LAMPIRAN-LAMPIRAN

A. Data Sheet

1. Data Sheet IC Atmega 328P

Features
- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20 MHz
- On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 4/8/16/32K Bytes of In-System Self-Programmable Flash program memory
    (ATmega48P/88P/168P/328P)
  - 256/512/1024 K Bytes EEPROM (ATmega48P/88P/168P/328P)
  - 512/1K/2K Bytes Internal SRAM (ATmega48P/88P/168P/328P)
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
- Data retention: 20 years at 85°C/100 years at 25°C
- Optional Boot Code Section with Independet Lock Bits
- In-System Programming by On-chip Boot Program
- True Read-While-Write Operation
- Programming Lock for Software Security
- Peripheral Features
- Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
- One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
- Real Time Counter with Separate Oscillator
- Six PWM Channels
- 8-channel 10-bit ADC in TQFP and QFN/MLF package
- Temperature Measurement
- 6-channel 10-bit ADC in PDIP Package
- Programmable Serial UART
- Master/Slave SPI Serial Interface
- 8-bit Timer/Counter 8-channel 10-bit ADC
- Programmable Watchdog Timer with Separate On-chip Oscillator
- On-chip Analog Comparator
- Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-pin TQFP, 28-lead PGUP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V for ATmega48P/88P/168PV
  - 2.7 - 5.5V for ATmega48P/88P/168P
  - 1.8 - 5.5V for ATmega328P
- Temperature Range:
  - -40°C to 85°C
- Speed Grade:
  - ATmega48P/88P/168P: 0 - 4 MHz @ 1.8 - 5.5V, 0 - 10 MHz @ 2.7 - 5.5V
  - ATmega48P/88P/168P: 0 - 10 MHz @ 2.7 - 3.5V, 0 - 20 MHz @ 4.5 - 5.5V
  - ATmega328P: 0 - 4 MHz @ 1.8 - 5.5V, 0 - 16 MHz @ 2.7 - 5.5V, 0 - 20 MHz @ 4.5 - 5.5V
- Low Power Consumption at 1 MHz, 1.8V, 25°C for ATmega48P/88P/168P:
  - Active Mode: 0.3 mA
  - Power-down Mode: 0.1 µA
  - Power-save Mode: 0.8 µA (including 32 kHz RTC)

Note: 1. See ‘Data Retention’ on page 7 for details.
1. Pin Configurations

Figure 1-1. Pinout ATmega48P/88P/168P/328P
1.1 Pin Descriptions

1.1.1 VCC
Digital supply voltage.

1.1.2 GND
Ground.

1.1.3 Port B (PB7:0) XTL1/XTAL2/TOSC1/TOSC2
Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.
Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.
Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.
If the Internal Calibrated RC Oscillator is used as chip clock source, PB7.6 is used as TOSC2.1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.
The various special features of Port B are elaborated in "Alternate Functions of Port B" on page 82 and "System Clock and Clock Options" on page 26.

1.1.4 Port C (PC5:0)
Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5:0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

1.1.5 PC6/RESET
If the RSTDISB Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.
If the RSTDISB Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. The minimum pulse length is given in Table 26-3 on page 320. Shorter pulses are not guaranteed to generate a Reset.
The various special features of Port C are elaborated in "Alternate Functions of Port C" on page 85.

1.1.6 Port D (PD7:0)
Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.
The various special features of Port D are elaborated in "Alternate Functions of Port D" on page 88.

1.1.7 \( \text{AV}_{\text{cc}} \)

\( \text{AV}_{\text{cc}} \) is the supply voltage pin for the A/D Converter, PC3/0, and ADC7/6. It should be externally connected to \( \text{V}_{\text{cc}} \) even if the ADC is not used. If the ADC is used, it should be connected to \( \text{V}_{\text{cc}} \) through a low-pass filter. Note that PC6..4 use digital supply voltage, \( \text{V}_{\text{cc}} \).

1.1.8 \( \text{AREF} \)

\( \text{AREF} \) is the analog reference pin for the A/D Converter.

1.1.9 \( \text{ADC7/6 (TQFP and QFN/MLF Package Only)} \)

In the TQFP and QFN/MLF package, ADC7-6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

2. Overview

The ATmega48P/88P/168P/328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega48P/88P/168P/328P achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.
The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega48P/88P/168P/328P provides the following features: 4K/8K/16K/32K bytes of In-System Programmable Flash with Read-While-Write capabilities, 256/512/512/1K bytes EEPROM, 512/1K/1K/2K bytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte-oriented 2-wire Serial Interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), a programmable
ATmega48P/88P/168P/328P

Watchdog Timer with internal Oscillator, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, USART, 2-wire Serial interface, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption.

The device is manufactured using Atmel’s high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip Boot program running on the AVR core. The Boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega48P/88P/168P/328P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega48P/88P/168P/328P AVR is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits.

2.2 Comparison Between ATmega48P, ATmega88P, ATmega168P, and ATmega328P

The ATmega48P, ATmega88P, ATmega168P, and ATmega328P differ only in memory sizes, boot loader support, and interrupt vector sizes. Table 2-1 summarizes the different memory and interrupt vector sizes for the three devices.

<table>
<thead>
<tr>
<th>Device</th>
<th>Flash</th>
<th>EEPROM</th>
<th>RAM</th>
<th>Interrupt Vector Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATmega48P</td>
<td>4K Bytes</td>
<td>256 Bytes</td>
<td>512 Bytes</td>
<td>1 instruction word/vector</td>
</tr>
<tr>
<td>ATmega88P</td>
<td>8K Bytes</td>
<td>512 Bytes</td>
<td>1K Bytes</td>
<td>1 instruction word/vector</td>
</tr>
<tr>
<td>ATmega168P</td>
<td>16K Bytes</td>
<td>512 Bytes</td>
<td>1K Bytes</td>
<td>2 instruction words/vector</td>
</tr>
<tr>
<td>ATmega328P</td>
<td>32K Bytes</td>
<td>1K Bytes</td>
<td>2K Bytes</td>
<td>2 instructions words/vector</td>
</tr>
</tbody>
</table>

ATmega88P, ATmega168P, and ATmega328P support a true Read-While-Write Self-Programmable mechanism. There is a separate Boot Loader Section, and the SPM instruction can only execute from there. In ATmega48P, there is no Read-While-Write support and no separate Boot Loader Section. The SPM instruction can execute from the entire Flash.
3. About

3.1 Disclaimer

Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

3.2 Resources

A comprehensive set of development tools, application notes and datasheets are available for download on http://www.atmel.com/avr.

3.3 Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 PPM over 20 years at 85°C or 100 years at 25°C.

3.4 Code Examples

This documentation contains simple code examples that briefly show how to use various parts of the device. These code examples assume that the part specific header file is included before compilation. Be aware that not all C compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Please confirm with the C compiler documentation for more details.

2. Data Sheet IC LM358D

Dual Operational Amplifiers

**FEATURES**
- Internally frequency compensated for unity gain
- Large DC voltage gain: 100 dB
- Wide power supply range: 3V to 32V (or 1.5V to 16V)
- Input common-mode voltage range includes ground
- Large output voltage swing: 0V DC to VCC-1.5V DC
- Power drain suitable for battery operation
- Moisture Sensitivity Level 3

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM358D</td>
<td>SOP-8</td>
</tr>
</tbody>
</table>

**DESCRIPTION**

The LM358D consists of two independent, high-gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits. Which now can be easily implemented in single power supply systems.

**ABSOLUTE MAXIMUM RATING**

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>SYMBOL</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>( V_{CC} )</td>
<td>( \pm 16V ) or 32V</td>
<td>V</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>( V_{\text{din}} )</td>
<td>( \pm 32V )</td>
<td>V</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>( V_i )</td>
<td>( -0.3V ) to 32V</td>
<td>V</td>
</tr>
<tr>
<td>Output Short Circuit to GND</td>
<td></td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>( V_{CC} ) ( \leq V ) ( T_A=25^\circ C ) (One Amp)</td>
<td>( V_{CC} )</td>
<td>( -3V ) to 32V</td>
<td>V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>( T_{\text{com}} )</td>
<td>0 to 70 ( ^\circ C )</td>
<td>( ^\circ C )</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>( T_{\text{stg}} )</td>
<td>-65 ( ^\circ C ) to 150 ( ^\circ C )</td>
<td>( ^\circ C )</td>
</tr>
</tbody>
</table>
# Electrical Characteristics

Electrical characteristics at specified free-air temperature, VCC=5V (unless otherwise noted)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
</table>
| V<sub>IN</sub>                   | V<sub>CC</sub>=5V to MAX,  
Input offset voltage             | V<sub>CC</sub>=1V,  
V<sub>CC</sub>=1V min,  
V<sub>CC</sub>=1.4V          | 25°C | 3   | 7   | mV   |
| V<sub>OUT</sub>                  | V<sub>CC</sub>=5V to MAX,  
Average temperature coefficient  
of input offset voltage           | Full range          | 9   |
| I<sub>le</sub>                   | V<sub>CC</sub>=1.4V     | 25°C | 2   | 50  | nA   |
| V<sub>IN</sub>                   | V<sub>CC</sub>=1.4V     | 25°C | 10  | 150 | pA/C |
| V<sub>OUT</sub>                  | V<sub>CC</sub>=5V to MAX,  
Average temperature coefficient  
of input offset voltage           | Full range          | 10  |
| I<sub>le</sub>                   | V<sub>CC</sub>=1.4V     | 25°C | -20 | -200| nA   |
| Common-mode input voltage range  | V<sub>CC</sub>=5V to MAX,  
High-level output voltage        | 25°C | 26  | 28  | V    |
| V<sub>CC</sub>                   | R<sub>g</sub>≥2kΩ       | 25°C | 25  | 100 | V/mV |
| Low-level output voltage         | V<sub>CC</sub>=10kΩ     | Full range | 5   | 20  | mV   |
| Large-signal differential         | V<sub>CC</sub>=15V      | 25°C | 15  | 100 | %    |
| voltage amplification            | V<sub>CC</sub>=11V,  
R<sub>g</sub>≥2kΩ          | 25°C | 15  |     |     |
| Total harmonic distortion        | F=1kHz, A<sub>in</sub>=20dB,  
R<sub>g</sub>=2kΩ,  
V<sub>CC</sub>=2V<sub>pe</sub>,  
C<sub>g</sub>=100pF       | 25°C | 0.02| %   |      |
| CMRR                             | V<sub>CC</sub>=5V to MAX,  
Supply voltage rejection ratio   | 25°C | 65  | 80  | dB   |
| Common-mode rejection ratio      | V<sub>CC</sub>=V<sub>IN</sub> min | 25°C | 65  | 80  | dB   |
| k<sub>ov</sub>                   | V<sub>CC</sub>=5V to MAX,  
(V<sub>CC</sub>/V<sub>IN</sub>) | 25°C | 65  | 100 | dB   |
| V<sub>CC</sub>/V<sub>IN</sub>2     | F=1kHz to 20kHz         | 25°C | 120 |     | dB   |
| Crosstalk attenuation            | V<sub>CC</sub>=15V      | 25°C | -20 | -30 | mA   |
| Output current                   | V<sub>CC</sub>=1V,  
V<sub>CC</sub>=0V          | Full range | -10 |     |     |
| I<sub>sc</sub>                   | V<sub>CC</sub>=15V,  
V<sub>CC</sub>=+1V,  
V<sub>CC</sub>=-15V        | 25°C | -10 | 20  | mA   |
| Supply current (Two amplifiers)   | V<sub>CC</sub>=2.5V,  
No load                      | Full range | 0.7 | 1.2 | mA   |
| Short-circuit current            | V<sub>CC</sub>=MAX,  
V<sub>CC</sub>=0.5V<sub>CC</sub>,  
No load                      | Full range | 1   | 2   | mA   |

Oct 2010 – Ver. 1.4

HTC
Dual Operational Amplifiers

LM358D

* All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. Maximum voltage is 30V. Full range is 0 °C to 70 °C.

EQUIVALENT CIRCUIT

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Package</th>
<th>Order No.</th>
<th>Description</th>
<th>Supply As</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOP-8</td>
<td>LM358D</td>
<td>Dual Operational Amplifier, Pb-Free</td>
<td>Reel</td>
<td>Active</td>
</tr>
</tbody>
</table>

PIN CONFIGURATION

OUT1: 1
IN1+: 2
IN1-: 3
GND: 4
OUT2: 5
IN2+: 6
IN2-: 7
Vcc: 8

SOP-8
Dual Operational Amplifiers

TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

TYPICAL APPLICATIONS

SINGLE SUPPLY INVERTING AMPLIFIER

INPUT BIASING VOLTAGE FOLLOWER

NON-INVERTING AMPLIFIER

 Oct. 2015 – Ver. 1.4

HTC
3. Data Sheet MQ-2

MQ-2 Semiconductor Sensor for Combustible Gas

Sensitive material of MQ-2 gas sensor is SnO₂, which with lower conductivity in clean air. When the target combustible gas exist, The sensor’s conductivity is more higher along with the gas concentration rising. Please use simple electrcircuit, Convert change of conductivity to correspond output signal of gas concentration.

MQ-2 gas sensor has high sensitivity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.

Character
* Good sensitivity to Combustible gas in wide range
* High sensitivity to LPG, Propane and Hydrogen
* Long life and low cost
* Simple drive circuit

Application
* Domestic gas leakage detector
* Industrial Combustible gas detector
* Portable gas detector

Technical Data

<table>
<thead>
<tr>
<th>Character</th>
<th>Technical Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration</td>
<td>300-10000ppm (Combustible gas)</td>
</tr>
<tr>
<td>Loop Voltage</td>
<td>V₁ ≤24V DC</td>
</tr>
<tr>
<td>Heaters Voltage</td>
<td>V₄ 5.0V±0.2V AC/DC</td>
</tr>
<tr>
<td>Load Resistance</td>
<td>R₄ Adjustable</td>
</tr>
<tr>
<td>Heater Resistance</td>
<td>R₄ 31Ω±3Ω (Room Temp.)</td>
</tr>
<tr>
<td>Heater consumption</td>
<td>P₄ ≤900mW</td>
</tr>
<tr>
<td>Sensing Resistance</td>
<td>Rₜ 2KΩ-20KΩ (in 2000ppm CO₂)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>S Rₜ(nair)Rₜ(1000ppm isobutane)≈5</td>
</tr>
<tr>
<td>Slope</td>
<td>a ≤0.6(Rₜ(nair)=Rₜ(isobutane)CH₄)</td>
</tr>
<tr>
<td>Tem. Humidity</td>
<td>20℃±2℃, 35%±5%RH</td>
</tr>
<tr>
<td>Standard test circuit</td>
<td>Vc=5.0V±0.1V, V₄=5.0V±0.1V</td>
</tr>
<tr>
<td>Preheat time</td>
<td>Over 48 hours</td>
</tr>
</tbody>
</table>

The above is basic test circuit of the sensor. The sensor need to be pu 2 voltage, heater voltage: VH, and test voltage: VC. Voltage used to supply certified working temperature to the sensor, while VC used to detect voltage (VRL) on load resistance (RL) which is in series with sensor. The sensor has light polarity, VC need DC power, VC and VH could use same power circuit with precondition to assure performance of sensor. In order to make the sensor with better performance, suitable RL value is needed:

Power of Sensitivity body (Pa):

\[ Pₚ=Vc²×Rₜ(Rₜ=RL)² \]
Resistance of sensor: \( R_\text{s} = \frac{V_\text{i}}{V_\text{o}} \times R_\text{L} \)

**Sensitivity Characteristics**

Fig. 1 shows the typical sensitivity characteristics of the MQ-2 sensor. Ordinate means resistance ratio of the sensor \( (R_\text{i}/R_\text{t}) \), abscissa is concentration of gases. \( R_\text{i} \) means resistance in different gases, and \( R_\text{t} \) means resistance of sensor in 1000 ppm Hydrogen. All test are under standard test conditions.

**Influence of Temperature/Humidity**

Fig. 2 shows the typical temperature and humidity characteristics. Ordinate means resistance ratio of the sensor \( (R_\text{i}/R_\text{t}) \), and \( R_\text{i} \) means resistance of sensor in 1000 ppm Butane under different temperature and humidity. \( R_\text{t} \) means resistance of the sensor in environment of 1000 ppm Methane, 20°C, 45% RH.

**Structure and Configuration**

Structure and configuration of MQ-2 gas sensor is shown as Fig. 3. The sensor is composed of micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary working conditions for work of sensitive components. The enveloped MQ-2 have 6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current.
Notification

1. Following conditions must be prohibited
1.1 Exposed to organic silicon steam
   Organic silicon steam cause sensors invalid, sensors must be avoid exposing to silicon bond, fixture, silicon latex, putty or plastic contain silicon environment
1.2 High Corrosive gas
   If the sensors exposed to high concentration corrosive gas (such as H₂S, SO₂, Cl₂, HCl etc), it will not only result in corrosion of sensors structure, also it cause sincere sensitivity attenuation.
1.3 Alkali, Alkali metals salt, halogen pollution
   The sensors performance will be changed badly if sensors be sprayed polluted by alkali metals salt especially brine, or be exposed to halogen such as fluor in.
1.4 Touch water
   Sensitivity of the sensors will be reduced when spattered or dipped in water.
1.5 Freezing
   Do avoid icing on sensor's surface, otherwise sensor would lose sensitivity.
1.6 Applied voltage higher
   Applied voltage on sensor should not be higher than stipulated value, otherwise it cause down-line or heater damaged, and bring on sensors' sensitivity characteristic changed badly.
1.7 Voltage on wrong pins
   For 6 pins sensor, if apply voltage on 1, 3 pins or 4, 6 pins, it will make lead broken, and without signal when apply on 2, 4 pins.

2. Following conditions must be avoided
2.1 Water Condensation
   Indoor conditions, slight water condensation will effect sensors performance lightly. However, if water condensation on sensors surface and keep a certain period, sensors' sensitivity will be decreased.
2.2 Used in high gas concentration
   No matter the sensor is electrified or not, if long time placed in high gas concentration, if will affect sensors characteristic.
2.3 Long time storage
   The sensors resistance produce reversible drift if it's stored for long time without electrify, this drift is related with storage conditions. Sensors should be stored in airproof without silicon gel bag with clean air.
   For the sensors with long time storage but no electrify, they need long aging time for stability before using.
2.4 Long time exposed to adverse environment
   No matter the sensors electrified or not, if exposed to adverse environment for long time, such as high humidity, high temperature, or high pollution etc, it will effect the sensors performance badly.
2.5 Vibration
   Continual vibration will result in sensors down-lead response then repute. In transportation or assembling line, pneumatic screwdriver/ultrasonic welding machine can lead this vibration.
2.6 Concussion
   If sensors meet strong concussion, it may lead its lead wire disconnected.
2.7 Usage
   For sensor, handmade welding is optimal way. If use wave crest welding should meet the following conditions:
   2.7.1 Soldering flux: Rosin soldering flux contains least chlorine
   2.7.2 Speed: 1-2 Meter/Minute
   2.7.3 Warm-up temperature: 100±20℃
   2.7.4 Welding temperature: 250±10℃
   2.7.5 1 time pass wave crest welding machine
   If disobey the above using terms, sensors sensitivity will be reduced.
4. Data Sheet SIM 800L

1. Introduction

This document describes SIM800 hardware interface in great detail. This document can help user to quickly understand SIM800 interface specifications, electrical and mechanical details. With the help of this document and other SIM800 application notes, user guide, users can use SIM800 to design various applications quickly.

2. SIM800 Overview

Designed for global market, SIM800 is a quad-band GSM/GPRS module that works on frequencies GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. SIM800 features GPRS multi-slot class 12/ class 10 (optional) and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4.

With a tiny configuration of 24*24*3mm, SIM800 can meet almost all the space requirements in users' applications, such as M2M, smart phone, FDA and other mobile devices.

SIM800 has 68 SMT pads, and provides all hardware interfaces between the module and customers' boards.

- Support up to 5*5*2 Keypads.
- One full function UART port, and can be configured to two independent serial ports.
- One USB port can be used as debugging and firmware upgrading.
- Audio channels which include a microphone input and a receiver output.
- Programmable general purpose input and output.
- One SIM card interface
- Support Bluetooth function.
- Support one PWM.
- PCM

SIM800 is designed with power saving technique so that the current consumption is as low as 1.2mA in sleep mode.

SIM800 integrates TCP/IP protocol and extended TCP/IP AT commands which are very useful for data transfer applications. For details about TCP/IP applications, please refer to document [11].

2.1. SIM800 Key Features

Table 1: SIM800 key features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>3.4V ~ 4.4V</td>
</tr>
<tr>
<td>Power saving</td>
<td>Typical power consumption in sleep mode is 1.2mA (BS=PA=MF=FRMS=9)</td>
</tr>
</tbody>
</table>
| Frequency bands    | SIM800 Quad-band: GSM 850, EGSM 900, DCS 1800, PCS 1900. SIM800 can search the 4 frequency bands automatically. The frequency bands also can be set by AT command "AT+CBAND". For details, please refer to document [1].
<p>|                    | Compliant to GSM Phase 2/2+                                                   |
| Transmitting power | Class 4 (2W): GSM850, EGSM900                                               |
|                    | Class 1 (1W): DCS1800, PCS1900                                              |
| GPRS connectivity  | GPRS multi-slot class 12 (default)                                            |</p>
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature range</strong></td>
<td>- Normal operation: -40°C ~ +85°C</td>
</tr>
<tr>
<td></td>
<td>- Storage temperature: -55°C ~ +90°C</td>
</tr>
<tr>
<td><strong>GPRS</strong></td>
<td>- GPRS data downlink transfer: max. 85.6 kbps</td>
</tr>
<tr>
<td></td>
<td>- GPRS data uplink transfer: max. 85.6 kbps</td>
</tr>
<tr>
<td></td>
<td>- Coding scheme: CS-1, CS-2, CS-3 and CS-4</td>
</tr>
<tr>
<td></td>
<td>- PAP protocol for PPP connect</td>
</tr>
<tr>
<td></td>
<td>- Integrate the TCP/IP protocol.</td>
</tr>
<tr>
<td></td>
<td>- Support Packet Broadcast Control Channel (PBCCH)</td>
</tr>
<tr>
<td><strong>CSD</strong></td>
<td>- Support CSD transmission</td>
</tr>
<tr>
<td></td>
<td>- CSD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps</td>
</tr>
<tr>
<td><strong>USSD</strong></td>
<td>- Unstructured Supplementary Services Data (USSD) support</td>
</tr>
<tr>
<td><strong>SMS</strong></td>
<td>- MT, MO, CB, Text and PDU mode</td>
</tr>
<tr>
<td></td>
<td>- SMS storage: SIM card</td>
</tr>
<tr>
<td><strong>SIM interface</strong></td>
<td>Support SIM card: 1.8V, 3V</td>
</tr>
<tr>
<td><strong>Antenna Interface</strong></td>
<td>Antenna pad</td>
</tr>
<tr>
<td><strong>Audio features</strong></td>
<td>Speech codec modes:</td>
</tr>
<tr>
<td></td>
<td>- Half Rate (ETS 06.20)</td>
</tr>
<tr>
<td></td>
<td>- Full Rate (ETS 06.10)</td>
</tr>
<tr>
<td></td>
<td>- Enhanced Full Rate (ETS 06.50 / 06.60 / 06.80)</td>
</tr>
<tr>
<td></td>
<td>- Adaptive multi rate (AMR)</td>
</tr>
<tr>
<td></td>
<td>- Echo Cancellation</td>
</tr>
<tr>
<td></td>
<td>- Noise Suppression</td>
</tr>
<tr>
<td><strong>Serial port</strong></td>
<td>Full modem interface with status and control lines, unbalanced, asynchronous.</td>
</tr>
<tr>
<td></td>
<td>1200 bps to 4608000 bps</td>
</tr>
<tr>
<td></td>
<td>Can be used for AT commands for data stream</td>
</tr>
<tr>
<td></td>
<td>Support RTS/CTS hardware handshake and software ON/OFF flow control</td>
</tr>
<tr>
<td></td>
<td>Multiplexing according to GSM 07.10 Multiplexer Protocol</td>
</tr>
<tr>
<td></td>
<td>Autobauding supports baud rate from 1200 bps to 1152000 bps</td>
</tr>
<tr>
<td><strong>USB interface</strong></td>
<td>Can be used as debugging and firmware upgrading</td>
</tr>
<tr>
<td><strong>Phonebook management</strong></td>
<td>Support phonebook types: SM, FD, LD, RC, ON, MC</td>
</tr>
<tr>
<td><strong>SIM application toolkit</strong></td>
<td>GSM 11.14 Release 99</td>
</tr>
<tr>
<td><strong>Real time clock</strong></td>
<td>Support RTC</td>
</tr>
<tr>
<td><strong>Alarm function</strong></td>
<td>Can be set by AT command</td>
</tr>
<tr>
<td><strong>Physical characteristics</strong></td>
<td>Size: 24x24x3mm</td>
</tr>
<tr>
<td></td>
<td>Weight: 3.2g</td>
</tr>
<tr>
<td><strong>Firmware upgrade</strong></td>
<td>Firmware upgrading by serial port or USB interface (recommend to use USB port)</td>
</tr>
</tbody>
</table>
Table 2: Coding schemes and maximum net data rates over air interface

<table>
<thead>
<tr>
<th>Coding scheme</th>
<th>1 timeslot</th>
<th>2 timeslot</th>
<th>3 timeslot</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS-1</td>
<td>9.05kbps</td>
<td>18.1kbps</td>
<td>36.2kbps</td>
</tr>
<tr>
<td>CS-2</td>
<td>13.4kbps</td>
<td>26.8kbps</td>
<td>53.6kbps</td>
</tr>
<tr>
<td>CS-3</td>
<td>15.6kbps</td>
<td>31.2kbps</td>
<td>62.4kbps</td>
</tr>
<tr>
<td>CS-4</td>
<td>21.4kbps</td>
<td>42.8kbps</td>
<td>85.6kbps</td>
</tr>
</tbody>
</table>

2.2. Operating Modes

The table below summarizes the various operating modes of SIM800.

Table 3: Overview of operating modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Function</th>
</tr>
</thead>
</table>
| Normal       | **GSM/GPRS SLEEP**  
Module will automatically go into sleep mode if the conditions of sleep mode are enabling and there is no on air or hardware interrupt (such as GPIO interrupt or data on serial port).  
In this case, the current consumption of module will reduce to the minimal level.  
*In sleep mode, the module can still receive paging message and SMS.*  

**GSM IDLE**  
Software is active. Module registered to the GSM network, and the module is ready to communicate.  

**GSM TALK**  
Connection between two subscribers is in progress. In this case, the power consumption depends on network settings such as DTX off/on, FR/EFR/HF, hopping sequences, antenna.  

**GPRS STANDBY**  
Module is ready for GPRS data transfer, but no data is currently sent or received. In this case, power consumption depends on network settings and GPRS configuration.  

**GPRS DATA**  
There is GPRS data transfer (PPP or TCP or UDP) in progress. In this case, power consumption is related with network settings (e.g. power control level), uplink/downlink data rates and GPRS configuration (e.g. used multi-slot settings). |
| Power off    | Normal Power off by sending the AT command “AT+CPWD=1” or using the PWRKEY.  
The power management unit shuts down the power supply for the baseband part of the module, and only the power supply for the R7C is remained. Software is not active. The serial port is not accessible. Power supply (connected to VBAT) remains applied. |
| Minimum       | AT command “AT+CFUN” can be used to set the module to a minimum functionality mode without removing the power supply. In this mode, the RF part of the module will not work or the SIM card will not be accessible, or both RF part and SIM card will be closed, and the serial port is still accessible. The power consumption in this mode is lower than normal mode. |
| functionality mode |                                                                  |
|               |                                                                  |
2.3. SIM800 Functional Diagram

The following figure shows a functional diagram of SIM800:

- GSM baseband engine
- PMU
- RF part
- Antenna interfaces
- Other interfaces

![SIM800 Functional Diagram](image)

Figure 1: SIM800 functional diagram
3. Package Information

3.1. Pin Out Diagram

Figure 2: SIM800 pin out diagram (Top view)
3.2. Pin Description

Table 4: Pin description

<table>
<thead>
<tr>
<th>Pin name</th>
<th>Pin number</th>
<th>I/O</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power supply</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VBAT</td>
<td>55,56,57</td>
<td>I</td>
<td>SIM800 supplies 3 VBAT pins, and the power range is from 3.4V to 4.4V. Power supply should provide sufficient current so that the module can work normally; the peak current is nearly 2A.</td>
<td>Zener diode is Strongly recommended to anti surge on VBAT.</td>
</tr>
<tr>
<td>VRTC</td>
<td>26</td>
<td>I/O</td>
<td>Power supply for RTC</td>
<td></td>
</tr>
<tr>
<td>VDD_EXT</td>
<td>15</td>
<td>O</td>
<td>2.8V power output</td>
<td>Keep floating if unused.</td>
</tr>
<tr>
<td>GND</td>
<td>2,17,18,29,3,9,45,46,54,5,8,59,61,62,6,3,64,65</td>
<td></td>
<td>Ground</td>
<td>GND for VBAT recommend to use 62, 63, 64, 65 pin.</td>
</tr>
<tr>
<td><strong>Power on/off</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWRKEY</td>
<td>1</td>
<td>I</td>
<td>PWRKEY should be pulled low at least 1.2 second and then released to power on/down the module.</td>
<td>Internally pulled up to VBAT.</td>
</tr>
<tr>
<td><strong>Audio interface</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MICP</td>
<td>19</td>
<td>I</td>
<td>Differential audio input</td>
<td>Keep floating if unused.</td>
</tr>
<tr>
<td>MICN</td>
<td>20</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPKP</td>
<td>21</td>
<td>O</td>
<td>Differential audio output</td>
<td></td>
</tr>
<tr>
<td>SPKN</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PCM interface</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCM_OUT</td>
<td>6</td>
<td>O</td>
<td></td>
<td>Keep floating if unused.</td>
</tr>
<tr>
<td>PCM_IN</td>
<td>12</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCM_SYNC</td>
<td>14</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCM_CLK</td>
<td>68</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Keypad interface</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBC4</td>
<td>47</td>
<td>I</td>
<td></td>
<td>Keep floating if unused. (KBC0 can not be pulled down).</td>
</tr>
<tr>
<td>KBC3</td>
<td>48</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBC2</td>
<td>49</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBC1</td>
<td>50</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBC0</td>
<td>51</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBR4</td>
<td>40</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Component</td>
<td>Pin</td>
<td>Mode</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-----</td>
<td>------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>KBR3</td>
<td>41</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBR2</td>
<td>42</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBR1</td>
<td>43</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KBR0</td>
<td>44</td>
<td>O</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GPIO**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPIO17</td>
<td>11</td>
<td>I/O</td>
<td>Programmable general purpose input and output.</td>
</tr>
<tr>
<td>GPIO19</td>
<td>13</td>
<td>I/O</td>
<td>Programmable general purpose input and output.</td>
</tr>
<tr>
<td>NETLIGHT</td>
<td>52</td>
<td>O</td>
<td>Network status</td>
</tr>
<tr>
<td>STATUS</td>
<td>66</td>
<td>O</td>
<td>Power on status</td>
</tr>
</tbody>
</table>

**Serial port**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTR</td>
<td>3</td>
<td>I</td>
<td>Data terminal ready</td>
</tr>
<tr>
<td>RI</td>
<td>4</td>
<td>O</td>
<td>Ring indicator</td>
</tr>
<tr>
<td>DCD</td>
<td>5</td>
<td>O</td>
<td>Data carrier detect</td>
</tr>
<tr>
<td>CTS</td>
<td>7</td>
<td>O</td>
<td>Clear to send</td>
</tr>
<tr>
<td>RTS</td>
<td>8</td>
<td>I</td>
<td>Request to send</td>
</tr>
<tr>
<td>TXD</td>
<td>9</td>
<td>O</td>
<td>Transmit data</td>
</tr>
<tr>
<td>RXD</td>
<td>10</td>
<td>I</td>
<td>Receive data</td>
</tr>
</tbody>
</table>

**USB interface**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB_VBLS</td>
<td>24</td>
<td>I</td>
<td>Debug and firmware upgrading</td>
</tr>
<tr>
<td>USB_DP</td>
<td>27</td>
<td>I/O</td>
<td>Socket power and signal</td>
</tr>
<tr>
<td>USB_DN</td>
<td>28</td>
<td>I/O</td>
<td>Socket power and signal</td>
</tr>
</tbody>
</table>

**ADC**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC</td>
<td>25</td>
<td>I</td>
<td>10 bit general analog to digital converter</td>
</tr>
</tbody>
</table>

**PWM**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWM0</td>
<td>35</td>
<td>O</td>
<td>Pulse-width modulation, multiplex with GPIO.</td>
</tr>
<tr>
<td>PWM1</td>
<td>36</td>
<td>O</td>
<td>Pulse-width modulation, multiplex with GPIO.</td>
</tr>
</tbody>
</table>

**I2C**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDA</td>
<td>37</td>
<td>I/O</td>
<td>I2C serial bus data</td>
</tr>
<tr>
<td>SCL</td>
<td>38</td>
<td>O</td>
<td>I2C serial bus clock</td>
</tr>
</tbody>
</table>

**SIM interface**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM_VDD</td>
<td>30</td>
<td>O</td>
<td>Voltage supply for SIM card. Support 1.8V or 3V for SIM card</td>
</tr>
<tr>
<td>SIM_DATA</td>
<td>31</td>
<td>I/O</td>
<td>SIM data input/output</td>
</tr>
<tr>
<td>SIM_CLK</td>
<td>32</td>
<td>O</td>
<td>SIM clock</td>
</tr>
<tr>
<td>SIM_RST</td>
<td>33</td>
<td>O</td>
<td>SIM reset</td>
</tr>
<tr>
<td>SIM_DET</td>
<td>34</td>
<td>I</td>
<td>SIM card detection</td>
</tr>
</tbody>
</table>

**Antenna**

<table>
<thead>
<tr>
<th>Component</th>
<th>Pin</th>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM_ANT</td>
<td>60</td>
<td>I/O</td>
<td>GSM antenna port</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
<td>------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>BT_ANT</td>
<td>53</td>
<td>FO</td>
<td>Bluetooth antenna port Impedence must be controlled to 50Ω</td>
</tr>
<tr>
<td>RF Sync</td>
<td>67</td>
<td>O</td>
<td>RF burst synchronous signal Do not pull up</td>
</tr>
<tr>
<td>Other Signal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESET</td>
<td>16</td>
<td>I</td>
<td>Reset input (Active low)</td>
</tr>
<tr>
<td>KPLED</td>
<td>23</td>
<td>I</td>
<td>Drive keypad backlight</td>
</tr>
</tbody>
</table>
3.3. Package Dimensions

![Diagram of SIM806 dimensions]

Figure 3: Dimensions of SIM806 (Unit: mm)
Figure 4: Recommended PCB footprint outline (Unit: mm)

Note: Keep copper out of area B and C.
5. Data Sheet SIM 800L

**I2C Interface for LCD**

**Description:**
This LCD2004 is a great I2C interface for 2x16 and 4x20 LCD displays. With the limited pin resources, your project may be out of resources using normal LCD shield. With this I2C Interface LCD module, you only need 2 lines (I2C) to display the information. If you already have I2C devices in your project, this LCD module actually cost no more resources at all. Fantastic for Arduino based projects.

**Specification:**
- Compatible with 16x2 and 20x4 LCD’s
- Default I2C Address = 0x27
- Address selectable - Range 0x20 to 0x27

**Board Layout:**

**I2C Address Setup:**

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A MOBICON Company.
The LCD2004 board utilized the PCF8574 I/O expander. This nifty little chip provides eight bits of parallel I/O addressable by a I2C bus address – 0x00 to 0x27. SamSmart lied all address leads to Vcc, so the LCD2004 board’s I2C address is permanently 0x27. This is rather limiting since no additional LCD2004s can be added to the bus.

Anyway, you simply address the board and write an eight bit value which is then presented on the output pins of the PCF8574, which, in this case, are connected to the HD44780 based LCD screen.

```c
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd((0x27,2,1,0,4,5,6,7,3, POSITIVE)); // Initialize LCD Display at address 0x27
void setup() {
  // activate LCD module
  lcd.begin(16,2); // for 16 x 2 LCD module
  lcd.setBacklightPin(3, POSITIVE);
  lcd.setBacklight(HIGH);
}

void loop() {
  lcd.home (); // set cursor to 0,0
  lcd.setCursor (0,1); // go to start of 2nd line
  lcd.print("Hello, world!");
  delay(1000);
  lcd.setBacklight(LOW); // Backlight off
  delay(500);
  lcd.setBacklight(HIGH); // Backlight on
  delay(1000);
} // END
```

Check for more info at
https://arduino-info.wikispaces.com/LCD-Blue-I2C
6. Data Sheet Arduino Uno

INTRODUCTION

Arduino is used for building different types of electronic circuits easily using both a physical programmable circuit board usually microcontroller and piece of code running on computer with USB connection between the computer and Arduino.

Programming language used in Arduino is just a simplified version of C++ that can easily replace thousands of wires with words.
ARDUINO UNO-R3 PHYSICAL COMPONENTS

ATMEGA328P-PU microcontroller

The most important element in Arduino Uno R3 is ATMEGA328P-PU is an 8-bit Microcontroller with flash memory reach to 32k bytes. It’s features as follow:

• High Performance, Low Power AVR

• Advanced RISC Architecture
  o 131 Powerful Instructions – Most Single Clock Cycle Execution
  o 32 x 8 General Purpose Working Registers
  o Up to 20 MIPS Throughput at 20 MHz
  o On-chip 2-cycle Multiplier

• High Endurance Non-volatile Memory Segments
  o 4/8/16/32K Bytes of In-System Self-Programmable Flash program memory
  o 256/512/512/1K Bytes EEPROM
  o 512/1K/1K/2K Bytes Internal SRAM
  o Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  o Data retention: 20 years at 85°C/100 years at 25°C
  o Optional Boot Code Section with Independent Lock Bits
  o In-System Programming by On-chip Boot Program
  o True Read-While-Write Operation
  o Programming Lock for Software Security

• Peripherals Features
  o Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  o One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  o Real Time Counter with Separate Oscillator
  o Six PWM Channels
  o 8-channel 10-bit ADC in TQFP and QFN/MLF package
  o Temperature Measurement
  o 6-channel 10-bit ADC in PDIP Package
  o Temperature Measurement
  o Programmable Serial USART
• Master/Slave SPI Serial Interface
  • Byte-oriented 2-wire Serial Interface (Philips I2C compatible)
  • Programmable Watchdog Timer with Separate On-chip Oscillator
  • On-chip Analog Comparator
  • Interrupt and Wake-up on Pin Change

• Special Microcontroller Features
  • Power-on Reset and Programmable Brown-out Detection
  • Internal Calibrated Oscillator
  • External and Internal Interrupt Sources
  • Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby

• I/O and Packages
  • 23 Programmable I/O Lines
  • 28-pin PDIP, 32-lead TCFP, 28-pad QFN/MLF and 32-pad QFN/MLF

• Operating Voltage:
  • 1.8 - 5.5V

• Temperature Range:
  • -40°C to 85°C

• Speed Grade:
  • 0 - 4 MHz @ 1.8 - 5.5V, 0 - 10 MHz @ 2.7 - 5.5V, 0 - 20 MHz @ 4.5 - 5.5V

• Power Consumption at 1 MHz, 1.8V, 25°C
  • Active Mode: 0.2 mA
  • Power-down Mode: 0.1 μA
  • Power-save Mode: 0.75 μA (including 32 kHz RTC)
Pin configuration

- ATMEGA16u2 - a microcontroller
  - Used as USB driver in Arduino uno R3
  - Features:
    - High Performance, Low Power AVR
    - Advanced RISC Architecture
      - 125 Powerful Instructions – Most Single Clock Cycle Execution
      - 32 x 8 General Purpose Working Registers
      - Fully Static Operation
      - Up to 16 MIPS Throughput at 16 MHz
    - Non-volatile Program and Data Memories
      - 8K/16K/32K Bytes of In-System Self-Programmable Flash
      - 512/512/1024 EEPROM
      - 512/512/1024 Internal SRAM
      - Write/Erase Cycles: 10,000 Flash / 100,000 EEPROM
      - Data retention: 20 years at 85°C/ 100 years at 25°C
• Optional Boot Code Section with Independent Lock Bits
• In-System Programming by on-chip Boot Program hardware-activated after reset
• Programming Lock for Software Security

• USB 2.0 Full-speed Device Module with Interrupt on Transfer Completion
  - Complies fully with Universal Serial Bus Specification REV 2.0
  - 48 MHz PLL for Full-speed Bus Operation: data transfer rates at 12 Mbit/s
  - Fully independent 176 bytes USB DRAM for endpoint memory allocation
  - Endpoint 0 for Control Transfers: from 8 up to 64-bytes
  - 4 Programmable Endpoints:
    - IN or Out Directions
    - Bulk, Interrupt and Isochronous Transfers
    - Programmable maximum packet size from 8 to 64 bytes
    - Programmable single or double buffer
  - Suspend/Resume Interrupts
  - Microcontroller reset on USB Bus Reset without detach
  - USB Bus Disconnection on Microcontroller Request

• Peripheral Features
  - One 8-bit Timer/Counters with Separate Prescaler and Compare Mode (two 8-bit PWM channels)
  - One 16-bit Timer/Counter with Separate Prescaler, Compare and Capture Mode (three 8-bit PWM channels)
  - USART with SPI master only mode and hardware flow control (RTS/CTS)
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change

• On Chip Debug Interface (debug WIRE)

• Special Microcontroller Features
  - Power-On Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Five Sleep Modes: Idle, Power-save, Power-down, Standby, and Extended Standby

• I/O and Packages
  - 22 Programmable I/O Lines
  - QFN32 (5x5mm) / TQFP32 packages
- **Operating Voltages**
  - 2.7 - 5.5V

- **Operating temperature**
  - Industrial (-40°C to +85°C)

- **Maximum Frequency**
  - 8 MHz at 2.7V - Industrial range
  - 16 MHz at 4.5V - Industrial range

- **Pin configuration**
OTHER ARDUINO UNO R3 PARTS

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial:** 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts:** 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM:** 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- **SPI:** 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- **LED:** 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it’s off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e., 1024 different values). By default, they measure from ground to 5 volts, though it is possible to change the upper end of their range using the AREF pin and the analogReference() function.

Additionally, some pins have specialized functionality:

- **TWI:** A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- **AREF:** Reference voltage for the analog inputs. Used with analogReference().
- **Reset:** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.
ARDUINO UNO R3 SCHEMATIC DIAGRAM
B. Listing Program Keseluruhan

```c
#include <SoftwareSerial.h> //untuk mengakses Module GSM
#include <Wire.h> //i2c
#include <LiquidCrystal_I2C.h> //menginclude kan library i2C LCD

#define ON 00 // Kondisi Relay hidup
#define OFF 1 //Kondisi Relay mati

LiquidCrystal_PCF8574 lcd(0x38); // dapat dicek menggunakan i2c finder
SoftwareSerial SIM800L(2, 3); // RX | TX

const int gas_pin = A0; //pin untuk dihubungkan ke output sensor gas
const int buttonTest = A1; //Button untuk test

const int buzzer = 11; //menggunakan buzzer aktif
const int alert_Pin = 12; //Out Digital To Emergency Lamp or Sirine drive with Relay
const int led_pin = 13; //indikator sensor yang berupa led

float gas_ppm; //nilai satuan Gas dikonversi kedalam 'ppm'
float persen_gas; //nilai satuan Gas dalam 'Persentase'
const int maks_gas = 20; //nilai maksimum Persentase Gas

uint8_t count_sms = 00; // penghitung sms
const int maks_sms = 3; //jumlah maksimal sms yang akan dikirim
const long interval_sms = 10; //jeda waktu pengiriman sms
unsigned long previousMillis = 00;
String gasStat;

int ledState = ;
unsigned long previousMillis2 = 00;
long interval = 1000;

void setup() {
  pinMode (A1,INPUT_PULLUP);
  pinMode (12,OUTPUT);
  digitalWrite (12, OFF); //nilai default awal
  pinMode (11,OUTPUT); pinMode (13,OUTPUT);
  lcd.begin(); // memulai koneksi i2c dengan LCD
  Serial.begin(9600);
  SIM800L.begin(9600);
  lcd.begin(16, 2); // 16 baris, 2 kolom
  lcd.setBacklight(255); //menyalakan lampu latar
}
```
void loop() {
    // mengubah nilai pembacaan dari tegangan menjadi data bit dan menjadi data persen, ppm, interval
    persen_gas = map(analogRead(gas_pin), 0, 1023, 0, 100); // range 0-100
    gas_ppm = map(analogRead(gas_pin), 0, 1023, 100000, 0); // 0-10000
    interval = map(analogRead(gas_pin), 0, 1023, 1000, 10); // range 10-1000

    // menuliskan data di serial monitor
    Serial.print(persen_gas); Serial.println(" %");
    Serial.print(gas_ppm, 00); Serial.println(" ppm");
    // baris 1
    lcd.setCursor(00, 00);
    lcd.print("P.Gas:"); lcd.print(persen_gas, 1);
    lcd.print(" ");
    // baris 2
    lcd.setCursor(00, 1);
    lcd.print("C.Gas:"); lcd.print(gas_ppm, 00);
    lcd.print(" ");

    if (persen_gas > maks_gas || digitalRead(TestPin) == LOW) {
        digitalWrite(buzzer, HIGH);
        digitalWrite(alert_Pin, ON);
        gasStat = "Lo";
        if (count_sms < maks_sms) {
            unsigned long currentMillis = millis();
            if (currentMillis - previousMillis >= (interval_sms * 1000)) {
                previousMillis = currentMillis;
                sendSMS();
                count_sms = count_sms + 1;
            }
        }
    } else {
        digitalWrite(buzzer, LOW);
        digitalWrite(alert_Pin, OFF);
        gasStat = "Hi";
        count_sms = 0; // Reset hitungan SMS
    }
}
void sendSMS () {
    int tes = 00;
    if(digitalRead(buttontest) == LOW){tes=1;}
    String isisms = ("Ada Kebocoran Gas LPG dengan konsentrasi")+("% ")+String(persen_gas)+(" ppm");
    lcd.clear();
    lcd.setCursor (00,00);
    if(tes==00){lcd.print (" BAHAYA!! ");}
    if(tes==1){lcd.print (" GAS BOCOR ");}
    lcd.setCursor (00,1);
    lcd.print ("Send SMS.");
    Serial.println("Menyiapkan Pesan Text");
    SIM800L.write("AT+CMGF=1\r\n");
    delay(500);
    lcd.print (" . ");
    delay(500);
    Serial.println("setting no tujuan sms");

    //No HP
    SIM800L.write("AT+CMGS="083896910641\r\n");
    delay(500);lcd.print (" . ");
    delay(500);lcd.print (" . ");
    Serial.println("Sending message");

    //Tulis pesan SMS pada baris perintah dibawah ini
    SIM800L.print(isisms);
    Serial.println(isisms);
    delay(500);
    lcd.print (" . ");
    delay(500);
    lcd.print (" . ");
    Serial.println("ending SMS");
    SIM800L.write((char)26);
    delay(500);
    lcd.print (" .. ");
    Serial.println("SMS terkirim!");
    delay(500);
    lcd.setCursor(00,1);
    lcd.print (" SMS terkirim!! ");
    delay(500);
    lcd.clear();
}
/indikator LED Blinking
void blinkingLed (long in ) {
unsigned long currentMillis2 = millis();
if (currentMillis2 - previousMillis2 >= in) {
    previousMillis2 = currentMillis2;
    if (ledState == LOW) {
        ledState = HIGH;
    } else {
        ledState = LOW;
    }
    digitalWrite(led_pin, ledState);
    lcd.setCursor (14,00);
    lcd.print (gasStat);
}
C. Tampilan Laporan Pada SMS

Ada Kebocoran Gas LPG dengan konsentrasi 0.00% 0.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 100.00% 10000.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 39.00% 3851.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 0.00% 0.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 1.00% 224.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 93.00% 9354.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 4.00% 606.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 93.00% 9354.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 1.00% 146.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 16.00% 1749.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 93.00% 9354.00 ppm
Ada Kebocoran Gas LPG dengan konsentrasi 31.00% 3098.00 ppm
D. Skema Rangkaian Keseluruhan
E. Daftar Komponen dan Harga

<table>
<thead>
<tr>
<th>No</th>
<th>Nama Komponen</th>
<th>Harga (Rp.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1pcs) Arduino Uno</td>
<td>Rp 95.000</td>
</tr>
<tr>
<td>2</td>
<td>(1pcs) Modul Sensor MQ-2</td>
<td>Rp 30.000</td>
</tr>
<tr>
<td>3</td>
<td>(1pcs) Modul SIM 800L</td>
<td>Rp 85.000</td>
</tr>
<tr>
<td>4</td>
<td>(1pcs) Buzzer</td>
<td>Rp 5.000</td>
</tr>
<tr>
<td>5</td>
<td>(1pcs) Modul Relay</td>
<td>Rp 15.000</td>
</tr>
<tr>
<td>6</td>
<td>(1pcs) Modul I2C</td>
<td>Rp 15.000</td>
</tr>
<tr>
<td>7</td>
<td>(1pcs) LCD 16 X 2</td>
<td>Rp 30.000</td>
</tr>
<tr>
<td>8</td>
<td>(1pcs) Soket KF3</td>
<td>Rp 2.000</td>
</tr>
<tr>
<td>9</td>
<td>(5pcs) Dioda 1N4007</td>
<td>Rp 5.000</td>
</tr>
<tr>
<td>10</td>
<td>(1pcs) PTC</td>
<td>Rp 2.000</td>
</tr>
<tr>
<td>11</td>
<td>(3pcs) ELCO</td>
<td>Rp 6.000</td>
</tr>
<tr>
<td>12</td>
<td>(2pcs) Capacitor Ceramic 104</td>
<td>Rp 2.000</td>
</tr>
<tr>
<td>13</td>
<td>(1pcs) LM 317</td>
<td>Rp 3.000</td>
</tr>
<tr>
<td>14</td>
<td>(1pcs) Heat Sink</td>
<td>Rp 3.000</td>
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<tr>
<td>15</td>
<td>(1pcs) Potensiometer</td>
<td>Rp 3.000</td>
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<tr>
<td>16</td>
<td>(1pcs) Transistor 2N5551</td>
<td>Rp 2.000</td>
</tr>
<tr>
<td>17</td>
<td>(2pcs) Resistor</td>
<td>Rp 2.000</td>
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<tr>
<td>18</td>
<td>(1pcs) LED</td>
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<tr>
<td>19</td>
<td>(1pcs) PCB Fiber 8X5cm</td>
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<tr>
<td>20</td>
<td>(10pcs) Kabel Male - Female</td>
<td>Rp 10.000</td>
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<tr>
<td>21</td>
<td>(10pcs) Kabel Female - Male</td>
<td>Rp 10.000</td>
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<tr>
<td>22</td>
<td>(10pcs) Kabel Female - Female</td>
<td>Rp 10.000</td>
</tr>
<tr>
<td>23</td>
<td>(1pcs) Nika 10X15X25 cm</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>Rp 486.000</strong></td>
</tr>
</tbody>
</table>
F. PCB Layout
G. Foto Alat