LAMPIRAN A

DATA SHEET KOMPONEN
Features
• Compatible with MCS-51™ Products
• 8K Bytes of In-System Reprogrammable Flash Memory
• Endurance: 1,000 Write/Erase Cycles
• Fully Static Operation: 0 Hz to 24 MHz
• Three-level Program Memory Lock
• 256 x 8-bit Internal RAM
• 32 Programmable I/O Lines
• Three 16-bit Timer/Counters
• Eight Interrupt Sources
• Programmable Serial Channel
• Low-power Idle and Power-down Modes

Description
The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel’s high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

Pin Configurations

PDIP

PLCC
The AT89C52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full-duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89C52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next hardware reset.

Pin Description

**VCC**
Supply voltage.

**GND**
Ground.

**Port 0**
Port 0 is an 8-bit open drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs.

Port 0 can also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode, P0 has internal pullups.

Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. External pullups are required during program verification.

**Port 1**
Port 1 is an 8-bit bi-directional I/O port with internal pullups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins, they are pulled high by the internal pullups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (I_{IL}) because of the internal pullups.

In addition, P1.0 and P1.1 can be configured to be the timer/counter 2 external count input (P1.0/T2) and the timer/counter 2 trigger input (P1.1/T2EX), respectively, as shown in the following table. Port 1 also receives the low-order address bytes during Flash programming and verification.

**Port Pin Alternate Functions**

<table>
<thead>
<tr>
<th>Port Pin</th>
<th>Alternate Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1.0</td>
<td>T2 (external count input to Timer/Counter 2), clock-out</td>
</tr>
<tr>
<td>P1.1</td>
<td>T2EX (Timer/Counter 2 capture/reload trigger and direction control)</td>
</tr>
</tbody>
</table>

**RST**
Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

**ALE/PROG**
Address Latch Enable is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming.

In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external
timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory.

If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

**PSEN**

Program Store Enable is the read strobe to external program memory.

When the AT89C52 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory.

**EA/VPP**

External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset.

EA should be strapped to VCC for internal program executions.

This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming when 12-volt programming is selected.

**XTAL1**

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

**XTAL2**

Output from the inverting oscillator amplifier.

### Table 1. AT89C52 SFR Map and Reset Values

<table>
<thead>
<tr>
<th>Offset</th>
<th>Register</th>
<th>Value after reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>0F8H</td>
<td>B</td>
<td>00000000</td>
</tr>
<tr>
<td>0F0H</td>
<td>ACC</td>
<td>00000000</td>
</tr>
<tr>
<td>0E8H</td>
<td>PSW</td>
<td>00000000</td>
</tr>
<tr>
<td>0E0H</td>
<td>T2CON</td>
<td>XXXXX00</td>
</tr>
<tr>
<td>0D8H</td>
<td>T2MOD</td>
<td>00000000</td>
</tr>
<tr>
<td>0D0H</td>
<td>RCAP2L</td>
<td>00000000</td>
</tr>
<tr>
<td>0C8H</td>
<td>RCAP2H</td>
<td>00000000</td>
</tr>
<tr>
<td>0C0H</td>
<td>TL2</td>
<td>00000000</td>
</tr>
<tr>
<td>0B8H</td>
<td>IP</td>
<td>XX000000</td>
</tr>
<tr>
<td>0B0H</td>
<td>P3</td>
<td>11111111</td>
</tr>
<tr>
<td>0A8H</td>
<td>IE</td>
<td>0X000000</td>
</tr>
<tr>
<td>0A0H</td>
<td>P2</td>
<td>11111111</td>
</tr>
<tr>
<td>98H</td>
<td>SCON</td>
<td>00000000</td>
</tr>
<tr>
<td>90H</td>
<td>P1</td>
<td>11111111</td>
</tr>
<tr>
<td>88H</td>
<td>TCON</td>
<td>00000000</td>
</tr>
<tr>
<td>80H</td>
<td>P0</td>
<td>11111111</td>
</tr>
<tr>
<td></td>
<td>SBUF</td>
<td>XXXXXX</td>
</tr>
<tr>
<td></td>
<td>DPL</td>
<td>00000000</td>
</tr>
<tr>
<td></td>
<td>DPH</td>
<td>00000000</td>
</tr>
<tr>
<td></td>
<td>TL0</td>
<td>00000000</td>
</tr>
<tr>
<td></td>
<td>TL1</td>
<td>00000000</td>
</tr>
<tr>
<td></td>
<td>TH0</td>
<td>00000000</td>
</tr>
<tr>
<td></td>
<td>TH1</td>
<td>00000000</td>
</tr>
<tr>
<td></td>
<td>PCON</td>
<td>0XXX0000</td>
</tr>
<tr>
<td></td>
<td>0FFH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0F7H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0EFH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0E7H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0DFH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0D7H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0CFH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0C7H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0BFH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0B7H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0AFH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0A7H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9FH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>97H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8FH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>87H</td>
<td></td>
</tr>
</tbody>
</table>
Special Function Registers

A map of the on-chip memory area called the Special Function Register (SFR) space is shown in Table 1.

Note that not all of the addresses are occupied, and unoccupied addresses may not be implemented on the chip. Read accesses to these addresses will in general return random data, and write accesses will have an indeterminate effect.

User software should not write 1s to these unlisted locations, since they may be used in future products to invoke new features. In that case, the reset or inactive values of the new bits will always be 0.

Timer 2 Registers Control and status bits are contained in registers T2CON (shown in Table 2) and T2MOD (shown in Table 4) for Timer 2. The register pair (RCAP2H, RCAP2L) are the Capture/Reload registers for Timer 2 in 16-bit capture mode or 16-bit auto-reload mode.

Interrupt Registers The individual interrupt enable bits are in the IE register. Two priorities can be set for each of the six interrupt sources in the IP register.

Table 2. T2CON – Timer/Counter 2 Control Register

<table>
<thead>
<tr>
<th>Bit Addressable</th>
<th>TF2</th>
<th>EXF2</th>
<th>RCLK</th>
<th>TCLK</th>
<th>EXEN2</th>
<th>TR2</th>
<th>C/T2</th>
<th>CP/RL2</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Symbol Function

TF2 Timer 2 overflow flag set by a Timer 2 overflow and must be cleared by software. TF2 will not be set when either RCLK = 1 or TCLK = 1.

EXF2 Timer 2 external flag set when either a capture or reload is caused by a negative transition on T2EX and EXEN2 = 1. When Timer 2 interrupt is enabled, EXF2 = 1 will cause the CPU to vector to the Timer 2 interrupt routine. EXF2 must be cleared by software. EXF2 does not cause an interrupt in up/down counter mode (DCEN = 1).

RCLK Receive clock enable. When set, causes the serial port to use Timer 2 overflow pulses for its receive clock in serial port Modes 1 and 3. RCLK = 0 causes Timer 1 overflow to be used for the receive clock.

TCLK Transmit clock enable. When set, causes the serial port to use Timer 2 overflow pulses for its transmit clock in serial port Modes 1 and 3. TCLK = 0 causes Timer 1 overflows to be used for the transmit clock.

EXEN2 Timer 2 external enable. When set, allows a capture or reload to occur as a result of a negative transition on T2EX if Timer 2 is not being used to clock the serial port. EXEN2 = 0 causes Timer 2 to ignore events at T2EX.

TR2 Start/Stop control for Timer 2. TR2 = 1 starts the timer.

C/T2 Timer or counter select for Timer 2. C/T2 = 0 for timer function. C/T2 = 1 for external event counter (falling edge triggered).

CP/RL2 Capture/Reload select. CP/RL2 = 1 causes captures to occur on negative transitions at T2EX if EXEN2 = 1. CP/RL2 = 0 causes automatic reloads to occur when Timer 2 overflows or negative transitions occur at T2EX when EXEN2 = 1. When either RCLK or TCLK = 1, this bit is ignored and the timer is forced to auto-reload on Timer 2 overflow.

Data Memory

The AT89C52 implements 256 bytes of on-chip RAM. The upper 128 bytes occupy a parallel address space to the Special Function Registers. That means the upper 128 bytes have the same addresses as the SFR space but are physically separate from SFR space.

When an instruction accesses an internal location above address 7FH, the address mode used in the instruction specifies whether the CPU accesses the upper 128 bytes of RAM or the SFR space. Instructions that use direct addressing access SFR space.

For example, the following direct addressing instruction accesses the SFR at location 0A0H (which is P2).

MOV 0A0H, #data
Instructions that use indirect addressing access the upper 128 bytes of RAM. For example, the following indirect addressing instruction, where R0 contains 0A0H, accesses the data byte at address 0A0H, rather than P2 (whose address is 0A0H).

\[ \text{MOV @R0, #data} \]

Note that stack operations are examples of indirect addressing, so the upper 128 bytes of data RAM are available as stack space.

**Timer 0 and 1**

Timer 0 and Timer 1 in the AT89C52 operate the same way as Timer 0 and Timer 1 in the AT89C51.

**Timer 2**

Timer 2 is a 16-bit Timer/Counter that can operate as either a timer or an event counter. The type of operation is selected by bit C/T2 in the SFR T2CON (shown in Table 2). Timer 2 has three operating modes: capture, auto-reload (up or down counting), and baud rate generator. The modes are selected by bits in T2CON, as shown in Table 3.

Timer 2 consists of two 8-bit registers, TH2 and TL2. In the Timer function, the TL2 register is incremented every machine cycle. Since a machine cycle consists of 12 oscillator periods, the count rate is 1/12 of the oscillator frequency.

In the Counter function, the register is incremented in response to a 1-to-0 transition at its corresponding external input pin, T2. In this function, the external input is sampled during S5P2 of every machine cycle. When the samples show a high in one cycle and a low in the next cycle, the count is incremented. The new count value appears in the register during S3P1 of the cycle following the one in which the transition was detected. Since two machine cycles (24 oscillator periods) are required to recognize a 1-to-0 transition, the maximum count rate is 1/24 of the oscillator frequency. To ensure that a given level is sampled at least once before it changes, the level should be held for at least one full machine cycle.

**Capture Mode**

In the capture mode, two options are selected by bit EXEN2 in T2CON. If \( \text{EXEN2} = 0 \), Timer 2 is a 16-bit timer or counter which upon overflow sets bit TF2 in T2CON. This bit can then be used to generate an interrupt. If \( \text{EXEN2} = 1 \), Timer 2 performs the same operation, but a 1-to-0 transition at external input T2EX also causes the current value in TH2 and TL2 to be captured into RCAP2H and RCAP2L, respectively. In addition, the transition at T2EX causes bit EXF2 in T2CON to be set. The EXF2 bit, like TF2, can generate an interrupt. The capture mode is illustrated in Figure 1.

**Auto-reload (Up or Down Counter)**

Timer 2 can be programmed to count up or down when configured in its 16-bit auto-reload mode. This feature is invoked by the DCEN (Down Counter Enable) bit located in the SFR T2MOD (see Table 4). Upon reset, the DCEN bit is set to 0 so that timer 2 will default to count up. When DCEN is set, Timer 2 can count up or down, depending on the value of the T2EX pin.
Figure 2 shows Timer 2 automatically counting up when DCEN = 0. In this mode, two options are selected by bit EXEN2 in T2CON. If EXEN2 = 0, Timer 2 counts up to 0FFFFH and then sets the TF2 bit upon overflow. The overflow also causes the timer registers to be reloaded with the 16-bit value in RCAP2H and RCAP2L. The values in Timer in Capture Mode RCAP2H and RCAP2L are preset by software. If EXEN2 = 1, a 16-bit reload can be triggered either by an overflow or by a 1-to-0 transition at external input T2EX. This transition also sets the EXF2 bit. Both the TF2 and EXF2 bits can generate an interrupt if enabled.

Setting the DCEN bit enables Timer 2 to count up or down, as shown in Figure 3. In this mode, the T2EX pin controls the direction of the count. A logic 1 at T2EX makes Timer 2 count up. The timer will overflow at 0FFFFH and set the TF2 bit. This overflow also causes the 16-bit value in RCAP2H and RCAP2L to be reloaded into the timer registers, TH2 and TL2, respectively.

A logic 0 at T2EX makes Timer 2 count down. The timer underflows when TH2 and TL2 equal the values stored in RCAP2H and RCAP2L. The underflow sets the TF2 bit and causes 0FFFFH to be reloaded into the timer registers.

The EXF2 bit toggles whenever Timer 2 overflows or underflows and can be used as a 17th bit of resolution. In this operating mode, EXF2 does not flag an interrupt.
Figure 2. Timer 2 Auto Reload Mode (DCEN = 0)

Table 4. T2MOD – Timer 2 Mode Control Register

<table>
<thead>
<tr>
<th>T2MOD Address = 0C9H</th>
<th>Reset Value = XXXX XX00B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Bit Addressable</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bit</th>
<th>Symbol</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>–</td>
<td>T2OE</td>
</tr>
<tr>
<td>1</td>
<td>DCEN</td>
<td>–</td>
</tr>
</tbody>
</table>

Symbol | Function
--- | ---
– | Not implemented, reserved for future
T2OE | Timer 2 Output Enable bit.
DCEN | When set, this bit allows Timer 2 to be configured as an up/down counter.
Figure 3. Timer 2 Auto Reload Mode (DCEN = 1)

Figure 4. Timer 2 in Baud Rate Generator Mode
DESCRIPTION
The ULN2801A-ULN2805A each contain eight darlington transistors with common emitters and integral suppression diodes for inductive loads. Each darlington features a peak load current rating of 600mA (500mA continuous) and can withstand at least 50V in the off state. Outputs may be paralleled for higher current capability.

Five versions are available to simplify interfacing to standard logic families: the ULN2801A is designed for general purpose applications with a current limit resistor; the ULN2802A has a 10.5kΩ input resistor and zener for 14-25V PMOS; the ULN2803A has a 2.7kΩ input resistor for 5V TTL and CMOS; the ULN2804A has a 10.5kΩ input resistor for 6-15V CMOS and the ULN2805A is designed to sink a minimum of 350mA for standard and Schottky TTL where higher output current is required.

All types are supplied in a 18-lead plastic DIP with a copper lead from and feature the convenient input-opposite-output pinout to simplify board layout.
SCHEMATIC DIAGRAM AND ORDER CODES

For ULN2801A (each driver for PMOS-CMOS)

For ULN2802A (each driver for 14-15 V PMOS)

For ULN2803A (each driver for 5 V, TTL/CMOS)

For ULN2804A (each driver for 6-15 V CMOS/PMOS)

For ULN2805A (each driver for high out TTL)
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_o$</td>
<td>Output Voltage</td>
<td>50</td>
<td>V</td>
</tr>
<tr>
<td>$V_i$</td>
<td>Input Voltage</td>
<td>for ULN2802A, ULN2803A, ULN2804A</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>for ULN2805A</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>$I_C$</td>
<td>Continuous Collector Current</td>
<td>500</td>
<td>mA</td>
</tr>
<tr>
<td>$I_B$</td>
<td>Continuous Base Current</td>
<td>25</td>
<td>mA</td>
</tr>
<tr>
<td>$P_{tot}$</td>
<td>Power Dissipation (one Darlington pair)</td>
<td>1.0</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>(total package)</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>$T_{amb}$</td>
<td>Operating Ambient Temperature Range</td>
<td>– 20 to 85</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature Range</td>
<td>– 55 to 150</td>
<td>°C</td>
</tr>
<tr>
<td>$T_j$</td>
<td>Junction Temperature Range</td>
<td>– 20 to 150</td>
<td>°C</td>
</tr>
</tbody>
</table>

### THERMAL DATA

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th,j-amb}$</td>
<td>Thermal Resistance Junction-ambient</td>
<td>Max.</td>
<td>55</td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^\circ C$ unless otherwise specified)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Fig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{CEX}$</td>
<td>Output Leakage Current</td>
<td>$V_{CE} = 50V$</td>
<td>$T_{amb} = 70^\circ C$, $V_{CE} = 50V$</td>
<td>50</td>
<td>100</td>
<td>μA</td>
<td>1a</td>
</tr>
<tr>
<td></td>
<td>for ULN2802A, ULN2803A, ULN2804A</td>
<td>$I_C = 100,mA$, $I_B = 250,\mu A$</td>
<td>$I_C = 200,mA$, $I_B = 350,\mu A$</td>
<td>0.9</td>
<td>1.1</td>
<td>V</td>
<td>1b</td>
</tr>
<tr>
<td></td>
<td>for ULN2804A</td>
<td>$I_C = 350,mA$, $I_B = 500,\mu A$</td>
<td>1.3</td>
<td>1.6</td>
<td>V</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>$V_{CE(sat)}$</td>
<td>Collector-emitter Saturation Voltage</td>
<td>$I_C = 100,mA$, $I_B = 250,\mu A$</td>
<td>$V_{CE} = 50V$, $V_i = 6V$</td>
<td>0.82</td>
<td>1.25</td>
<td>mA</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>for ULN2804A</td>
<td>$V_i = 1V$</td>
<td>0.93</td>
<td>1.35</td>
<td>mA</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for ULN2805A</td>
<td>$V_i = 3V$</td>
<td>0.35</td>
<td>0.5</td>
<td>mA</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>$I_{(on)}$</td>
<td>Input Current</td>
<td>$V_{CE} = 17V$</td>
<td>$V_i = 3.85V$</td>
<td>1</td>
<td>1.45</td>
<td>mA</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>for ULN2804A</td>
<td>$V_i = 5V$</td>
<td>1.5</td>
<td>2.4</td>
<td>mA</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for ULN2805A</td>
<td>$V_i = 3V$</td>
<td>5</td>
<td>6</td>
<td>V</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>$I_{(off)}$</td>
<td>Input Current</td>
<td>$T_{amb} = 70^\circ C$, $I_C = 500,\mu A$</td>
<td>50</td>
<td>65</td>
<td>μA</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>$V_{(on)}$</td>
<td>Input Voltage</td>
<td>$V_{CE} = 2V$, $I_C = 350,mA$</td>
<td>13</td>
<td>27</td>
<td>V</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for ULN2802A</td>
<td>$I_C = 300,mA$</td>
<td>3</td>
<td>6</td>
<td>V</td>
<td>5</td>
<td></td>
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<tr>
<td></td>
<td>for ULN2803A</td>
<td>$I_C = 200,mA$</td>
<td>2.7</td>
<td>6</td>
<td>V</td>
<td>5</td>
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<tr>
<td></td>
<td>for ULN2804A</td>
<td>$I_C = 250,mA$</td>
<td>3</td>
<td>7</td>
<td>V</td>
<td>5</td>
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<td></td>
<td>for ULN2804A</td>
<td>$I_C = 350,mA$</td>
<td>2.4</td>
<td>–</td>
<td>V</td>
<td>5</td>
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<tr>
<td>$h_{FE}$</td>
<td>DC Forward Current Gain</td>
<td>for ULN2801A</td>
<td>$V_{CE} = 2V$, $I_C = 350,mA$</td>
<td>1000</td>
<td>–</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>$C_i$</td>
<td>Input Capacitance</td>
<td>15</td>
<td>25</td>
<td>pF</td>
<td>–</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>$t_{PLH}$</td>
<td>Turn-on Delay Time</td>
<td>0.5 V, 0.5 $V_o$</td>
<td>0.25</td>
<td>1</td>
<td>μs</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>$t_{PHL}$</td>
<td>Turn-off Delay Time</td>
<td>0.5 V, 0.5 $V_o$</td>
<td>0.25</td>
<td>1</td>
<td>μs</td>
<td>–</td>
<td></td>
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<tr>
<td>$I_R$</td>
<td>Clamp Diode Leakage Current</td>
<td>$V_R = 50V$, $T_{amb} = 70^\circ C$, $V_R = 50V$</td>
<td>50</td>
<td>100</td>
<td>μA</td>
<td>6</td>
<td></td>
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<tr>
<td>$V_F$</td>
<td>Clamp Diode Forward Voltage</td>
<td>$I_F = 350,mA$</td>
<td>1.7</td>
<td>2</td>
<td>V</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>
TEST CIRCUITS

Figure 1a.

Figure 1b.

Figure 2.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

Figure 7.
Figure 8: Collector Current as a Function of Saturation Voltage.

Figure 9: Collector Current as a Function of Input Current.

Figure 10: Allowable Average Power Dissipation as a Function of Ambient Temperature.

Figure 11: Peak Collector Current as a Function of Duty Cycle.

Figure 12: Peak Collector Current as a Function of Duty.

Figure 13: Input Current as a Function of Input Voltage (for ULN2802A).
Figure 14: Input Current as a Function of Input Voltage (for ULN2804A)

Figure 15: Input Current as a Function of Input Voltage (for ULN2803A)

Figure 16: Input Current as a Function of Input Voltage (for ULN2805A)
### DIP18 PACKAGE MECHANICAL DATA

<table>
<thead>
<tr>
<th>DIM.</th>
<th>mm</th>
<th>inch</th>
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<td>0.254</td>
<td>0.010</td>
</tr>
<tr>
<td>B</td>
<td>1.39</td>
<td>1.65</td>
</tr>
<tr>
<td>b</td>
<td>0.46</td>
<td>0.018</td>
</tr>
<tr>
<td>b1</td>
<td>0.25</td>
<td>0.010</td>
</tr>
<tr>
<td>D</td>
<td>23.24</td>
<td>0.915</td>
</tr>
<tr>
<td>E</td>
<td>8.5</td>
<td>0.335</td>
</tr>
<tr>
<td>e</td>
<td>2.54</td>
<td>0.100</td>
</tr>
<tr>
<td>e3</td>
<td>20.32</td>
<td>0.800</td>
</tr>
<tr>
<td>F</td>
<td>7.1</td>
<td>0.280</td>
</tr>
<tr>
<td>I</td>
<td>3.93</td>
<td>0.155</td>
</tr>
<tr>
<td>L</td>
<td>3.3</td>
<td>0.130</td>
</tr>
<tr>
<td>Z</td>
<td>1.27</td>
<td>0.050</td>
</tr>
</tbody>
</table>

- **a1** 0.254 0.010
- **B** 1.39 1.65 0.055 0.065
- **b** 0.46 0.018
- **b1** 0.25 0.010
- **D** 23.24 0.915
- **E** 8.5 0.335
- **e** 2.54 0.100
- **e3** 20.32 0.800
- **F** 7.1 0.280
- **I** 3.93 0.155
- **L** 3.3 0.130
- **Z** 1.27 0.050
CMPS03 - Robot Compass Module

This compass module has been specifically designed for use in robots as an aid to navigation. The aim was to produce a unique number to represent the direction the robot is facing. The compass uses the Philips KMZ51 magnetic field sensor, which is sensitive enough to detect the Earth's magnetic field. The output from two of them mounted at right angles to each other is used to compute the direction of the horizontal component of the Earth's magnetic field.

Connections to the compass module

The compass module requires a 5v power supply at a nominal 15mA. There are two ways of getting the bearing from the module. A PWM signal is available on pin 4, or an I2C interface is provided on pins 2,3.

The PWM signal is a pulse width modulated signal with the positive width of the pulse representing the angle. The pulse width varies from 1mS (0°) to 36.99mS (359.9°) – in other words 100μS/° with a +1mS offset. The signal goes low for 65mS between pulses, so the cycle time is 65mS + the pulse width - i.e. 66ms-102ms. The pulse is generated by a 16 bit timer in the processor giving a 1μS resolution, however I would not recommend measuring this to anything better than 0.1° (10μS). Make sure you connect the I2C pins, SCL and SDA, to the 5v supply if you are using the PWM, as there are no pull-up resistors on these pins.

Pin 2,3 are an I2C interface and can be used to get a direct readout of the bearing. If the I2C interface is not used then these pins should be pulled high (to +5v) via a couple of resistors. Around 47k is ok, the values are not at all critical.
I2C communication protocol with the compass module is the same as popular eeprom's such as the 24C04. First send a start bit, the module address (0XCO) with the read/write bit low, then the register number you wish to read. This is followed by a repeated start and the module address again with the read/write bit high (0XC1). You now read one or two bytes for 8bit or 16bit registers respectively. 16bit registers are read high byte first. The compass has a 16 byte array of registers, some of which double up as 16 bit registers as follows;

<table>
<thead>
<tr>
<th>Register</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Software Revision Number</td>
</tr>
<tr>
<td>1</td>
<td>Compass Bearing as a byte, i.e. 0-255 for a full circle</td>
</tr>
<tr>
<td>2,3</td>
<td>Compass Bearing as a word, i.e. 0-3599 for a full circle, representing 0-359.9 degrees.</td>
</tr>
<tr>
<td>4,5</td>
<td>Internal Test - Sensor1 difference signal - 16 bit signed word</td>
</tr>
<tr>
<td>6,7</td>
<td>Internal Test - Sensor2 difference signal - 16 bit signed word</td>
</tr>
<tr>
<td>8,9</td>
<td>Internal Test - Calibration value 1 - 16 bit signed word</td>
</tr>
<tr>
<td>10,11</td>
<td>Internal Test - Calibration value 2 - 16 bit signed word</td>
</tr>
<tr>
<td>12</td>
<td>Unused - Read as Zero</td>
</tr>
<tr>
<td>13</td>
<td>Unused - Read as Zero</td>
</tr>
<tr>
<td>14</td>
<td>Unused - Read as Undefined</td>
</tr>
<tr>
<td>15</td>
<td>Calibrate Command - Write 255 to perform calibration step. See text.</td>
</tr>
</tbody>
</table>

Register 0 is the Software revision number (8 at the time of writing). Register 1 is the bearing converted to a 0-255 value. This may be easier for some applications than 0-360 which requires two bytes. For those who require better resolution registers 2 and 3 (high byte first) are a 16 bit unsigned integer in the range 0-3599. This represents 0-359.9°. Registers 4 to 11 are internal test registers and 12,13 are unused. Register 14 is undefined. Don't read them if you don't want them - you'll just waste your I2C bandwidth. Register 15 is used to calibrate the compass.
The I2C interface does not have any pull-up resistors on the board, these should be provided elsewhere, most probably with the bus master. They are required on both the SCL and SDA lines, but only once for the whole bus, not on each module. I suggest a value of 1k8 if you are going to be working up to 400KHz and 1k2 or even 1k if you are going up to 1MHz. The compass is designed to work at up to the standard clock speed (SCL) of 100KHz, however the clock speed can be raised to 1MHz providing the following precaution is taken; At speeds above around 160KHz the CPU cannot respond fast enough to read the I2C data. Therefore a small delay of 50uS should be inserted either side of writing the register address. No delays are required anywhere else in the sequence. By doing this, I have tested the compass module up to 1.3MHz SCL clock speed. The compass module always operates as a slave, its never a bus master.

Pin 7 is an input pin selecting either 50Hz (low) or 60Hz (high) operation. I added this option after noticing a jitter of around 1.5° in the output. The cause was the 50Hz mains field in my workshop. By converting in synchronism with the mains frequency this was reduced to around 0.2° . An internal conversion is done every 40mS (50Hz) or every 33.3mS (60Hz). The pin has an on-board pull-up can be left unconnected for 60Hz operation. There is no synchronism between the PWM or I2C outputs and the conversion. They both retrieve the most recent internal reading, which is continuously converted, whether it is used or not.

Pin 6 is used to calibrate the compass. The calibrate input (pin 6) has an on-board pull-up resistor and can be left unconnected after calibration.

Pins 5 and 8 are No Connect. Actually pin 8 is the processor reset line and has an on-board pull-up resistor. It is there so that we can program the processor chip after placement on the PCB.

**PCB Drilling Plan**

The following diagram shows the CMPS03 PCB mounting hole positions.
SLOTTED OPTICAL SWITCH

H21A1/2/3

PACKAGE DIMENSIONS

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>MILLIMETERS</th>
<th>INCHES</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.7</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>3.0</td>
<td>3.2</td>
<td>119</td>
</tr>
<tr>
<td>A2</td>
<td>3.0</td>
<td>3.2</td>
<td>119</td>
</tr>
<tr>
<td>Bb</td>
<td>.600</td>
<td>.750</td>
<td>.024</td>
</tr>
<tr>
<td>Bb1</td>
<td>.50</td>
<td>.50</td>
<td>.020</td>
</tr>
<tr>
<td>D</td>
<td>24.3</td>
<td>24.7</td>
<td>.957</td>
</tr>
<tr>
<td>D1</td>
<td>11.6</td>
<td>12.0</td>
<td>.457</td>
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<tr>
<td>D2</td>
<td>3.0</td>
<td>3.3</td>
<td>119</td>
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<tr>
<td>e</td>
<td>.6</td>
<td>.75</td>
<td>.027</td>
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<td>e1</td>
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<tr>
<td>E</td>
<td>6.15</td>
<td>6.35</td>
<td>2.43</td>
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<tr>
<td>L</td>
<td>8.00</td>
<td>315</td>
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</tr>
<tr>
<td>Rp</td>
<td>3.2</td>
<td>3.4</td>
<td>.126</td>
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<tr>
<td>Q</td>
<td>16.9</td>
<td>19.2</td>
<td>.745</td>
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<tr>
<td>S</td>
<td>.85</td>
<td>1.0</td>
<td>.034</td>
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<tr>
<td>S1</td>
<td>3.45</td>
<td>3.75</td>
<td>.136</td>
</tr>
<tr>
<td>T</td>
<td>2.6</td>
<td>.103</td>
<td>Nom.</td>
</tr>
</tbody>
</table>

NOTES:
1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27mm (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ± .125mm (.0.050 INCH).

PACKAGE OUTLINE

DESCRIPTION

The H21A Slotted Optical Switch is a gallium arsenide light emitting diode coupled to a silicon phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" to an "OFF" state.

FEATURES

- Opaque housing
- Low cost
- .035" apertures
- High I_{on}
### ABSOLUTE MAXIMUM RATINGs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>TYP.</th>
<th>Max.</th>
<th>Units</th>
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<tbody>
<tr>
<td>Storage Temperature</td>
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<tr>
<td>Operating Temperature</td>
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<td></td>
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<tr>
<td>Soldering:</td>
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<tr>
<td>Lead Temperature (Iron)</td>
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<td></td>
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<tr>
<td>Lead Temperature (Flow)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT DIODE</td>
<td></td>
<td></td>
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<tr>
<td>Continuous Forward Current</td>
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<td></td>
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<td></td>
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<tr>
<td>Reverse Voltage</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Dissipation</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>OUTPUT TRANSISTOR</td>
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<td>Emitter-Collector Voltage</td>
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<tr>
<td>Power Dissipation</td>
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### ELECTRICAL CHARACTERISTICS

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<th>Parameter</th>
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<th>Max.</th>
<th>Units</th>
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<td>INPUT DIODE</td>
<td></td>
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<tr>
<td>Forward Voltage</td>
<td>V_f</td>
<td></td>
<td>1.7</td>
<td>V</td>
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<tr>
<td>Reverse Breakdown Voltage</td>
<td>V IDb</td>
<td>6.0</td>
<td></td>
<td>V</td>
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<tr>
<td>Reverse Leakage Current</td>
<td>I r</td>
<td></td>
<td>1.0</td>
<td>μA</td>
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<td>OUTPUT TRANSISTOR</td>
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<tr>
<td>Emitter-Collector Breakdown</td>
<td>BVCEO</td>
<td>6.0</td>
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<td>V</td>
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<td>30</td>
<td></td>
<td>V</td>
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<tr>
<td>Collector-Emitter Leakage</td>
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<td>100</td>
<td>nA</td>
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<td>COUPLED</td>
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<tr>
<td>On-State Collector Current</td>
<td>I CM</td>
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<td></td>
<td>mA</td>
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<td>Saturation Voltage</td>
<td>V CM</td>
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<td>V</td>
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<tr>
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<td>t p</td>
<td></td>
<td></td>
<td>μS</td>
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<td>Turn-Off Time</td>
<td>t r</td>
<td></td>
<td></td>
<td>μS</td>
<td></td>
</tr>
</tbody>
</table>

### NOTES

1. Derate power dissipation linearly 1.33 mW/°C above 25°C.
2. Derate power dissipation linearly 2.00 mW/°C above 25°C.
3. RMA flux is recommended.
4. Methanol or Isopropyl alcohols are recommended as cleaning agents.
5. Soldering iron tip 1/8" (1.6 mm) from housing.
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON-STATE COLLECTOR CURRENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H21A1</td>
<td>I_{ON}</td>
<td>0.15</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 5mA, V_{CE} = 5V</td>
</tr>
<tr>
<td>H21A2</td>
<td>I_{ON}</td>
<td>0.30</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 5mA, V_{CE} = 5V</td>
</tr>
<tr>
<td>H21A3</td>
<td>I_{ON}</td>
<td>0.60</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 5mA, V_{CE} = 5V</td>
</tr>
<tr>
<td>H21A1</td>
<td>I_{ON}</td>
<td>1.0</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 20mA, V_{CE} = 5V</td>
</tr>
<tr>
<td>H21A2</td>
<td>I_{ON}</td>
<td>2.0</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 20mA, V_{CE} = 5V</td>
</tr>
<tr>
<td>H21A3</td>
<td>I_{ON}</td>
<td>4.0</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 20mA, V_{CE} = 5V</td>
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<tr>
<td>H21A1</td>
<td>I_{ON}</td>
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<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 30mA, V_{CE} = 5V</td>
</tr>
<tr>
<td>H21A2</td>
<td>I_{ON}</td>
<td>3.0</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 30mA, V_{CE} = 5V</td>
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<tr>
<td>H21A3</td>
<td>I_{ON}</td>
<td>5.5</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>I_{p} = 30mA, V_{CE} = 5V</td>
</tr>
<tr>
<td>SATURATION VOLTAGE</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>H21A2</td>
<td>V_{CE(sat)}</td>
<td>—</td>
<td>—</td>
<td>0.40</td>
<td>V</td>
<td>I_{p} = 20mA, I_{C} = 1.8mA</td>
</tr>
<tr>
<td>H21A3</td>
<td>V_{CE(sat)}</td>
<td>—</td>
<td>—</td>
<td>0.40</td>
<td>V</td>
<td>I_{p} = 20mA, I_{C} = 1.8mA</td>
</tr>
<tr>
<td>H21A1</td>
<td>V_{CE(sat)}</td>
<td>—</td>
<td>—</td>
<td>0.40</td>
<td>V</td>
<td>I_{p} = 30mA, I_{C} = 1.8mA</td>
</tr>
<tr>
<td>Turn-On Time</td>
<td>t_{on}</td>
<td>8</td>
<td>—</td>
<td>—</td>
<td>μS</td>
<td>V_{CC} = 5V, I_{C} = 30 mA, R_{L} = 2.5KΩ</td>
</tr>
<tr>
<td>Turn-Off Time</td>
<td>t_{off}</td>
<td>50</td>
<td>—</td>
<td>—</td>
<td>μS</td>
<td>V_{CC} = 5V, I_{C} = 30 mA, R_{L} = 2.5KΩ</td>
</tr>
</tbody>
</table>
### The Extended Concise LCD Data Sheet for HD44780

**Version:** 25.6.1999

#### Instruction

<table>
<thead>
<tr>
<th>Instruction</th>
<th>RS</th>
<th>RW</th>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
<th>Description</th>
<th>Clock-Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOP</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>No Operation</td>
<td>0</td>
</tr>
<tr>
<td>Clear Display</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Clear display &amp; set address counter to zero</td>
<td>165</td>
</tr>
<tr>
<td>Cursor Home</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Set address counter to zero, return shifted display to original position. DD RAM contents remains unchanged.</td>
<td>3</td>
</tr>
<tr>
<td>Entry Mode Set</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>I/D S</td>
<td>Set cursor move direction (I/D) and specify automatic display shift (S).</td>
<td>3</td>
</tr>
<tr>
<td>Display Control</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>D C B</td>
<td>Turn display (D), cursor on/off (C), and cursor blinking (B).</td>
<td>3</td>
</tr>
<tr>
<td>Cursor / Display shift</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>S/C</td>
<td>R/L</td>
<td>x</td>
<td>Shift display or move cursor (S/C) and specify direction (R/L).</td>
<td>3</td>
</tr>
<tr>
<td>Function Set</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>DL</td>
<td>N</td>
<td>F</td>
<td>Set interface data width (DL), number of display lines (N) and character font (F).</td>
<td>3</td>
</tr>
<tr>
<td>Set CGRAM Address</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>DL N</td>
<td>CGRAM Address</td>
<td>Set CGRAM address. CGRAM data is sent afterwards.</td>
<td>3</td>
</tr>
<tr>
<td>Set DDRAM Address</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DDRAM Address</td>
<td>Set DDRAM address. DDRAM data is sent afterwards.</td>
</tr>
<tr>
<td>Busy Flag &amp; Address</td>
<td>0</td>
<td>1</td>
<td>BF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Address Counter</td>
<td>Read busy flag (BF) and address counter</td>
</tr>
<tr>
<td>Write Data</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Data</td>
<td>Write data into DDRAM or CGRAM</td>
</tr>
<tr>
<td>Read Data</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Data</td>
<td>Read data from DDRAM or CGRAM</td>
</tr>
</tbody>
</table>

* x: Don't care

#### PIN DESCRIPTION

- **Vss**: Power Ground (-5 V)
- **Vdd**: Power Supply (5 V)
- **Vee**: Contrast Adjust (-2) 0 to -5 V
- **RS**: Command Register Select
- **R/W**: Command Read / Write
- **E**: Command Enable (Strobe)
- **D0**, **D1**, **D2**, **D3**, **D4**, **D5**, **D6**, **D7**: Data Input

#### LCD Display with 2 lines x 40 characters:

![LCD Display with 2 lines x 40 characters](image)

#### LCD Display with 2 lines x 16 characters:

![LCD Display with 2 lines x 16 characters](image)
Bus Timing Characteristics

(\(T_a = -20\) to \(+75^\circ C\))

Write Cycle

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min(^{(1)})</th>
<th>Typ(^{(1)})</th>
<th>Max(^{(1)})</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable Cycle Time</td>
<td>(t_c)</td>
<td>1000</td>
<td>500</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Enable Pulse Width (High)</td>
<td>(t_w)</td>
<td>450</td>
<td>230</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Enable Rise/Fall Time</td>
<td>(t_r, t_f)</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Address Setup Time</td>
<td>(t_{as})</td>
<td>60</td>
<td>40</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Address Hold Time</td>
<td>(t_{ah})</td>
<td>20</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Data Setup Time</td>
<td>(t_{ds})</td>
<td>195</td>
<td>80</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Data Hold Time</td>
<td>(t_h)</td>
<td>10</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^{(1)}\) The above specifications are indications only (based on Hitachi HD44780). Timing will vary from manufacturer to manufacturer.

\(^{(2)}\) Power Supply :  
HD44780 S : \(V_{DD} = 4.5 - 5.5\) V  
HD44780 U : \(V_{DD} = 2.7 - 5.5\) V

This data sheet refers to specifications for the Hitachi HD44780 LCD Driver chip, which is used for most LCD modules.

Common types are :
1 line x 20 characters
2 lines x 16 characters
2 lines x 20 characters
2 lines x 40 characters
4 lines x 20 characters
4 lines x 40 characters

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Peter Luethi, Switzerland http://www.electronic-engineering.ch
LAMPIRAN B

PERANGKAT LUNAK
PROGRAM UTAMA PENGENDALI
PROTOTIPE MOBIL
BY: RIKIAN CHANDRAWAN DS

INISIALISASI REGISTER DAN ALAMAT

$MOD52

$OPTOCOUPLE$ EQU P3.5

$KEYPAD EQU P1

ALAMAT UNTUK MEMORI SUDUT

$DATA_SUDUT_LOW EQ U 35H
$DATA_SUDUT_HIGH EQ U 34H
$S_SATUAN EQ U 33H
$S_PULUHAN EQ U 32H
$S_RATUSAN EQ U 31H

ALAMAT UNTUK MEMORI JARAK

$DATA_JARAK_HIGH EQU 3AH
$DATA_JARAK_LOW EQU 39H
$J_SATUAN EQU 38H
$J_PULUHAN EQU 37H
$J_RATUSAN EQU 36H

PENGALI_PULUHAN EQU U 0AH
PENGALI_RATUSAN EQU U 64H
MILI_KE_MIKRO EQU 1000D
KELILING EQU U 0DH

TENTANG MOTOR STEPPER

$STEPPER EQU P2
$SKA1 EQU 00001001B
$SKA2 EQU 00001000B
$SKA3 EQU 00001100B
$SKA4 EQU 00000100B
$SKA5 EQU 00000110B
$SKA6 EQU 00000010B
$SKA7 EQU 00000011B
$SKA8 EQU 00000001B

SI$S_KIRI
$SKI1 EQU 10010000B
$SKI2 EQU 10000000B
$SKI3 EQU 11000000B
$SKI4 EQU 01000000B
$SKI5 EQU 01100000B
$SKI6 EQU 00100000B
$SKI7 EQU 00110000B
$SKI8 EQU 00010000B

TENTANG LCD

$LCD EQU P0
$LCD_FUNC_SET EQU 00111000B
$LCD_CLEAR EQU 00000001B
$LCD_TAMPILKAN_CTRL EQU 00001111B
$LCD_LINE1 EQU 10000000B
$LCD_LINE2 EQU 11000000B
$LCD_LINE1_9 EQU 10001000B
$LCD_LINE2_9 EQU 11001000B
$LCD_DRJT EQU 10001011B
$LCD_CM EQU 11001011B
$ENABLE EQU P3.0
$RW EQU P3.1
$RS EQU P3.2

ORG 0000H
LJMP START

ORG 50H

START:

MOV P0,#0H
MOV P1,#0H
MOV P2,#0H
MOV P3,#0H

ACALL INISIALISASI PEMBUAT

ACALL MENAMPAI KAN NAMA

PEMBUAT

START1:

ACALL LCD DIBERSIHKAN
ACALL DIS_SUDUT
ACALL DIS_JARAK

SUDUT1:

ACALL DIS_SUDUT
MOV R0,#31H
ACALL AMBIL_SUDUT

JARAK1:

ACALL DIS_JARAK
MOV R0,#36H
ACALL AMBIL_JARAK
ACALL BELOK

START2:

CLR TR2
ACALL MAJU

START3:

ACALL LCD DIBERSIHKAN
ACALL OPTION

;UNTUK ULANG LAGI ATAU TIDAK
LJMP SELESAI

B-1
; TAMPILAN SUDUT
DAN JARAK
;-----------------------------------------------------

DIS_SUDUT:
    MOV A,#80H
    ACALL PERINTAH
    MOV A,'#' ;I
    ACALL TAMPILKAN
    MOV A,'#N' ;N
    ACALL TAMPILKAN
    MOV A,'#P' ;P
    ACALL TAMPILKAN
    MOV A,'#20H' ;SPASI
    ACALL TAMPILKAN
    MOV A,'#S' ;S
    ACALL TAMPILKAN
    MOV A,'#D' ;D
    ACALL TAMPILKAN
    MOV A,'#T' ;T
    ACALL TAMPILKAN
    MOV A,'#3AH' ;;
    ACALL TAMPILKAN
    MOV A,'#LCD_DRJT
    ACALL PERINTAH
    MOV A,'#0DFH
    ACALL CEK_KEYPAD
    CJNE A,#0E5H,SUDUT_BENAR
    LJMP SUDUT1

SUDUT_BENAR:
    MOV A,'#S_PULUHAN
    MOV B,'#PENGALI_PULUHAN
    MUL AB
    MOV B,'#S_SATUAN
    ADD A,B
    ADD A,'#0AH
    ;supaya sama dengan kompas
    MOV R1,A  ;BYTE RENDAH
    MOV A,'#S_RATUSAN
    MOV B,'#PENGALI_RATUSAN
    MUL AB
    CLR C
    ADD A,R1
    MOV A,'#DATA_SUDUT_LOW
    MOV B,'#DATA_SUDUT_HIGH
    MO
    ADDC A,'#00H
    CJNE A,'#01H,CEK1
    SJMP TAMBAH1
    CEK1:
    CJNE A,'#01H,CEK2
    SJMP TAMBAH1

CEK2:
    CJNE A,'#02H,CEK3
    SJMP TAMBAH2

CEK3:
    CJNE A,'#03H,TETAP
    MOV B,'#64H
    MOV A,'#DATA_SUDUT_LOW
    MUL AB
    MOV A,'#DATA_SUDUT_LOW
    ADD A,B
    MOV A,'#DATA_SUDUT_HIGH
    SJMP TETAP

TAMBAH1:
    MOV B,'#64H
    MOV A,'#DATA_SUDUT_LOW
    MUL AB
    RET

;-----------------------------------------------------

DIS_JARAK:
    MOV A,'#C0H
    ACALL PERINTAH
    MOV A,'#T' ;I
    ACALL TAMPILKAN
    MOV A,'#N' ;N
    ACALL TAMPILKAN
    MOV A,'#P' ;P
    ACALL TAMPILKAN
    MOV A,'#20H' ;SPASI
    ACALL TAMPILKAN
    MOV A,'#J' ;J
    ACALL TAMPILKAN
    MOV A,'#R' ;R
    ACALL TAMPILKAN
    MOV A,'#K' ;K
    ACALL TAMPILKAN
    MOV A,'#3AH' ;;
    ACALL TAMPILKAN
    MOV A,'#LCD_CM
    ACALL PERINTAH
    MOV A,'#43H' ;C
    ACALL TAMPILKAN
    MOV A,'#4DH' ;M
    ACALL TAMPILKAN
    RET
MOV DATA_SUDUT_LOW,A
MOV DATA_SUDUT_HIGH,B
SJMP TETAP

TAMBAH2:
MOV B,#64H
MOV A,DATA_SUDUT_LOW
MUL AB
MOV DATA_SUDUT_LOW,A
MOV DATA_SUDUT_HIGH,B
MOV A,DATA_SUDUT_HIGH
CJNE A,#01H,TETAP
MOV B,#64H
ADD A,B
MOV DATA_SUDUT_HIGH,A
TETAP:
MOV A,DATA_SUDUT_LOW
CLR C
ADD A,#7EH
MOV DATA_SUDUT_LOW,A
MOV DATA_SUDUT_HIGH
ADD A,#04H
MOV DATA_SUDUT_HIGH,A
RET

AMBIL_JARAK:
MOV A,#LCD_LINE2_9
ACALL PERINTAH
ACALL CEK_KEYPAD
CJNE A,#0E5H,JARAK_BENAR
MOV A,#LCD_LINE1_9
LJMP JARAK1

JARAK_BENAR:
MOV A,J_PULUHAN
MOV B,#PENGAJI_PULUHAN
MUL AB
MOV B,J_SATUAN
ADD A,B
MOV A,R1
MOV A,J_RATUSAN
MOV B,#PENGAJI_RATUSAN
MUL AB
CLR C
ADD A,R1
MOV DATA_JARAK_LOW,A
MOV A,B
ADDC A,#04H
MOV DATA_JARAK_LOW,A
RET

CEK_KEYPAD:
MOV 2FH,#03H
CEK_DATA:
MOV KEYPAD,#7FH ;KIRIM DATA
MOV A,KEYPAD
ANL A,#0FDH

TOMBOL1:
CJNE A,#7CH,TOMBOL2
ACALL DELAY_KEYPAD
MOV A,#01H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL2:
CJNE A,#79H,TOMBOL3
ACALL DELAY_KEYPAD
MOV A,#02H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL3:
CJNE A,#75H,TOMBOL4
ACALL DELAY_KEYPAD
MOV A,#03H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL4:
MOV KEYPAD,#0BFH ;KIRIM DATA
MOV A,KEYPAD
ANL A,#0FDH
CJNE A,#0BCH,TOMBOL5
ACALL DELAY_KEYPAD
MOV A,#04H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL5:
CJNE A,#0B9H,TOMBOL6
ACALL DELAY_KEYPAD
MOV A,#05H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL6:
CJNE A,#0B5H,TOMBOL7
ACALL DELAY_KEYPAD
MOV A,#06H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL7:
MOV KEYPAD,#0DFH ;KIRIM DATA
MOV A,KEYPAD
ANL A,#0FDH
CJNE A,#0DCH,TOMBOL8
ACALL DELAY_KEYPAD
MOV A,#07H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL8:
CJNE A,#0D9H,TOMBOL9
ACALL DELAY_KEYPAD
MOV A,#08H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL9:
CJNE A,#0D5H,TOMBOL_BINTANG
ACALL DELAY_KEYPAD
MOV A,#09H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL_BINTANG:
MOV KEYPAD,#0EFH;KIRIM DATA
MOV A,KEYPAD
ANL A,#0FDH
CJNE A,#0ECH,TOMBOL0
ACALL DELAY_KEYPAD
AJMP MASUKKAN_DATA_OK

TOMBOL0:
CJNE A,#0E9H,TOMBOL_PAGAR
ACALL DELAY_KEYPAD
MOV A,#09H
ACALL TAMPILKAN_KEYPAD
AJMP MEMASUKKAN_DATA

TOMBOL_PAGAR:
CJNE A,#0E5H,KEMBALI
ACALL DELAY_KEYPAD
AJMP SALAH

KEMBALI:
AJMP CEK_DATA

MEMASUKKAN_DATA:
MOV @R0,A
INC R0
DEC 2FH
LJMP CEK_DATA

MASUKKAN_DATA_OK:
RET

SALAH:
RET

;-----------------------------------------------------
; PROGRAM YANG BERHUBUNGAN DENGAN LCD
;-----------------------------------------------------

INISIALISASI_PEMBUAT:
MOV A,#3CH
ACALL PERINTAH
MOV A,#0FH
ACALL PERINTAH
MOV A,#06H
ACALL PERINTAH
MOV A,#LCD_CLEAR
ACALL PERINTAH
MOV A,#80H
ACALL PERINTAH
MOV A,#R
A CALL TAMPILKAN
MOV A,#I
A CALL TAMPILKAN
MOV A,#K
A CALL TAMPILKAN
MOV A,#I
A CALL TAMPILKAN
MOV A,#20h
A CALL TAMPILKAN
MOV A,'0'
A CALL TAMPILKAN
MOV A,'1'
A CALL TAMPILKAN
MOV A,'2'
A CALL TAMPILKAN
MOV A,'2'
A CALL TAMPILKAN
MOV A,'0'
A CALL TAMPILKAN
MOV A,'2'
A CALL TAMPILKAN
MOV A,'0'
A CALL TAMPILKAN
MOV A,#0C0h
ACALL PERINTAH
MOV A,#00100111B ;'
A CALL TAMPILKAN
MOV A,#'=
A CALL TAMPILKAN
MOV A,#'0'
A CALL TAMPILKAN
MOV A,#00h
ACALL PERINTAH
MOV A,#00100111B ;'
A CALL TAMPILKAN
MOV A,#20H
ACALL TAMPILKAN
MOV A,#'C' ;C
ACALL TAMPILKAN
MOV A,#'M' ;M
ACALL TAMPILKAN
MOV A,#'P' ;P
ACALL TAMPILKAN
MOV A,#'S' ;S
ACALL TAMPILKAN
MOV A,#'-' ;-
ACALL TAMPILKAN
MOV A, #'0' ;0
ACALL TAMPILKAN
MOV A, #'3' ;3
ACALL TAMPILKAN
ACALL DELAY_PEMBUAT
RET

PERINTAH:
ACALL CEK_BUSY
MOV LCD,A
CLR RS
CLR RW
SETB ENABLE
CLR ENABLE
RET

TAMPILKAN_KEYPAD:
ADD A,#30H
TAMPILKAN:
ACALL CEK_BUSY
MOV LCD,A
SETB RS
CLR RW
SETB ENABLE
CLR ENABLE
RET

CEK_BUSY:
CLR ENABLE
MOV LCD,#0FFH
CLR RS
SETB RW

TUNGGU:
CLR ENABLE
SETB ENABLE
JB P0.7,TUNGGU
CLR ENABLE
RET

LCD_DIBERSIHkan:
MOV A,#LCD_CLEAR
ACALL PERINTAH
ACALL PERINTAH
RET

LCD_OPTION:
MOV A,#80H
ACALL PERINTAH
MOV A,#43H ;C
ACALL TAMPILKAN
MOV A,#4Fh ;O
ACALL TAMPILKAN
MOV A,#42H ;B
ACALL TAMPILKAN
MOV A,#41H ;A
ACALL TAMPILKAN
MOV A,#20H ;SPASI
ACALL TAMPILKAN
MOV A,#4CH ;L
ACALL TAMPILKAN
MOV A,#41H ;A
ACALL TAMPILKAN
MOV A,#47H ;G
ACALL TAMPILKAN
MOV A,#49H ;I
ACALL TAMPILKAN
MOV A,#3FH ;?
ACALL TAMPILKAN
MOV A,#0C0H
;BARIS2
ACALL PERINTAH
MOV A,#59H ;Y
ACALL TAMPILKAN
MOV A,#45H ;E
ACALL TAMPILKAN
MOV A,#53H ;S
ACALL TAMPILKAN
MOV A,#20H ;SPASI
ACALL TAMPILKAN
MOV A,#2FH ;/
ACALL TAMPILKAN
MOV A,#20H ;SPASI
ACALL TAMPILKAN
MOV A,#4EH ;N
ACALL TAMPILKAN
MOV A,#4FH ;O
ACALL TAMPILKAN
RET

;-----------------------------------------------------
; PROGRAM UNTUK
;MENGAMBIL PWM DARI CMPS-03
;-----------------------------------------------------

COMPASS:
MOV TL2,#00H
MOV TH2,#00H
JNB P1.1,$
SETB TR2
JNB EXF2,$
CLR EXF2
CLR TR2

B-5
CLR C
MOV A,RCAP2L
ADD A,#7EH
MOV B,A
MOV A,RCAP2H
ADDC A,#04H
MOV R3,A
MOV A,B
CJNE A,DATA_SUDUT_LOW,TERUS
MOV A,R3
CJNE A,DATA_SUDUT_HIGH,TERUS
CLR EXF2
CLR TR2
LJMP START2
TERUS:
RET

;-----------------------------------------------------
;PROGRAM UNTUK MENGATUR ARAH
; BELOK DARI MOTOR STEPPER
;-----------------------------------------------------

BELOK:
MOV T2MOD,#00000001B
MOV T2CON,#00001001B
;MODE CAPTURE
SETB ET2
SETB TR2
MOV R3,#03H
SAFE1:
;UNTUK MENGETAHUI BAHWA DATA
;DARI TIMER 2 BENAR
MOV TL2,#00H
MOV TH2,#00H
JNB P1.1,$
SETB TR2
JNB EXF2,$
CLR EXF2
CLR TR2
DJNZ R3,SAFE1

MOVA,R3
ADDA,#04H
MOVR4,A
MOVA,DATA_SUDUT_HIGH
CLR C
SUBB A,R4
JNC KANAN

KIRI:
MOV A,#SKI8
MOV R2,#SKA1
ORLA,R2
MOVP2,A
ACALLDELAY_STEPPER
ACALLCOMPASS

KANAN:
MOV A,#SKI11
MOV R2,#SKA8
ORLA,R2
MOVP2,A
ACALLDELAY_STEPPER
ACALLCOMPASS
MOV A,#SKI2
MOV R2,#SKA7
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL COMPASS

MOV A,#SKI3
MOV R2,#SKA6
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL COMPASS

MOV A,#SKI4
MOV R2,#SKA5
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL COMPASS

MOV A,#SKI5
MOV R2,#SKA4
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL COMPASS

MOV A,#SKI6
MOV R2,#SKA3
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL COMPASS

MOV A,#SKI7
MOV R2,#SKA2
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL COMPASS

MOV A,#SKI8
MOV R2,#SKA1
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL COMPASS

LJMP KANAN

MAJU:
MOV TMOD,#01010000B
;PAKAI TIMER1
SETB TR1

MAJU1:
MOV A,#SKI11

MOV R2,#SKA1
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

MOV A,#SKI2
MOV R2,#SKA2
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

MOV A,#SKI3
MOV R2,#SKA3
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

MOV A,#SKI4
MOV R2,#SKA4
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

MOV A,#SKI5
MOV R2,#SKA5
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

MOV A,#SKI6
MOV R2,#SKA6
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

MOV A,#SKI7
MOV R2,#SKA7
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

MOV A,#SKI8
MOV R2,#SKA8
ORL A,R2
MOV P2,A
ACALL DELAY_STEPPER
ACALL JALAN

LJMP MAJU1
; PROGRAM UNTUK
MENGETAHUI JARAK
DENGA N MENGGUNAKAN
OPTOCOPLER
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
JALAN:
MOV A,TL1
CJNE
A,DATA_JARAK_LOW,TERUS1
MOV A,TH1
CJNE
A,DATA_JARAK_HIGH,TERUS1
CLR TR1
LJMP START3

TERUS1:
RET
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;  DELAY-DELAY
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
DELAY_PEMBUAT:
MOV R5,#18H
DELAY_PEMBUAT1:
MOV R6,#0F9H
DELAY_PEMBUAT2:
MOV R7,#0FBH
DELAY_PEMBUAT3:
DJNZ R7,DELAY_PEMBUAT3
DJNZ R6,DELAY_PEMBUAT2
DJNZ R5,DELAY_PEMBUAT1
RET

DELAY_STEPPER:
MOV R5,#01AH
DELAY_STEPPER2:
MOV R4,#0FFH
DELAY_STEPPER1:
DJNZ R4,DELAY_STEPPER1
DJNZ R5,DELAY_STEPPER2
RET

DELAY_KEYPAD:
MOV R5,#02H
DELAY_KEYPAD1:
MOV R6,#0EAH
DELAY_KEYPAD2:
MOV R7,#0FAH
DELAY_KEYPAD3:
DJNZ R7,DELAY_KEYPAD3
DJNZ R6,DELAY_KEYPAD2
DJNZ R5,DELAY_KEYPAD1
RET

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;  OPTION
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
OPTION:
ACALL LCD_OPTION
CHECK:
ACALL CEK_KEYPAD
CJNE A,#0ECH,OPTION_NO
LJMP START1

OPTION_NO:
CJNE A,#0E5H,CHECK
ACALL LCD_DIBERSIHKAN
MOV A,#02H
ACALL PERINTAH
MOV A,#'T'
;T
ACALL TAMPILKAN
MOV A,#'E'
;E
ACALL TAMPILKAN
MOV A,#'R'
;R
ACALL TAMPILKAN
MOV A,#'I'
;I
ACALL TAMPILKAN
MOV A,#'M'
;M
ACALL TAMPILKAN
MOV A,#'A'
;A
ACALL TAMPILKAN
MOV A,#20H
;SPASI
ACALL TAMPILKAN
MOV A,#'K'
;K
ACALL TAMPILKAN
MOV A,#'A'
;A
ACALL TAMPILKAN
MOV A,#'S'
;S
ACALL TAMPILKAN
MO V A,#'T'
;I
ACALL TAMPILKAN
MOV A,#'H'
;H
ACALL TAMPILKAN
MOV A,#0C2H
ACALL PERINTAH
MOV A,#'B'
;B
ACALL TAMPILKAN
MOV A,#'y'
;y
ACALL TAMPILKAN
MOV A,#'e'
;e
ACALL TAMPILKAN
MOV A,#'B'
;B
ACALL TAMPILKAN
MOV A,#'y'
;y
ACALL TAMPILKAN
MOV A,#'e'
;e
ACALL TAMPILKAN
MOV A,#'B'
;B
ACALL TAMPILKAN
MOV A,#'y'
;y
ACALL TAMPILKAN
MOV A,#'e'
;e
ACALL TAMPILKAN
MOV A,#'B'
;B
ACALL TAMPILKAN
MOV A,#20H
;SPASI
ACALL TAMPILKAN
MOV A,#20H
;SPASI
ACALL TAMPILKAN
MOV A,#5EH
ACALL TAMPILKAN
MOV A,#5FH
ACALL TAMPILKAN
MOV A,#5EH
ACALL TAMPILKAN
SELESAI:
END
LAMPIRAN C

SKEMA RANGKAIAN
LAMPIRAN D

FOTO ALAT