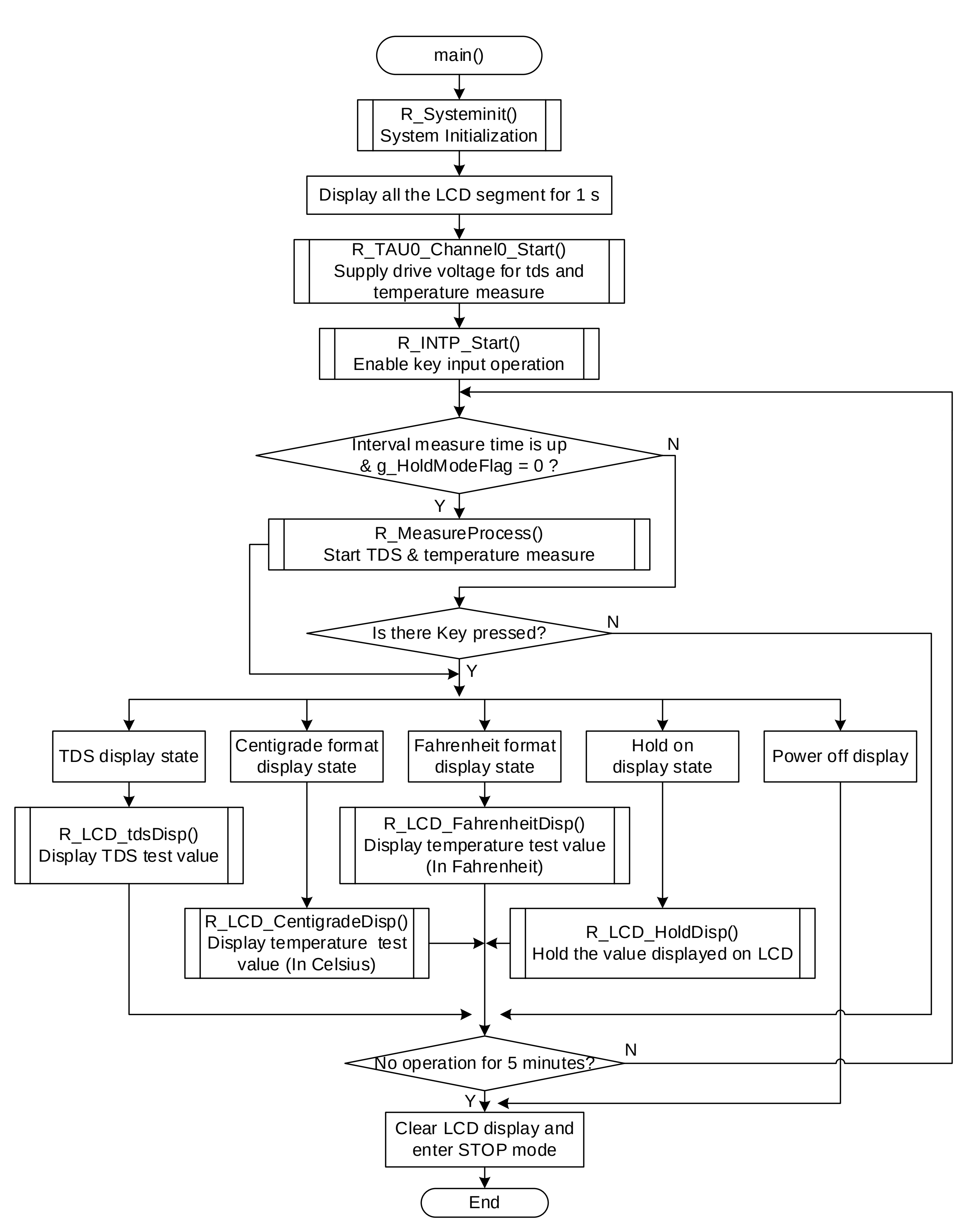


Figure 4.1 Flow Chart of Main Program

4.3.2 Flow Chart of Measure Process

The flow chart of the TDS and temperature measurement process is shown in Figure 4.2.

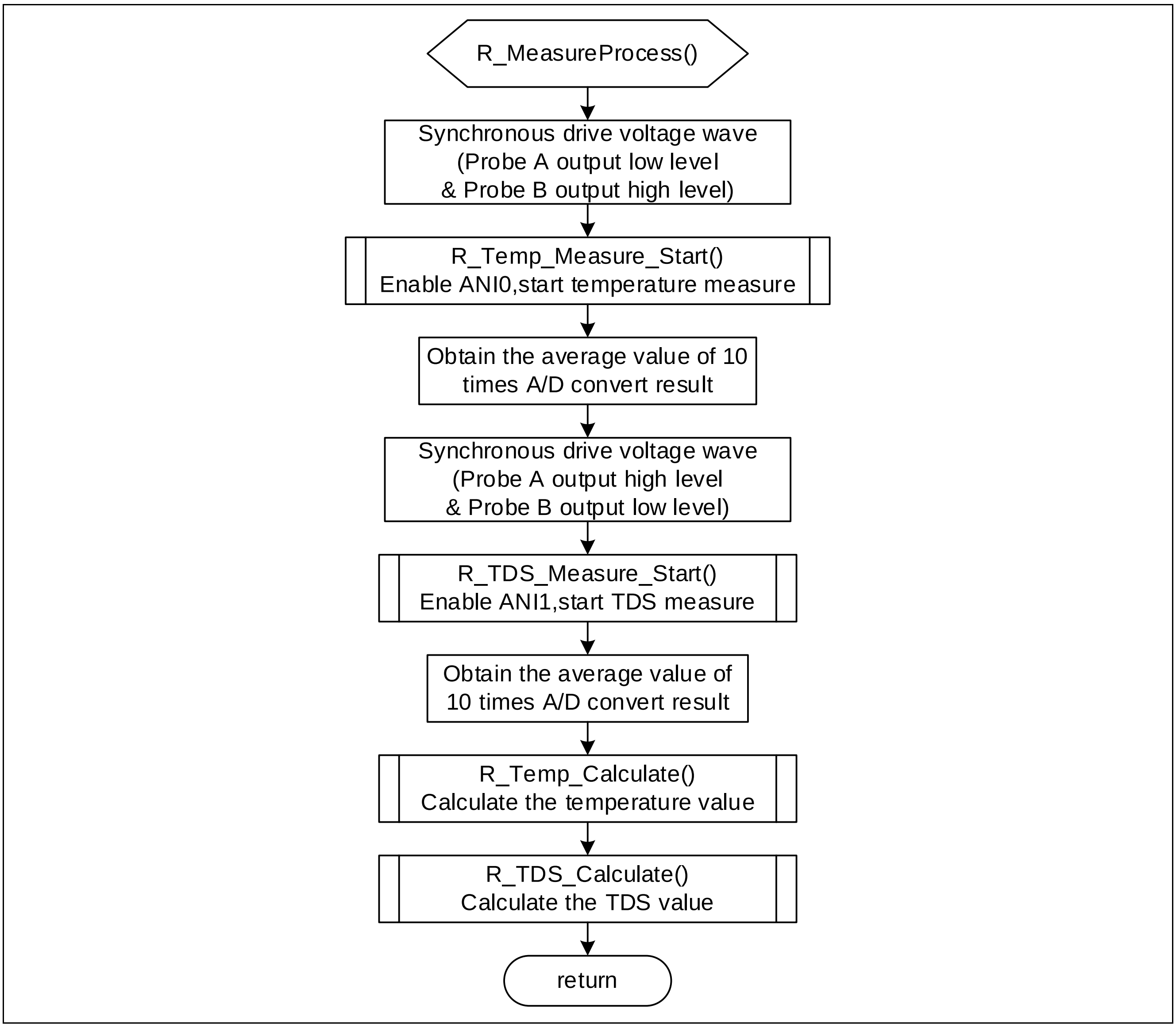


Figure 4.2 Flow Chart of Measure Process

5. Sample Code

The sample code is available on the Renesas Electronics Website.

6. Reference Documents

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
The latest information can be downloaded from the Renesas Electronics website.

Website and Support

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jun. 30, 2017	-	First edition issued
1.01	Sep. 15, 2017	10	Update the description information about the bill of materials
1.02	Aug. 21, 2018	9	Update the schematic in Figure 3.1
		10	Update the part number (from R5F1056AGNA to R5F1056AASP) of U1
			Update the description (from HWQFN to LSSOP) of U1

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

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

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.
   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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