LAMPIRAN A

DATA SHEET KOMPONEN

Features

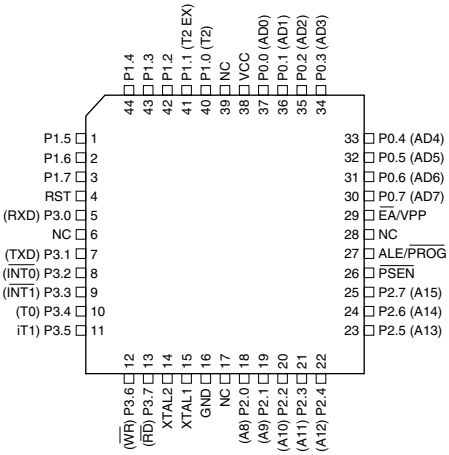
- **Compatible with MCS-51™ Products**
- **8K Bytes of In-System Reprogrammable Flash Memory**
- **Endurance: 1,000 Write/Erase Cycles**
- **Fully Static Operation: 0 Hz to 24 MHz**
- **Three-level Program Memory Lock**
- **256 x 8-bit Internal RAM**
- **32 Programmable I/O Lines**
- **Three 16-bit Timer/Counters**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

Description

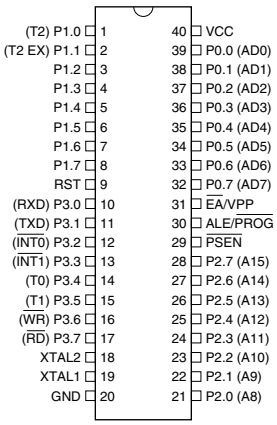
The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction 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

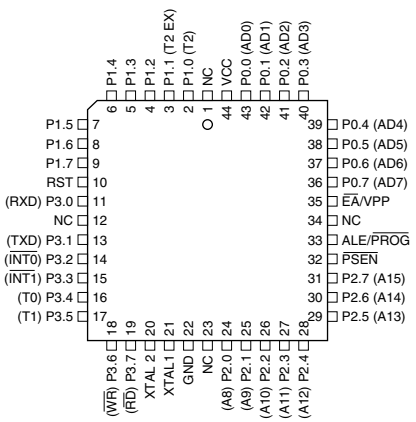
PQFP/TQFP



PDIP



PLCC

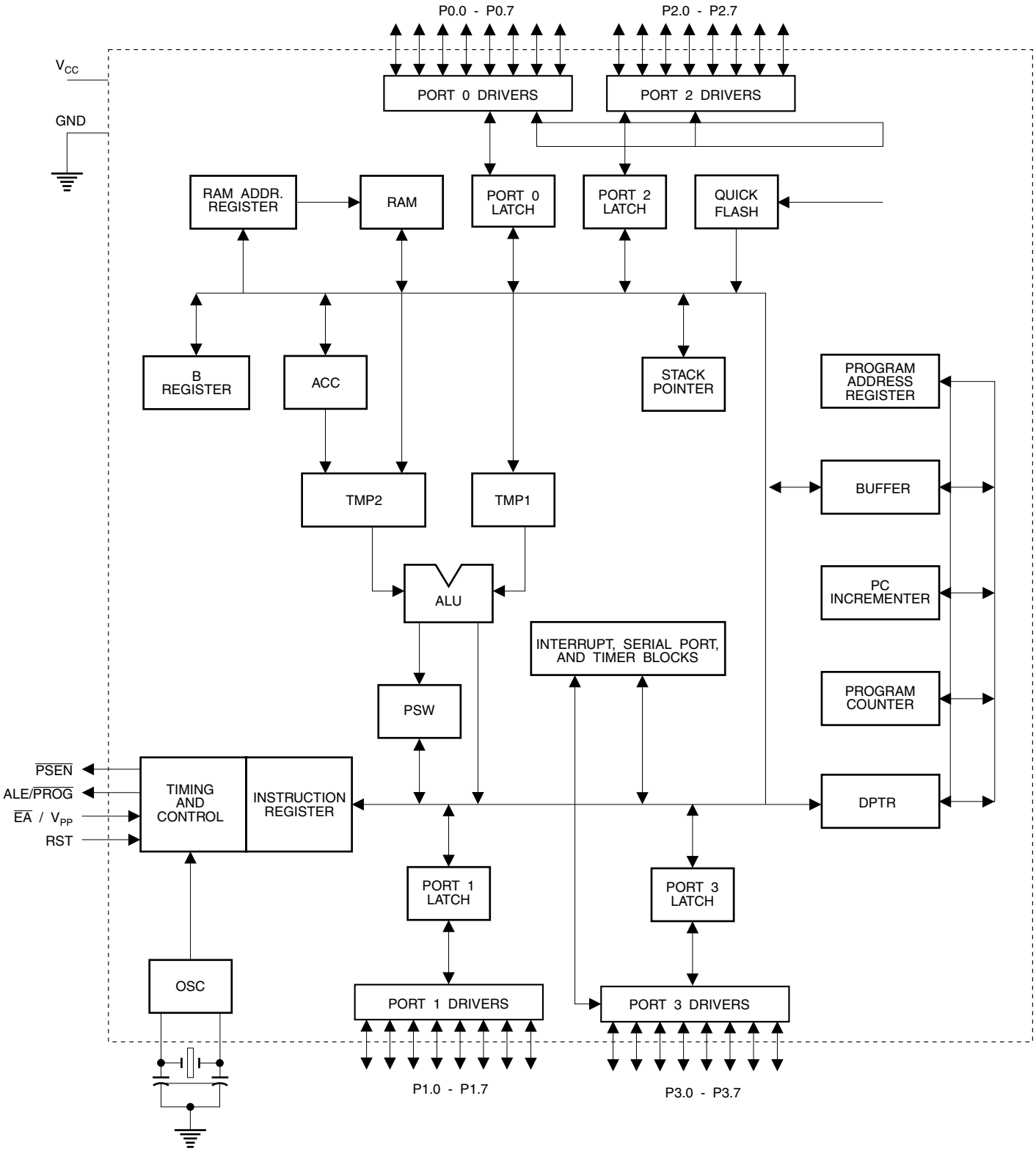


8-bit Microcontroller with 8K Bytes Flash

AT89C52

Rev. 0313H–02/00

Block Diagram



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
P1.0	T2 (external count input to Timer/Counter 2), clock-out
P1.1	T2EX (Timer/Counter 2 capture/reload trigger and direction control)

Port 2

Port 2 is an 8-bit bi-directional I/O port with internal pullups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pullups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (I_{IL}) because of the internal pullups.

Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @ DPTR). In this application, Port 2 uses strong internal pullups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function Register.

Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

Port 3

Port 3 is an 8-bit bi-directional I/O port with internal pullups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pullups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (I_{IL}) because of the pullups.

Port 3 also serves the functions of various special features of the AT89C51, as shown in the following table.

Port 3 also receives some control signals for Flash programming and verification.

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

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

ALE/$\overline{PROG}$
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 ($\overline{PROG}$) 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.

$\overline{\text{PSEN}}$

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

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

$\overline{\text{EA}}$/VPP

External Access Enable. $\overline{\text{EA}}$ 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, $\overline{\text{EA}}$ will be internally latched on reset.

$\overline{\text{EA}}$ should be strapped to V_{CC} for internal program executions.

This pin also receives the 12-volt programming enable voltage (V_{PP}) 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

0F8H									0FFH
0F0H	B 00000000								0F7H
0E8H									0EFH
0E0H	ACC 00000000								0E7H
0D8H									0DFH
0D0H	PSW 00000000								0D7H
0C8H	T2CON 00000000	T2MOD XXXXXX00	RCAP2L 00000000	RCAP2H 00000000	TL2 00000000	TH2 00000000			0CFH
0C0H									0C7H
0B8H	IP XX000000								0BFH
0B0H	P3 11111111								0B7H
0A8H	IE 0X000000								0AFH
0A0H	P2 11111111								0A7H
98H	SCON 00000000	SBUF XXXXXXXX							9FH
90H	P1 11111111								97H
88H	TCON 00000000	TMOD 00000000	TL0 00000000	TL1 00000000	TH0 00000000	TH1 00000000			8FH
80H	P0 11111111	SP 00000111	DPL 00000000	DPH 00000000				PCON 0XXX0000	87H

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.r

Table 2. T2CON – Timer/Counter 2 Control Registe

T2CON Address = 0C8H — Reset Value = 0000 0000B

Bit Addressable

Bit	TF2	EXF2	RCLK	TCLK	EXEN2	TR2	C/$\overline{T2}$	CP/$\overline{RL2}$
	7	6	5	4	3	2	1	0

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/$\overline{T2}$	Timer or counter select for Timer 2. C/$\overline{T2}$ = 0 for timer function. C/$\overline{T2}$ = 1 for external event counter (falling edge triggered).
CP/$\overline{RL2}$	Capture/Reload select. CP/$\overline{RL2}$ = 1 causes captures to occur on negative transitions at T2EX if EXEN2 = 1. CP/$\overline{RL2}$ = 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).

```
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/$\overline{T2}$ 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.

Table 3. Timer 2 Operating Modes

RCLK +TCLK	CP/$\overline{RL2}$	TR2	MODE
0	0	1	16-bit Auto-reload
0	1	1	16-bit Capture
1	X	1	Baud Rate Generator
X	X	0	(Off)

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 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 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 1. Timer in Capture Mode

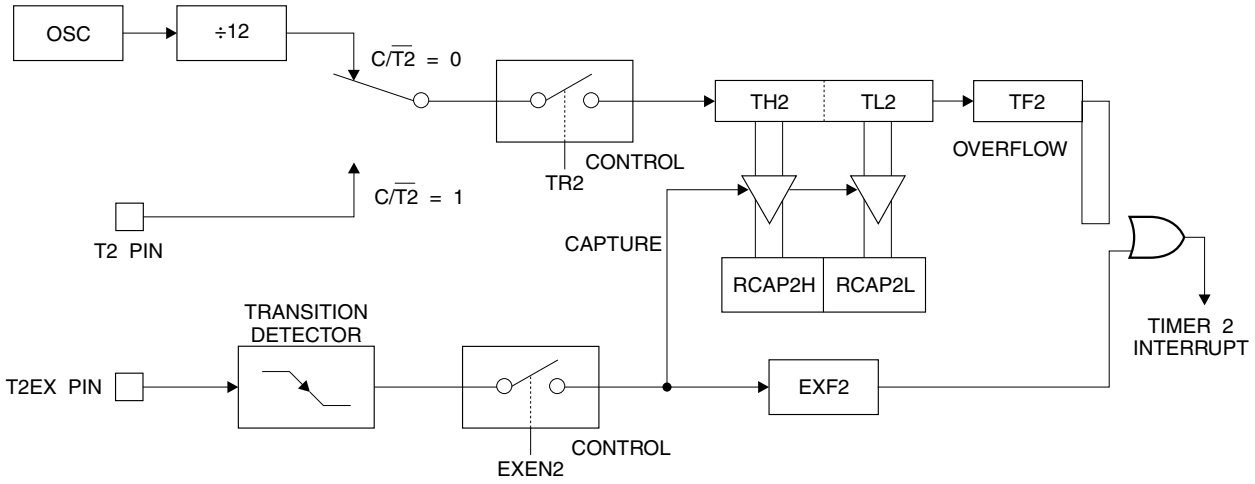


Figure 2 shows Timer 2 automatically counting up when DCEN = 0. In this mode, two options are selected by bit EXEN2 in T2CON. If EXEN2 = 0, Timer 2 counts up to 0FFFFH and then sets the TF2 bit upon overflow. The overflow also causes the timer registers to be reloaded with the 16-bit value in RCAP2H and RCAP2L. The values in Timer in Capture ModeRCAP2H 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)

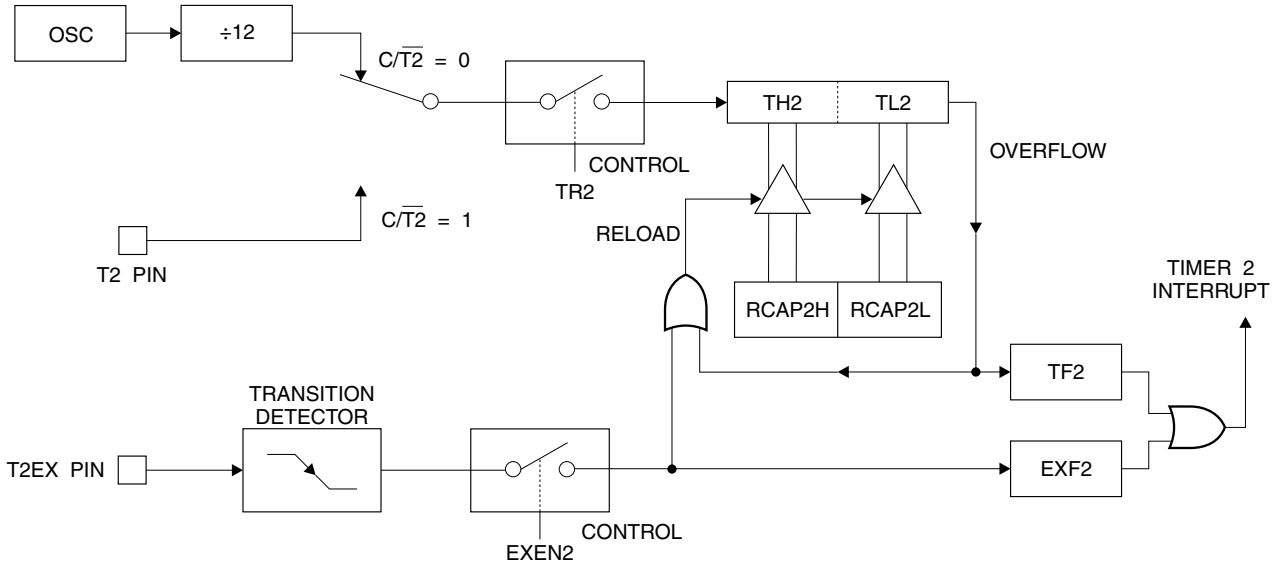


Table 4. T2MOD – Timer 2 Mode Control Register

T2MOD Address = 0C9H — Reset Value = XXXX XX00B

Not Bit Addressable

	–	–	–	–	–	–	T2OE	DCEN
Bit	7	6	5	4	3	2	1	0

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)

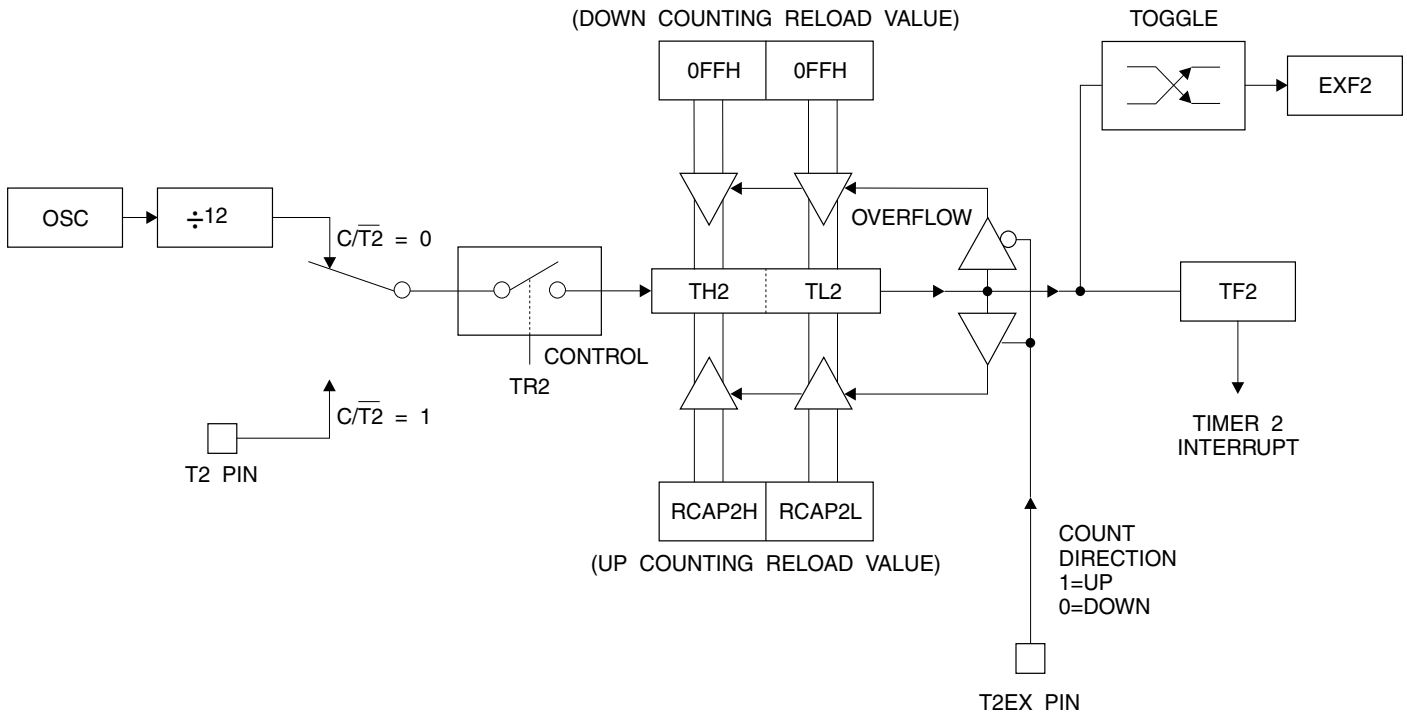
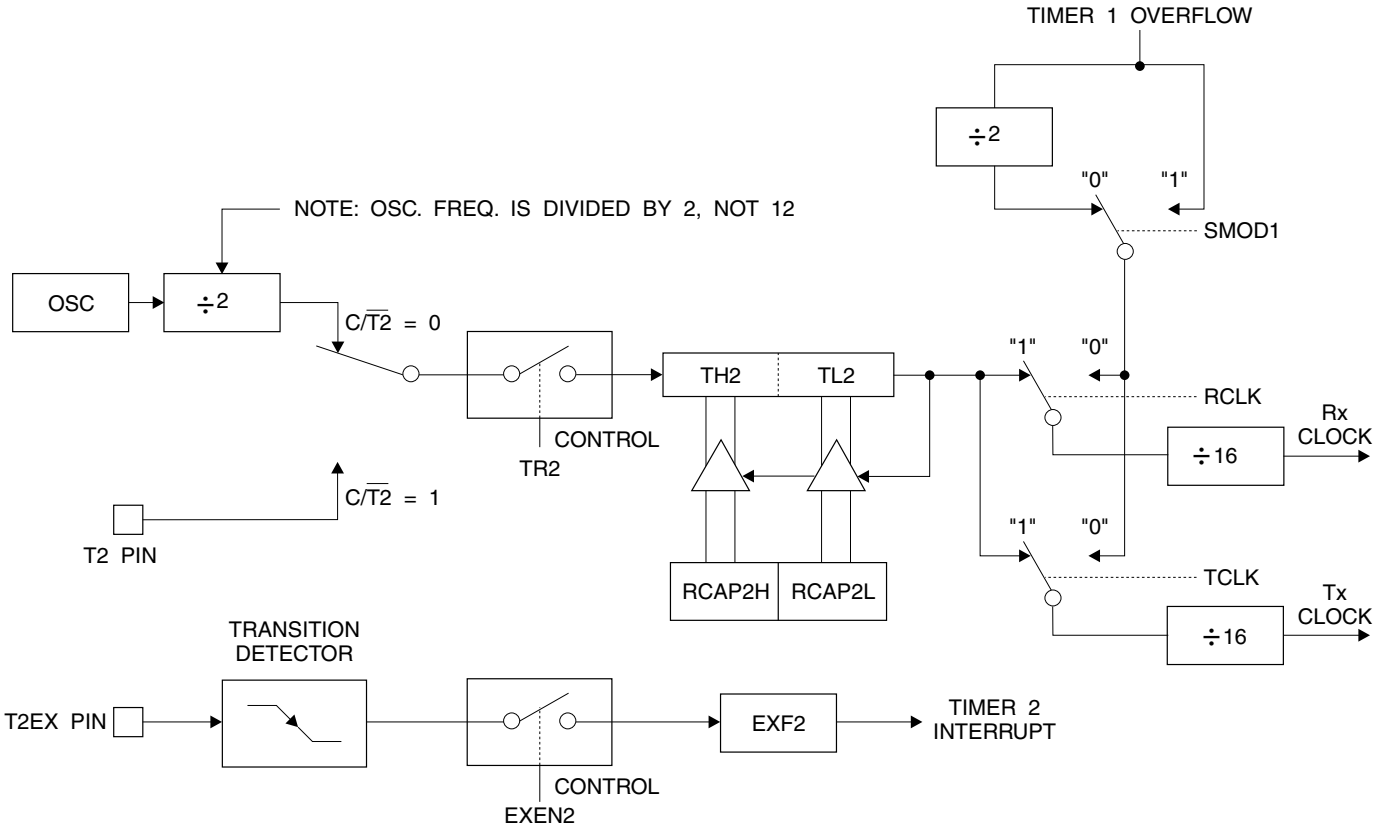
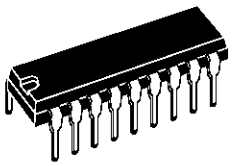


Figure 4. Timer 2 in Baud Rate Generator Mode



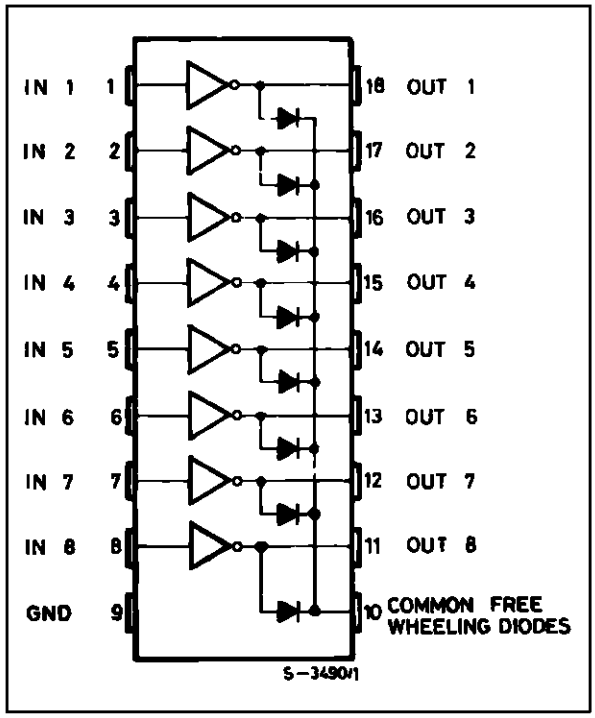
EIGHT DARLINGTON ARRAYS

- EIGHT DARLINGTONS WITH COMMON EMITTERS
- OUTPUT CURRENT TO 500 mA
- OUTPUT VOLTAGE TO 50 V
- INTEGRAL SUPPRESSION DIODES
- VERSIONS FOR ALL POPULAR LOGIC FAMILIES
- OUTPUT CAN BE PARALLELED
- INPUTS PINNED OPPOSITE OUTPUTS TO SIMPLIFY BOARD LAYOUT



DIP18

PIN CONNECTION (top view)8



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.

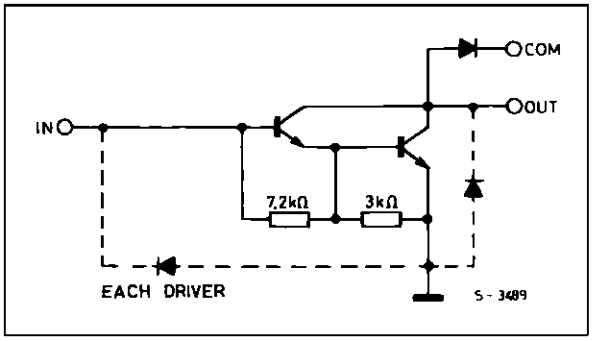
Five versions are available to simplify interfacing to standard logic families : the ULN2801A is designed for general purpose applications with a current limit resistor ; the ULN2802A has a 10.5kΩ input resistor and zener for 14-25V PMOS ; the ULN2803A has a 2.7kΩ input resistor for 5V TTL and CMOS ; 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.

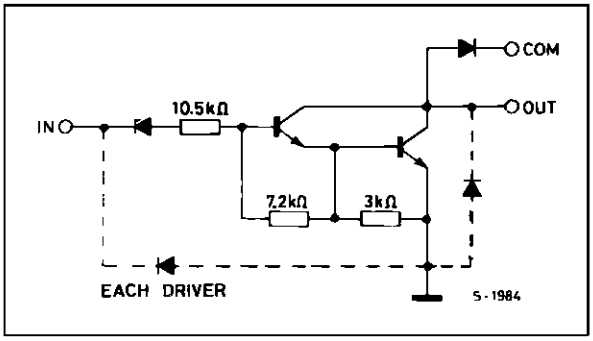
September 1997

SCHEMATIC DIAGRAM AND ORDER CODES

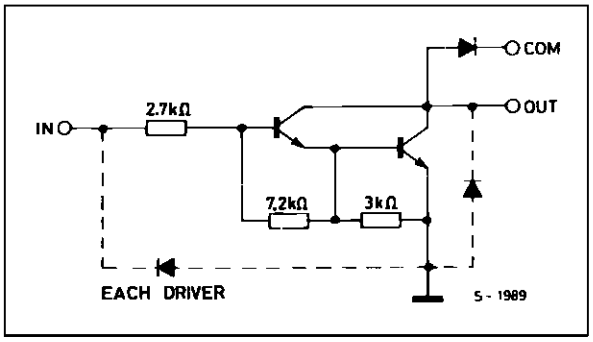
For ULN2801A (each driver for PMOS-CMOS)



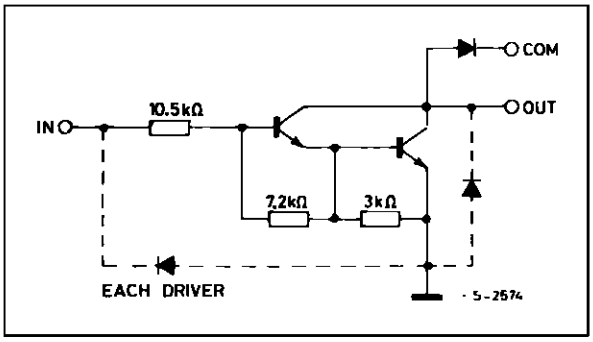
For ULN2802A (each driver for 14-15 V PMOS)



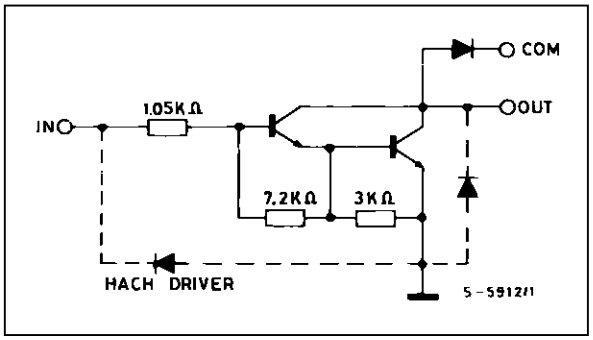
For ULN2803A (each driver for 5 V, TTL/CMOS)



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



For ULN2805A (each driver for high out TTL)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_o	Output Voltage	50	V
V_i	Input Voltage for ULN2802A, UL2803A, ULN2804A for ULN2805A	 30 15	V
I_C	Continuous Collector Current	500	mA
I_B	Continuous Base Current	25	mA
P_{tot}	Power Dissipation (one Darlington pair) (total package)	 1.0 2.25	W
T_{amb}	Operating Ambient Temperature Range	– 20 to 85	°C
T_{stg}	Storage Temperature Range	– 55 to 150	°C
Tj	Junction Temperature Range	– 20 to 150	°C

THERMAL DATA

Symbol	Parameter		Value	Unit
$R_{th\ j-amb}$	Thermal Resistance Junction-ambient	Max.	55	°C/W

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit	Fig.
I_{CEX}	Output Leakage Current	V_{CE} = 50V T_{amb} = 70°C, V_{CE} = 50V T_{amb} = 70°C for ULN2802A V_{CE} = 50V, V_i = 6V for ULN2804A V_{CE} = 50V, V_i = 1V			50 100 500 500	µA µA µA µA	1a 1a 1b 1b
$V_{CE(sat)}$	Collector-emitter Saturation Voltage	I_C = 100mA, I_B = 250µA I_C = 200mA, I_B = 350µA I_C = 350mA, I_B = 500µA		0.9 1.1 1.3	1.1 1.3 1.6	V V V	2
$I_{i(on)}$	Input Current	for ULN2802A V_i = 17V for ULN2803A V_i = 3.85V for ULN2804A V_i = 5V V_i = 12V for ULN2805A V_i = 3V		0.82 0.93 0.35 1 1.5	1.25 1.35 0.5 1.45 2.4	mA mA mA mA mA	3
$I_{i(off)}$	Input Current	T_{amb} = 70°C, I_C = 500µA	50	65		µA	4
$V_{i(on)}$	Input Voltage	V_{CE} = 2 V for ULN2802A I_C = 300mA for ULN2803A I_C = 200mA I_C = 250mA I_C = 300mA for ULN2804A I_C = 125mA I_C = 200mA I_C = 275mA I_C = 350mA for ULN2805A I_C = 350mA			 13 2.4 2.7 3 5 6 7 8 2.4	 V V V V V V V V V	5
h_{FE}	DC Forward Current Gain	for ULN2801A V_{CE} = 2V, I_C = 350mA	1000			–	2
C_i	Input Capacitance			15	25	pF	–
t_{PLH}	Turn-on Delay Time	0.5 V_i to 0.5 V_o		0.25	1	µs	–
t_{PHL}	Turn-off Delay Time	0.5 V_i to 0.5 V_o		0.25	1	µs	–
I_R	Clamp Diode Leakage Current	V_R = 50V T_{amb} = 70°C, V_R = 50V			50 100	µA µA	6 6
V_F	Clamp Diode Forward Voltage	I_F = 350mA		1.7	2	V	7

TEST CIRCUITS

Figure 1a.

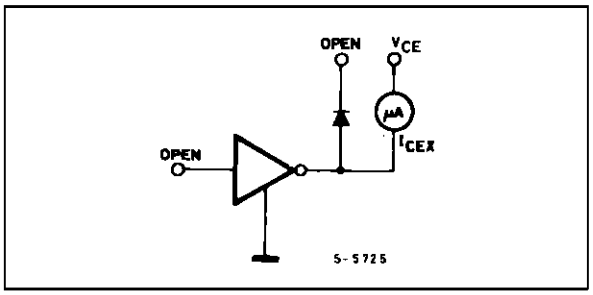


Figure 1b.

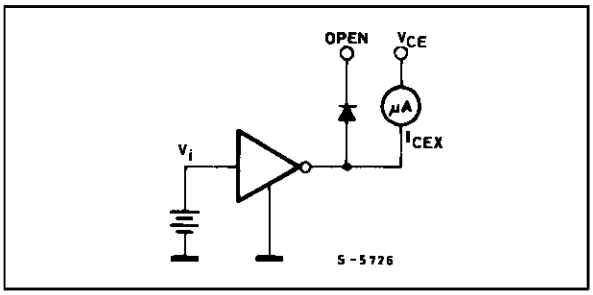


Figure 2.

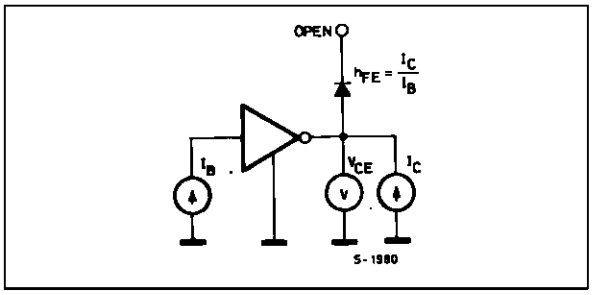


Figure 3.

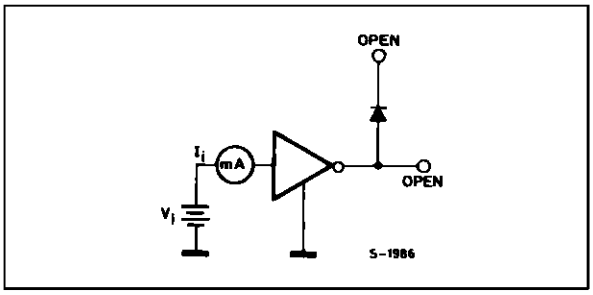


Figure 4.

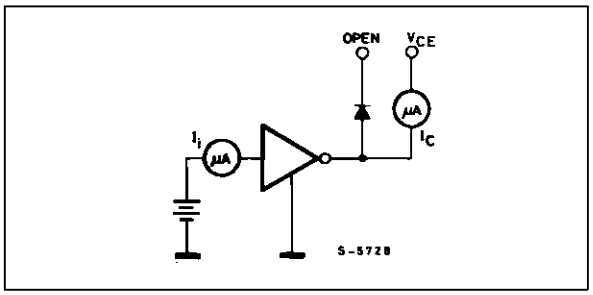


Figure 5.

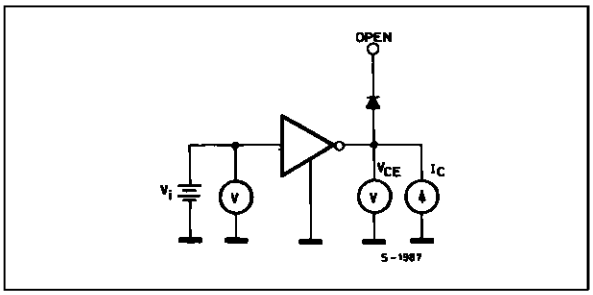


Figure 6.

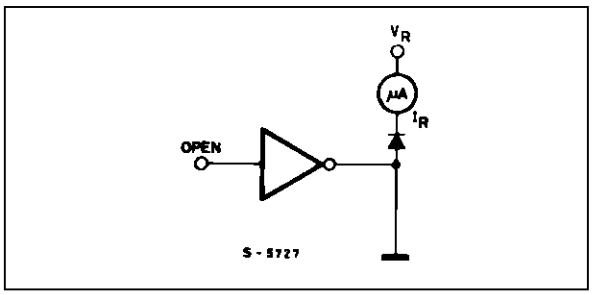


Figure 7.

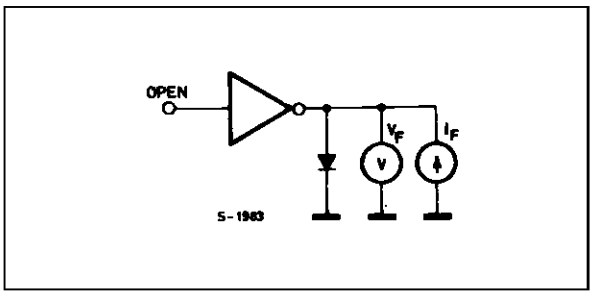


Figure 8 : Collector Current as a Function of Saturation Voltage.

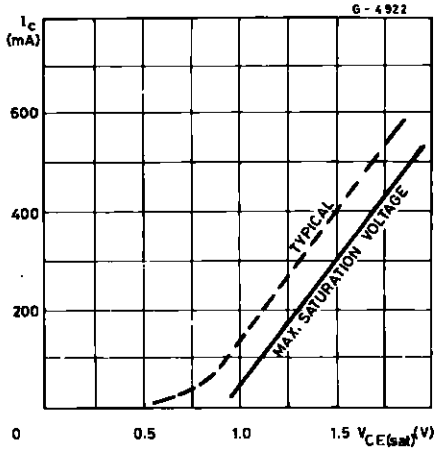


Figure 9 : Collector Current as a Function of Input Current.

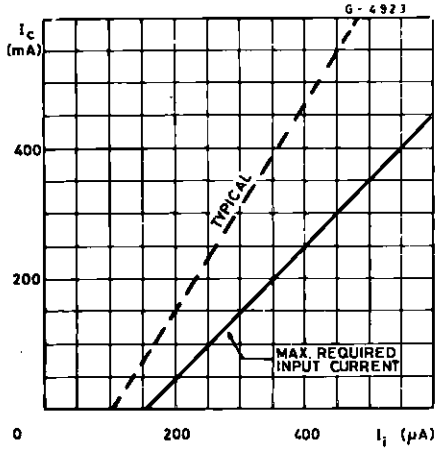


Figure 10 : Allowable Average Power Dissipation as a Function of Ambient Temperature.

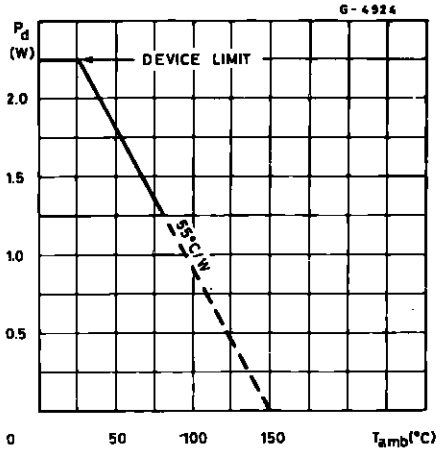


Figure 11 : Peak Collector Current as a Function of Duty Cycle.

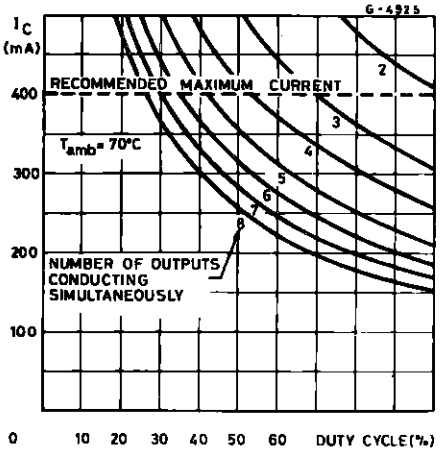


Figure 12 : Peak Collector Current as a Function of Duty.

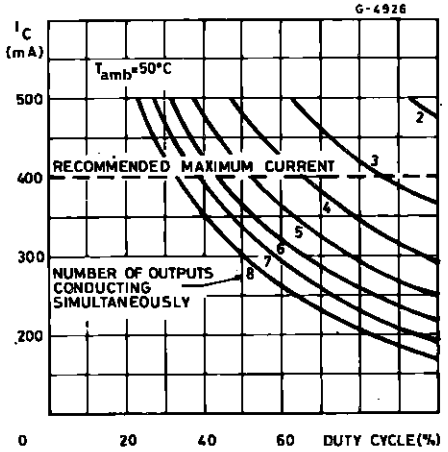


Figure 13 : Input Current as a Function of Input Voltage (for ULN2802A).

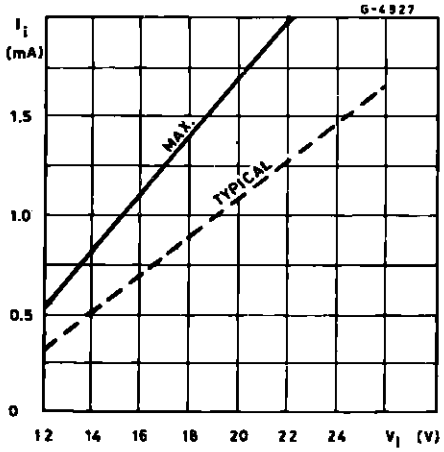


Figure 14 : Input Current as a Function of Input Voltage (for ULN2804A)

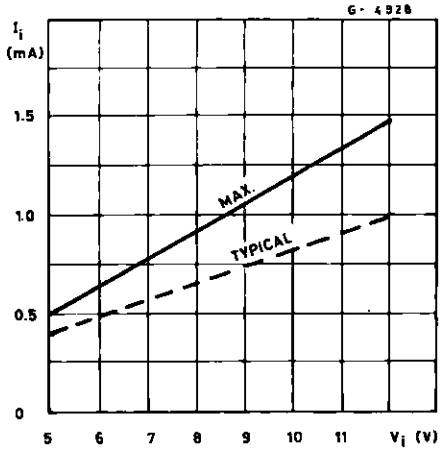


Figure 15 : Input Current as a Function of Input Voltage (for ULN2803A)

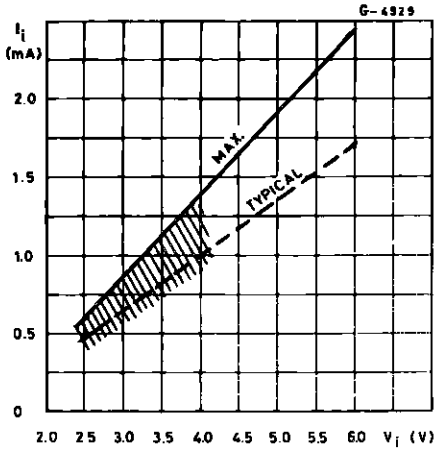
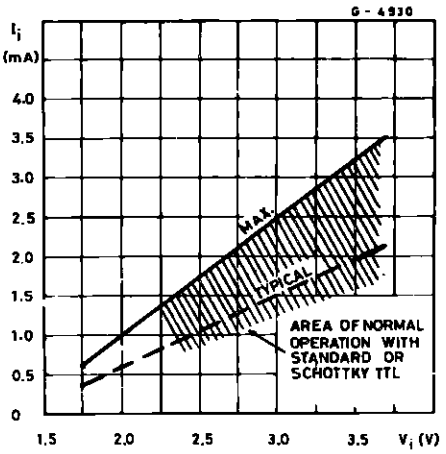
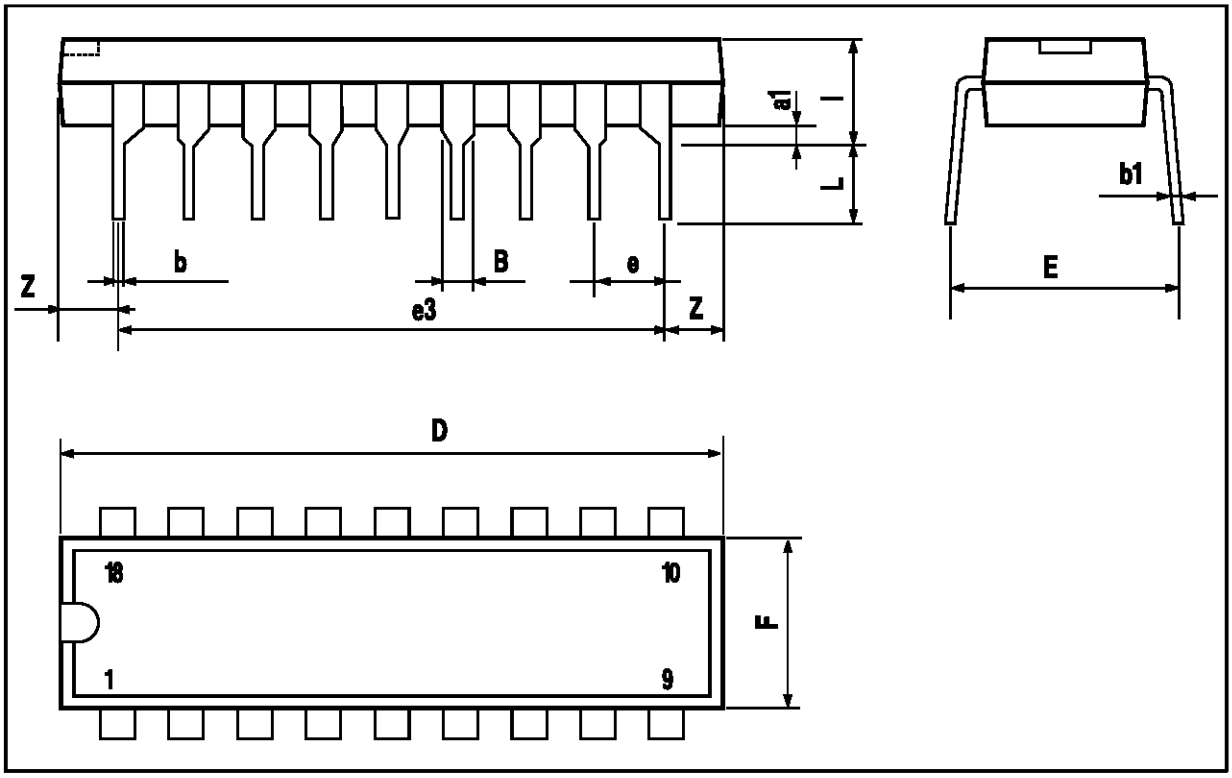


Figure 16 : Input Current as a Function of Input Voltage (for ULN2805A)



DIP18 PACKAGE MECHANICAL DATA

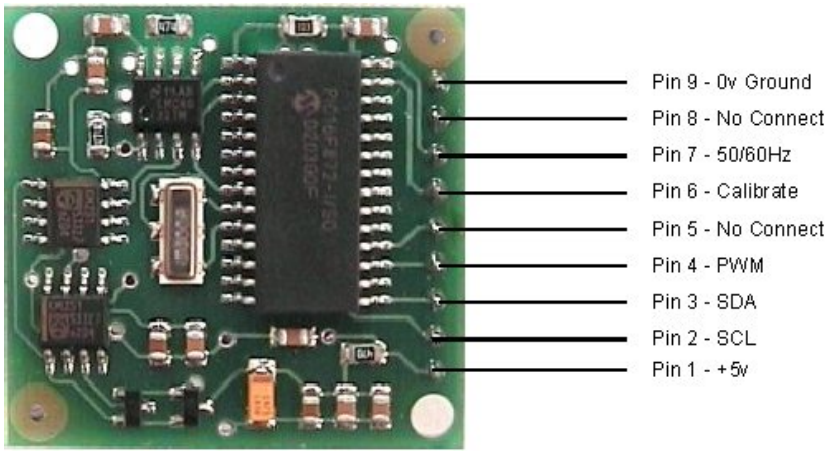
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
a1	0.254			0.010		
B	1.39		1.65	0.055		0.065
b		0.46			0.018	
b1		0.25			0.010	
D			23.24			0.915
E		8.5			0.335	
e		2.54			0.100	
e3		20.32			0.800	
F			7.1			0.280
I			3.93			0.155
L		3.3			0.130	
Z		1.27	1.59		0.050	0.063



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 Earths 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 Earths magnetic field.

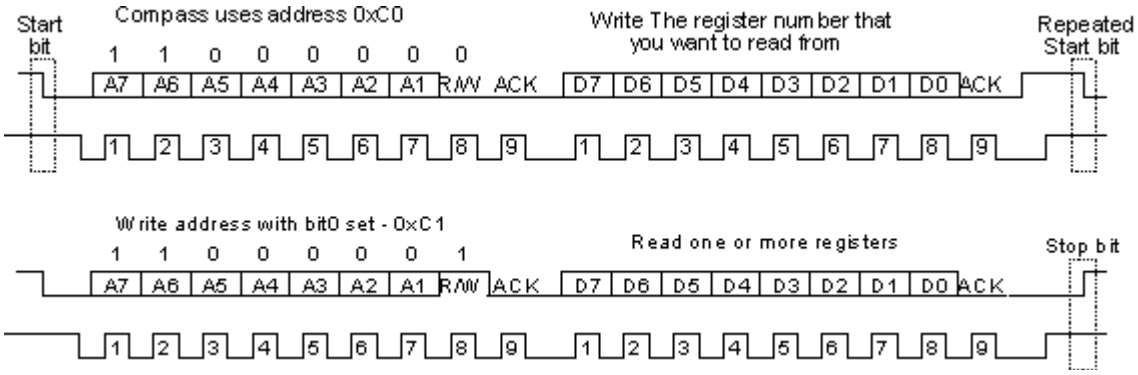
Connections to the compass module



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 100uS/° 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 1uS resolution, however I would not recommend measuring this to anything better than 0.1° (10uS). 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 (0XC0) 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;

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

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.

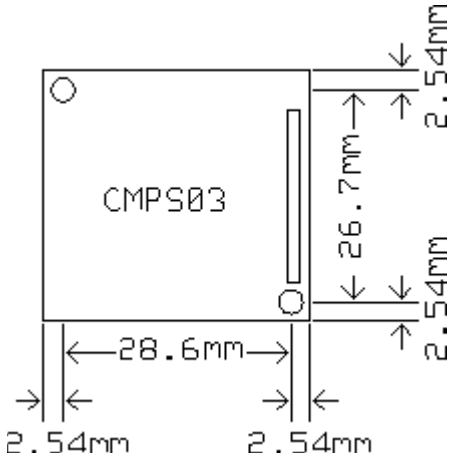
Pin 7 is an input pin selecting either 50Hz (low) or 60Hz (high) operation. I added this option after noticing a jitter of around 1.5° in the output. The cause was the 50Hz mains field in my workshop. By converting in synchronism with the mains frequency this was reduced to around 0.2° . An internal 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 us ed 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.

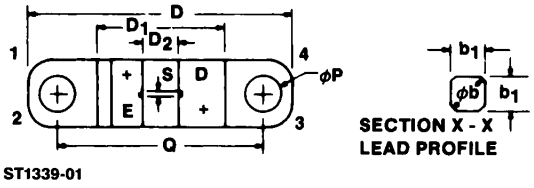


OPTOELECTRONICS

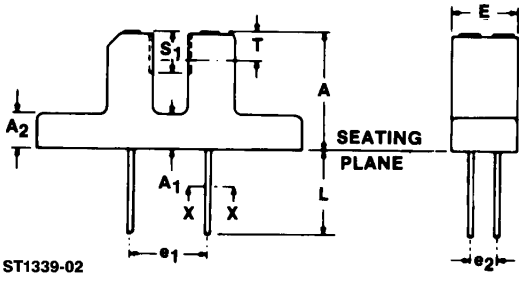
SLOTTED OPTICAL SWITCH

H21A1/2/3

PACKAGE DIMENSIONS



ST1339-01

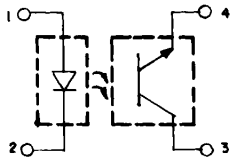


ST1339-02

SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
A_2	3.0	3.2	.119	.125	
Øb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D	24.3	24.7	.957	.972	
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
Øp	3.2	3.4	.126	.133	
Q	18.9	19.2	.745	.755	
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

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" ±0.75mm (±.030 INCH).

PACKAGE OUTLINE



ST1609

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 $I_{C(ON)}$

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C Unless Otherwise Specified)

Storage Temperature ..... −55°C to +100°C
Operating Temperature ..... −55°C to +100°C
Soldering:
Lead Temperature (Iron) ..... 240°C for 5 sec.[3,4,5]
Lead Temperature (Flow) ..... 260°C for 10 sec.[3,4]

INPUT DIODE
Continuous Forward Current ..... 60 mA
Reverse Voltage ..... 6.0 Volts
Power Dissipation ..... 100 mW[1]

OUTPUT TRANSISTOR
Collector-Emitter Voltage ..... 30 Volts
Emitter-Collector Voltage ..... 6 Volts
Power Dissipation ..... 150 mW[2]

ELECTRICAL CHARACTERISTICS (T_A = 25°C Unless Otherwise Specified)
(All measurements made under pulse conditions.)

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNITS	TEST CONDITIONS
INPUT DIODE						
Forward Voltage	V_F	—		1.7	V	I_F = 60 mA
Reverse Breakdown Voltage	V_R	6.0		—	V	I_R = 10μA
Reverse Leakage Current	I_R	—		1.0	μA	V_R = 3 V
OUTPUT TRANSISTOR						
Emitter-Collector Breakdown	BV_{ECO}	6.0		—	V	I_E = 100 μA, Ee = 0
Collector-Emitter Breakdown	BV_{CEO}	30		—	V	I_C = 1 mA, Ee = 0
Collector-Emitter Leakage	I_{CEO}	—		100	nA	V_{CE} = 25 V, Ee = 0
COUPLED						
On-State Collector Current	$I_{C(ON)}$		See page 3.		mA	
Saturation Voltage	$V_{CE(SAT)}$		See page 3.		V	
Turn-On Time	t_{on}		See page 3.		μS	
Turn-Off Time	t_{off}		See page 3.		μS	

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 1/16" (1.6 mm) from housing.*

$I_{C(ON)}$, $V_{CE(SAT)}$, t_{on}, AND t_{off}						
PARAMETER	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNITS**	**TEST CONDITIONS**
ON-STATE COLLECTOR CURRENT						
H21A1	$I_{C(ON)}$	0.15	—	—	mA	I_F = 5mA, V_{CE} = 5V
H21A2	$I_{C(ON)}$	0.30	—	—	mA	I_F = 5mA, V_{CE} = 5V
H21A3	$I_{C(ON)}$	0.60	—	—	mA	I_F = 5mA, V_{CE} = 5V
H21A1	$I_{C(ON)}$	1.0	—	—	mA	I_F = 20mA, V_{CE} = 5V
H21A2	$I_{C(ON)}$	2.0	—	—	mA	I_F = 20mA, V_{CE} = 5V
H21A3	$I_{C(ON)}$	4.0	—	—	mA	I_F = 20mA, V_{CE} = 5V
H21A1	$I_{C(ON)}$	1.9	—	—	mA	I_F = 30mA, V_{CE} = 5V
H21A2	$I_{C(ON)}$	3.0	—	—	mA	I_F = 30mA, V_{CE} = 5V
H21A3	$I_{C(ON)}$	5.5	—	—	mA	I_F = 30mA, V_{CE} = 5V
SATURATION VOLTAGE						
H21A2	$V_{CE(SAT)}$	—	—	0.40	V	I_F = 20mA, I_C = 1.8mA
H21A3	$V_{CE(SAT)}$	—	—	0.40	V	I_F = 20mA, I_C = 1.8mA
H21A1	$V_{CE(SAT)}$	—	—	0.40	V	I_F = 30mA, I_C = 1.8mA
Turn-On Time	t_{on}	—	8	—	μS	V_{CC} = 5V, I_F = 30 mA, R_L = 2.5KΩ
Turn-Off Time	t_{off}	—	50	—	μS	V_{CC} = 5V, I_F = 30 mA, R_L = 2.5KΩ

TYPICAL CHARACTERISTICS

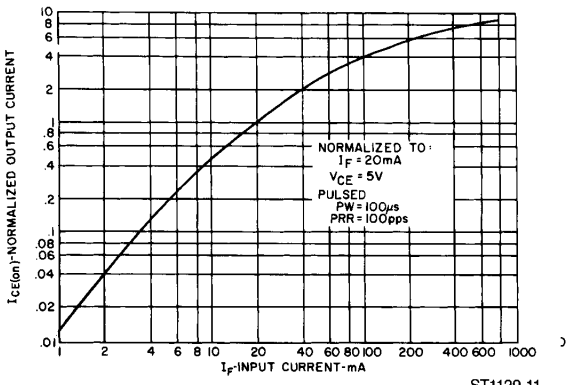


Fig. 1. Output Current vs. Input Current

ST1129-11

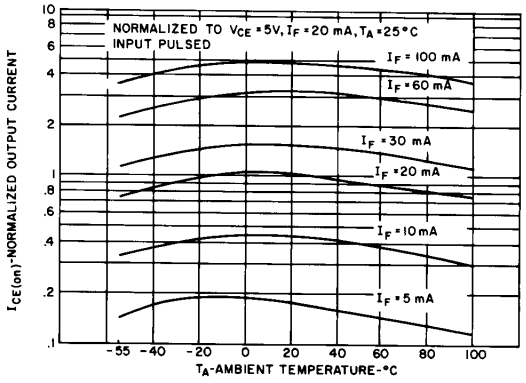


Fig. 2. Output Current vs. Temperature

ST1134-11

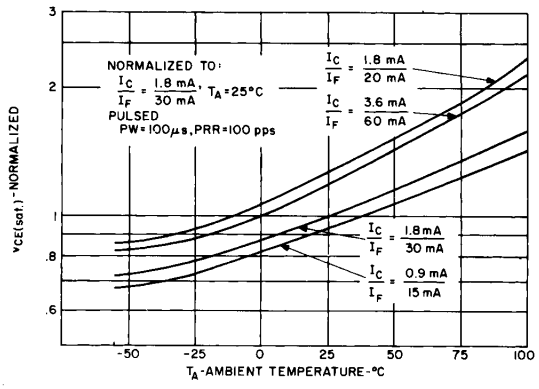


Fig. 3. $V_{CE(SAT)}$ vs. Temperature

ST1130-11

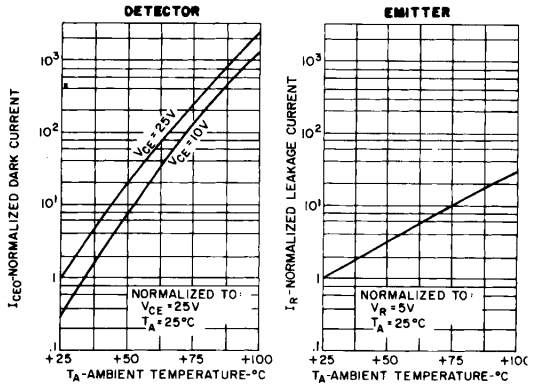


Fig. 4. Leakage Currents vs. Temperature

ST1133-11

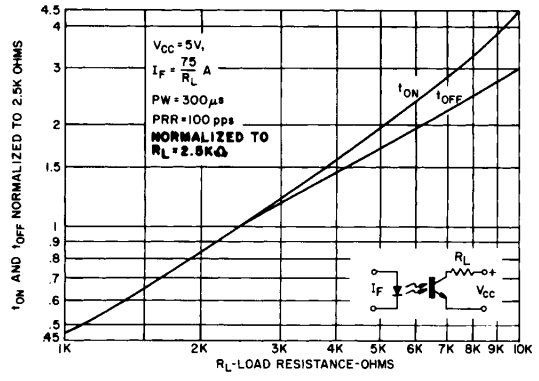


Fig. 5. Switching Speed vs. R_L

ST1131-11

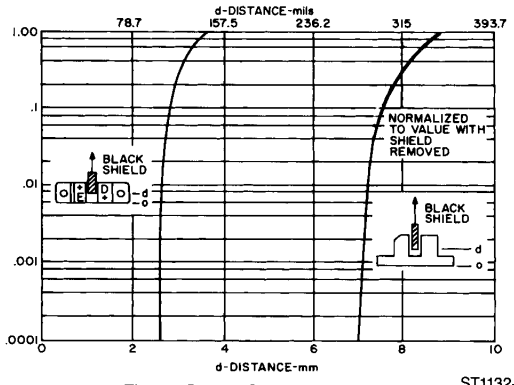


Fig. 6. Output Current vs. Distance

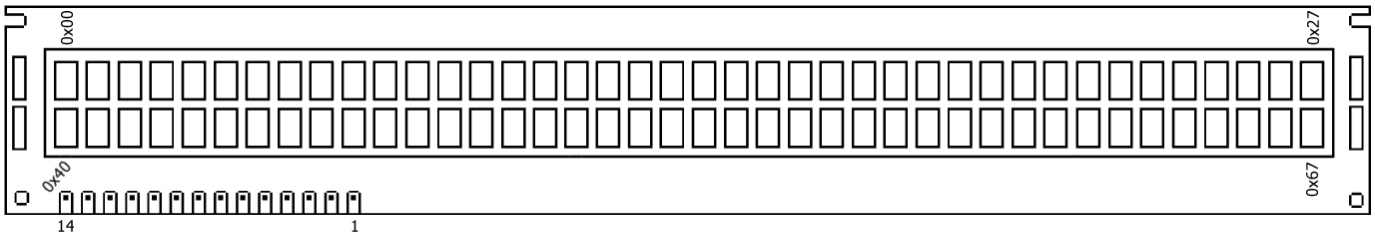
ST1132-11

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

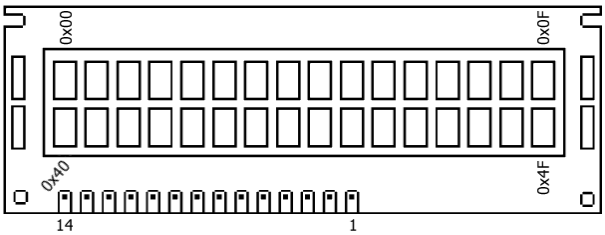
x : Don't care

I/D	1	Increment	R/L	1	Shift to the right
	0	Decrement		0	Shift to the left
S	1	Automatic display shift	DL	1	8 bit interface
	0			0	4 bit interface
D	1	Display ON	N	1	2 lines
	0	Display OFF		0	1 line
C	1	Cursor ON	F	1	5x10 dots
	0	Cursor OFF		0	5x7 dots
B	1	Cursor blinking	DDRAM : Display Data RAM CGRAM : Character Generator RAM		
	0				
S/C	1	Display shift			
	0	Cursor move			

LCD Display with 2 lines x 40 characters :



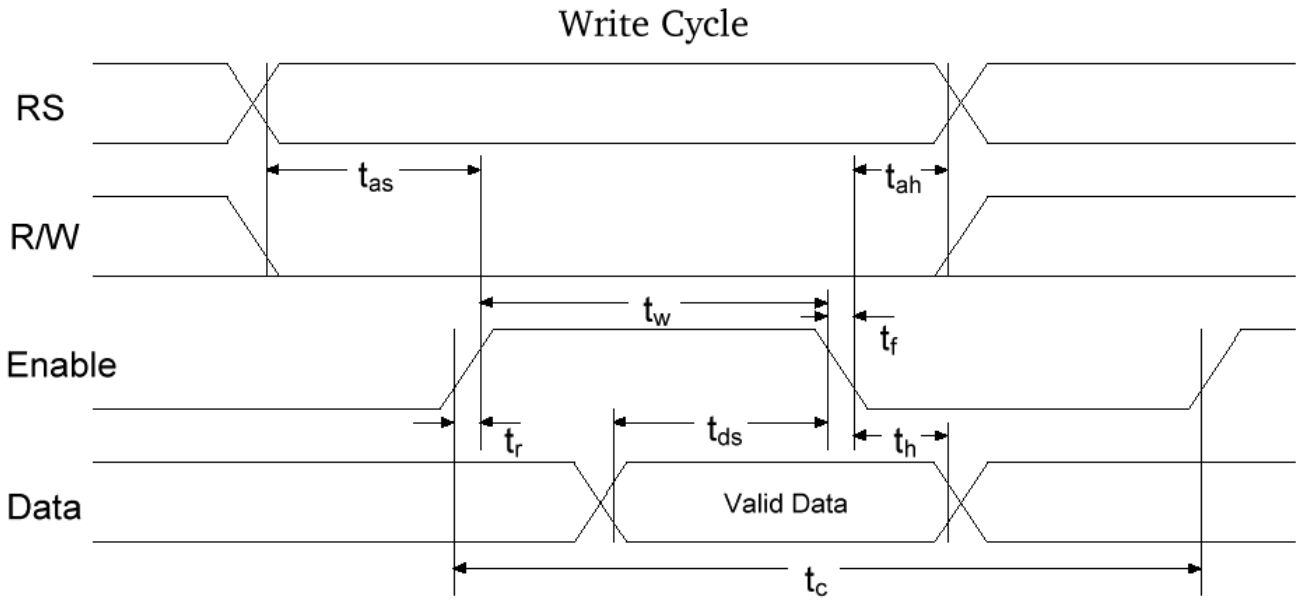
LCD Display with 2 lines x 16 characters :



Pin No	Name	Function	Description
1	Vss	Power	GND
2	Vdd	Power	+ 5 V
3	Vee	Contrast Adj.	(-2) 0 - 5 V
4	RS	Command	Register Select
5	R/W	Command	Read / Write
6	E	Command	Enable (Strobe)
7	D0	I/O	Data LSB
8	D1	I/O	Data
9	D2	I/O	Data
10	D3	I/O	Data
11	D4	I/O	Data
12	D5	I/O	Data
13	D6	I/O	Data
14	D7	I/O	Data MSB

Bus Timing Characteristics

(Ta = - 20 to + 75°C)



Write-Cycle	**V_{DD}**	2.7 - 4.5 V (2)	4.5 - 5.5 V (2)		2.7 - 4.5 V (2)	4.5 - 5.5 V (2)	
Parameter	**Symbol**	**Min(1)**		**Typ(1)**	**Max(1)**		**Unit**
Enable Cycle Time	t_c	1000	500	-	-	-	ns
Enable Pulse Width (High)	t_w	450	230	-	-	-	ns
Enable Rise/Fall Time	t_r, t_f	-	-	-	25	20	ns
Address Setup Time	t_{as}	60	40	-	-	-	ns
Address Hold Time	t_{ah}	20	10	-	-	-	ns
Data Setup Time	t_{ds}	195	80	-	-	-	ns
Data Hold Time	t_h	10	10	-	-	-	ns

(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

LAMPIRAN B

PERANGKAT LUNAK

```
;-------------------------------------------------
;PROGRAM UTAMA PENGENDALI
;PROTOTIPE MOBIL
;BY: RIKIAN CHANDRAWAN DS
;-------------------------------------------------
;INISIALISASI REGISTER DAN
;ALAMAT

$MOD52

OPTOCOUPLER          EQU     P3.5
        ;(TIMER1)
KEYPAD               EQU     P1
;==============================
;ALAMAT UNTUK MEMORI SUDUT
;==============================
DATA_SUDUT_LOW    EQU     35H
DATA_SUDUT_HIGH   EQU     34H
S_SATUAN      EQU     33H
S_PULUHAN     EQU     32H
S_RATUSAN     EQU     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     0AH
PENGALI_RATUSAN   EQU     64H
MILI_KE_MIKRO     EQU     1000D
KELILING      EQU     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
;SISI 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
        ;MENAMPILKAN 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
```

```
;-----------------------------------------------------
;                   TAMPILAN SUDUT
DAN JARAK
;-----------------------------------------------------
DIS_SUDUT:
        MOV     A,#80H
        ACALL PERINTAH
        MOV     A,#'I'          ;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
        ;DERAJAT
        ACALL TAMPILKAN
RET

DIS_JARAK:
        MOV     A,#0C0H
        ACALL PERINTAH
        MOV     A,#'I'          ;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
```

```
;-----------------------------------------------------
;                PROGRAM UNTUK
;MENGAMBIL MASUKAN SUDUT DAN
;                   JARAK
;-----------------------------------------------------
AMBIL_SUDUT:
        MOV     A,#LCD_LINE1_9
        ACALL PERINTAH
        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     DATA_SUDUT_LOW,A
        MOV     A,B
        ADDC    A,#00H
        MOV     DATA_SUDUT_HIGH,A
        MOV     A,S_RATUSAN
        CJNE    A,#0H,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     DATA_SUDUT_LOW,A
        MOV     A,#64H
        ADD     A,B
        MOV     DATA_SUDUT_HIGH,A
        SJMP    TETAP
TAMBAH1:
        MOV     B,#64H
        MOV     A,DATA_SUDUT_LOW
        MUL     AB
```

```
        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     A,DATA_SUDUT_HIGH
        ADDC    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,#PENGALI_PULUHAN
        MUL     AB
        MOV     B,J_SATUAN
        ADD     A,B
        MOV     A,R1
        MOV     A,J_RATUSAN
        MOV
        B,#PENGALI_RATUSAN
        MUL     AB
        CLR     C
        ADD     A,R1
        MOV     DATA_JARAK_LOW,A
        MOV     A,B
        ADDC    A,#00H
        MOV     DATA_JARAK_HIGH,A
RET

;-----------------------------------------------------
;       PROGRAM UNTUK
;MENGAMBIL MASUKKAN DARI
;               KEYPAD
;-----------------------------------------------------

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,#00H
        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'          ;R
        ACALL TAMPILKAN
        MOV     A,#'I'          ;I
        ACALL TAMPILKAN
        MOV     A,#'K'          ;K
        ACALL TAMPILKAN
        MOV     A,#'I'          ;I
        ACALL TAMPILKAN
        MOV     A,#20h
        ACALL TAMPILKAN
        MOV     A,#'0'          ;0
        ACALL TAMPILKAN
        MOV     A,#'1'          ;1
        ACALL TAMPILKAN
        MOV     A,#'2'          ;2
        ACALL TAMPILKAN
        MOV     A,#'2'          ;2
        ACALL TAMPILKAN
        MOV     A,#'0'          ;0
        ACALL TAMPILKAN
        MOV     A,#'2'          ;2
        ACALL TAMPILKAN
        MOV     A,#'0'          ;0
        ACALL TAMPILKAN

        MOV     A,#0C0h
        ACALL PERINTAH
        MOV     A,#'0'          ;0
        ACALL TAMPILKAN
        MOV     A,#'-'          ;-
        ACALL TAMPILKAN
        MOV     A,#00100111B    ;'
        ACALL TAMPILKAN
        MOV     A,#'='          ;=
        ACALL TAMPILKAN
        MOV     A,#'0'          ;0
        ACALL 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
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
```

```
        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
SAFETY1:
;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,SAFETY1

        MOV     A,RCAP2H
        ADD     A,#04H
        MOV     R4,A
        MOV     A,DATA_SUDUT_HIGH
        CLR     C
        SUBB    A,R4
        JNC     KANAN
KIRI:
        MOV     A,#SKI8
        MOV     R2,#SKA1
        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,#SKI6
        MOV     R2,#SKA3
        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,#SKI4
        MOV     R2,#SKA5
        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,#SKI2
        MOV     R2,#SKA7
        ORL     A,R2
        MOV     P2,A
        ACALL DELAY_STEPPER
        ACALL COMPASS

        MOV     A,#SKI1
        MOV     R2,#SKA8
        ORL     A,R2
        MOV     P2,A
        ACALL DELAY_STEPPER
        ACALL COMPASS
        LJMP    KIRI

KANAN:
        MOV     A,#SKI1
        MOV     R2,#SKA8
        ORL     A,R2
        MOV     P2,A
        ACALL DELAY_STEPPER
        ACALL COMPASS
```

```
        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,#SKI1
        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
```

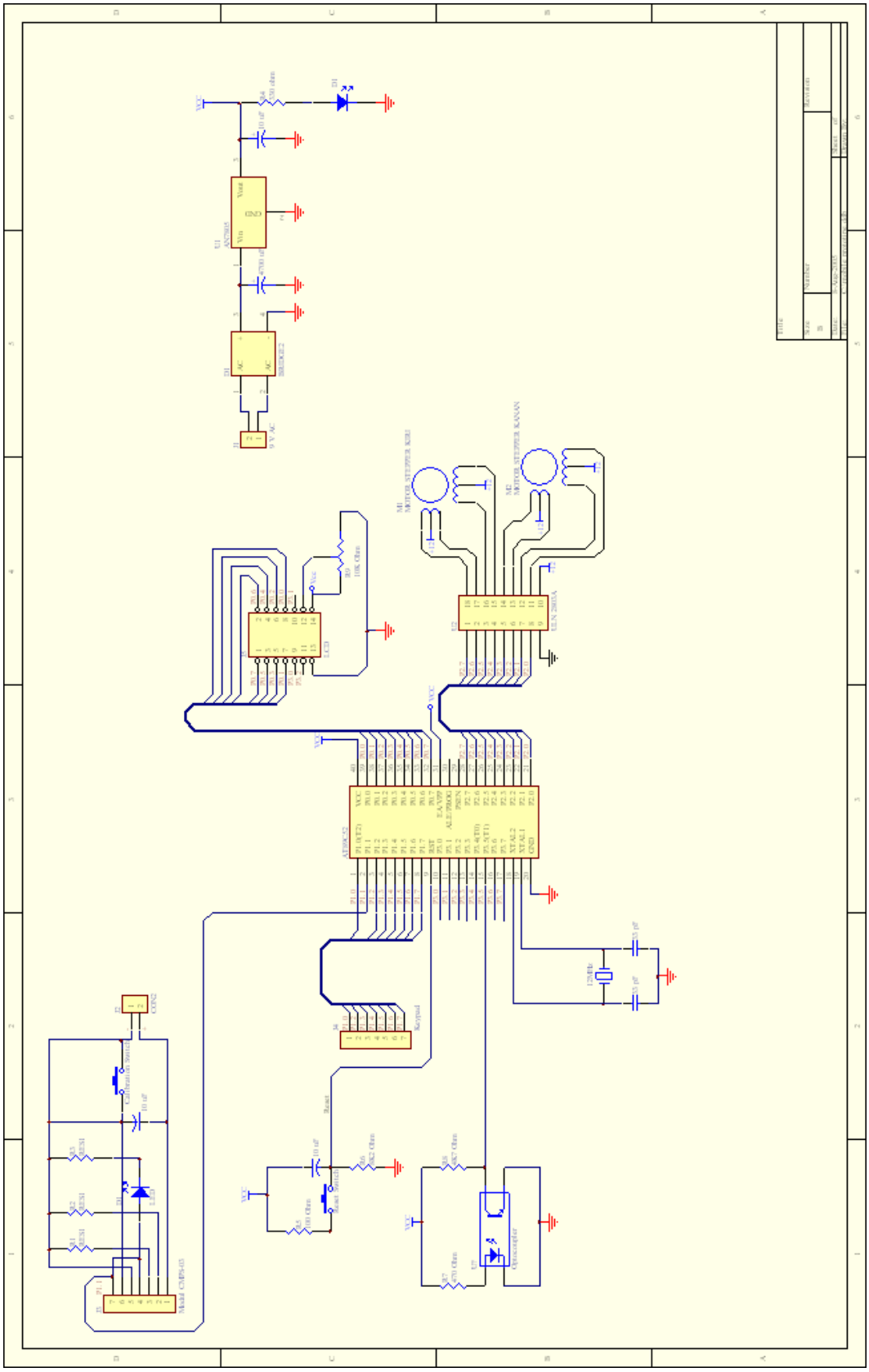
```
;-------------------------------------------------
;       PROGRAM UNTUK
MENGETAHUI JARAK
;       DENGAN MENGGUNAKAN
OPTOCOPLER
;-------------------------------------------------
JALAN:
        MOV     A,TL1
        CJNE
        A,DATA_JARAK_LOW,TERUS1
        MOV     A,TH1
        CJNE
        A,DATA_JARAK_HIGH,TERUS1
        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
        MOV     A,#'I'          ;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,#'-'          ;-
        ACALL TAMPILKAN
        MOV     A,#'B'          ;B
        ACALL TAMPILKAN
        MOV     A,#'y'          ;y
        ACALL TAMPILKAN
        MOV     A,#'e'          ;e
        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