LAMPIRAN
1. Gambar PCB dan susunan komponen
   - Susunan komponen system minimum

   ![Susunan komponen system minimum](image1.png)

   ![Susunan komponen LCD](image2.png)
- Susunan komponen Catu daya

- Susunan komponen sensor
2. Program Mikrokontroller Atmega 8535 Dengan Bahasa C

/****************************************************************************
This program was produced by the
CodeWizardAVR V2.03.4 Standard
Automatic Program Generator
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http://www.hpinfotech.com
Project : 
Version : 
Date : 1/29/2012
Author : 
Company : 
Comments : 
Chip type : ATmega8535
Program type : Application
Clock frequency : 11.059200 MHz
Memory model : Small
External RAM size : 0
Data Stack size : 128
****************************************************************************/
#include <mega8535.h>
#include <delay.h>
#include <stdio.h>

//global variables
int i, hitung=0, kecepatan=0;
float kecepatan1;
char lcd_buffer[33];
// Alphanumeric LCD Module functions

#asm
.equ __lcd_port=0x15 ;PORTC
#endasm

#include <lcd.h>

// External Interrupt 0 service routine
interrupt [EXT_INT0] void ext_int0_isr(void)
{
    // Place your code here
    hitung=hitung+1; // menghitung lingkaran yg dilalui
}

// Timer 1 overflow interrupt service routine
interrupt [TIM1_OVF] void timer1_ovf_isr(void)
{
    // Reinitialize Timer 1 value
    TCNT1H=0xD5;
    TCNT1L=0xD0;
    // Place your code here
    kecepatan=hitung*1.8*9.856; //kecepatan=hitung*jarak antar lubang*data kalibrasi;
    hitung=0; //mereset untuk kembali 0;
}

// Declare your global variables here

void main(void)
{
    // Declare your local variables here
    // Port D initialization
    // Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=Out
    Func0=Out
PORTD=0x04;
DDRD=0x03;

// Timer/Counter 1 initialization
// Clock source: System Clock
// Clock value: 10.800 kHz
// Mode: Normal top=FFFFh
// OC1A output: Discon.
// OC1B output: Discon.
// Noise Canceler: Off
// Input Capture on Falling Edge
// Timer 1 Overflow Interrupt: On
// Input Capture Interrupt: Off
// Compare A Match Interrupt: Off
// Compare B Match Interrupt: Off
TCCR1A=0x00;
TCCR1B=0x05;
TCNT1H=0xD5;
TCNT1L=0xD0;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;

// External Interrupt(s) initialization
// INTO: On
// INT0 Mode: Any change
// INT1: Off
// INT2: Off
GICR|=0x40;
MCUCR=0x01;
MCUCSR=0x00;
GIFR=0x40;
// Timer(s)/Counter(s) Interrupt(s) initialization
TIMSK=0x04;
// Analog Comparator initialization
// Analog Comparator: Off
// Analog Comparator Input Capture by Timer/Counter 1: Off
ACSR=0x80;
SFIOR=0x00;
// LCD module initialization
lcd_init(16);
// Global enable interrupts
#asm("sei")
PORTD.0=0;
lcd_gotoxy(3,0);
lcd_putsf("NUR BUDI H");
lcd_gotoxy(2,1);
lcd_putsf("08506131001");
delay_ms(1500);
lcd_clear();
lcd_gotoxy(3,0);
lcd_putsf("ANEMOMETER");
lcd_gotoxy(4,1);
lcd_putsf("SEBAGAI");
delay_ms(1500);
lcd_clear();
lcd_gotoxy(1,0);
lcd_putsf("PERINGATAN DINI");
lcd_gotoxy(1,1);
lcd_putsf("PUTING BELIUNG");
delay_ms(1500);
lcd_clear();
lcd_gotoxy(5,0);
lcd_putsf("DENGAN");
lcd_gotoxy(2,1);
lcd_putsf("TAMPILAN LCD");
delay_ms(1500);
   lcd_clear();
lcd_gotoxy(4,0);
lcd_putsf("LOADING");
lcd_gotoxy(0,1);
for (i=0; i<16; i++)
{
   lcd_putchar(0x2A);
   delay_ms(50);
}
delay_ms(500);
while (1)
{
   // Place your code here
   kecepatan1=kecepatan*0.01;      //dikonversi dalam m/dt;
lcd_gotoxy(0,0);
sprintf(lcd_buffer,"KEC :%2.2f m/dt", kecepatan1);
lcd_puts(lcd_buffer);
lcd_gotoxy(0,1);
lcd_putsf("STATUS:");
if (kecepatan1<5.4)
{
    PORTD.0=0; //buzzer mati;
lcd_gotoxy(7,1);
lcd_putsf("LEMAH ");
}
else if (kecepatan1<13.8)
{
    PORTD.0=0; //buzzer mati;
lcd_gotoxy(7,1);
lcd_putsf("SEDANG ");
}
else if (kecepatan1>13.8)
{
    PORTD.0=1; //menyalakan buzzer;
lcd_gotoxy(7,1);
lcd_putsf("KUAT ");
}
};
3. Datasheet ATmega8535

Features
- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 136 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories
  - 6K Bytes of In-System Self-Programmable Flash
  - Endurance: 10,000 Write/Erase Cycles
  - Optional Boot Code Section with Independent Lock Bits
  - In-System Programming by On-chip Boot Program
  - True Read While Write Operation
  - 512 Bytes EEPROM
  - Endurance: 100,000 Write/Erase Cycles
  - 512 Bytes Internal SRAM
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
  - 8 Single-ended Channels
  - 7 Differential Channels for TQFP Package Only
  - 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x for TQFP Package Only
  - 8x8-bit Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, 44-lead PLCC, and 44-pad QFN/MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega89S5L
  - 4.5 - 5.5V for ATmega89S5S
- Speed Grades
  - 0 - 9 MHz for ATmega89S5L
  - 0 - 16 MHz for ATmega89S5S
Overview

The ATmega8535 is a low-power CMOS 8-bit microcontroller based on the A enhanced RISC architecture. By executing instructions in a single clock cycle, ATmega8535 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Figure 2. Block Diagram
Pin Descriptions

\( V_{CC} \)  
Digital supply voltage.

GND  
Ground.

Port A (PA7..PA0)  
Port A serves as the analog inputs to the A/D Converter.
Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7..PB0)  
Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.
Port B also serves the functions of various special features of the ATmega8535 as listed on page 60.

Port C (PC7..PC0)  
Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D (PD7..PD0)  
Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.
Port D also serves the functions of various special features of the ATmega8535 as listed on page 64.

RESET  
Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in Table 15 on page 37. Shorter pulses are not guaranteed to generate a reset.

XTAL1  
Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2  
Output from the inverting Oscillator amplifier.

AVCC  
AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to \( V_{CC} \), even if the ADC is not used. If the ADC is used, it should be connected to \( V_{CC} \) through a low-pass filter.

AREF  
AREF is the analog reference pin for the A/D Converter.
AVR CPU Core

Introduction

This section discusses the AVR core architecture in general. The main function of the CPU core is to ensure correct program execution. The CPU must therefore be able to access memories, perform calculations, control peripherals, and handle interrupts.

Architectural Overview

Figure 3. Block Diagram of the AVR MCU Architecture

In order to maximize performance and parallelism, the AVR uses a Harvard architecture—with separate memories and buses for program and data. Instructions in the program memory are executed with a single level pipelining. While one instruction is being executed, the next instruction is pre-fetched from the program memory. This concept enables instructions to be executed in every clock cycle. The program memory is In-System Re-Programmable Flash memory.

The fast-access Register File contains 32 x 8-bit general purpose working registers with a single clock cycle access time. This allows single-cycle Arithmetic Logic Unit (ALU) operation. In a typical ALU operation, two operands are output from the Register File, the operation is executed, and the result is stored back in the Register File—in one clock cycle.

ATmega8535(L)
Interrupts

This section describes the specifics of the interrupt handling as performed in ATmega8535. For a general explanation of the AVR interrupt handling, refer to “Reset and Interrupt Handling” on page 13.

Interrupt Vectors in ATmega8535

Table 19. Reset and Interrupt Vectors

<table>
<thead>
<tr>
<th>Vector No.</th>
<th>Program Address(1)</th>
<th>Source</th>
<th>Interrupt Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0x000</td>
<td>RESET</td>
<td>External Pin, Power-on Reset, Brown-out Reset and Watchdog Reset</td>
</tr>
<tr>
<td>2</td>
<td>0x001</td>
<td>INT0</td>
<td>External Interrupt Request 0</td>
</tr>
<tr>
<td>3</td>
<td>0x002</td>
<td>INT1</td>
<td>External Interrupt Request 1</td>
</tr>
<tr>
<td>4</td>
<td>0x003</td>
<td>TIMER2 COMP</td>
<td>Timer/Counter2 Compare Match</td>
</tr>
<tr>
<td>5</td>
<td>0x004</td>
<td>TIMER2 OVF</td>
<td>Timer/Counter2 Overflow</td>
</tr>
<tr>
<td>6</td>
<td>0x005</td>
<td>TIMER1 CAPT</td>
<td>Timer/Counter1 Capture Event</td>
</tr>
<tr>
<td>7</td>
<td>0x006</td>
<td>TIMER1 COMPA</td>
<td>Timer/Counter1 Compare Match A</td>
</tr>
<tr>
<td>8</td>
<td>0x007</td>
<td>TIMER1 COMPB</td>
<td>Timer/Counter1 Compare Match B</td>
</tr>
<tr>
<td>9</td>
<td>0x008</td>
<td>TIMER1 OVF</td>
<td>Timer/Counter1 Overflow</td>
</tr>
<tr>
<td>10</td>
<td>0x009</td>
<td>TIMER0 OVF</td>
<td>Timer/Counter0 Overflow</td>
</tr>
<tr>
<td>11</td>
<td>0x00A</td>
<td>SPI, STC</td>
<td>Serial Transfer Complete</td>
</tr>
<tr>
<td>12</td>
<td>0x00B</td>
<td>USART, RXC</td>
<td>USART, Rx Complete</td>
</tr>
<tr>
<td>13</td>
<td>0x00C</td>
<td>USART, UDRE</td>
<td>USART Data Register Empty</td>
</tr>
<tr>
<td>14</td>
<td>0x00D</td>
<td>USART, TXC</td>
<td>USART, Tx Complete</td>
</tr>
<tr>
<td>15</td>
<td>0x00E</td>
<td>ADC</td>
<td>ADC Conversion Complete</td>
</tr>
<tr>
<td>16</td>
<td>0x00F</td>
<td>EE_RDY</td>
<td>EEPROM Ready</td>
</tr>
<tr>
<td>17</td>
<td>0x010</td>
<td>ANA_COMP</td>
<td>Analog Comparator</td>
</tr>
<tr>
<td>18</td>
<td>0x011</td>
<td>TWI</td>
<td>Two-wire Serial Interface</td>
</tr>
<tr>
<td>19</td>
<td>0x012</td>
<td>INT2</td>
<td>External Interrupt Request 2</td>
</tr>
<tr>
<td>20</td>
<td>0x013</td>
<td>TIMER0 COMP</td>
<td>Timer/Counter0 Compare Match</td>
</tr>
<tr>
<td>21</td>
<td>0x014</td>
<td>SPM_RDY</td>
<td>Store Program Memory Ready</td>
</tr>
</tbody>
</table>

Notes:
1. When the BOOTRST Fuse is programmed, the device will jump to the Boot Loader address at reset, see “Boot Loader Support – Read-While-Write Self-Programming” on page 224.
2. When the IVSEL bit in GICR is set, Interrupt Vectors will be moved to the start of the Boot Flash section. The address of each Interrupt Vector will then be the address in this table added to the start address of the Boot Flash section.

Table 20 shows reset and Interrupt Vectors placement for the various combinations of BOOTRST and IVSEL settings. If the program never enables an interrupt source, the Interrupt Vectors are not used, and regular program code can be placed at these locations. This is also the case if the Reset Vector is in the Application section while the Interrupt Vectors are in the Boot section or vice versa.
4. Datasheet IC LM393

LOW POWER DUAL VOLTAGE COMPARATORS

- WIDE SINGLE SUPPLY VOLTAGE RANGE OR DUAL SUPPLIES: +2V TO +36V OR ±1V TO ±18V
- VERY LOW SUPPLY CURRENT (0.4mA) INDEPENDENT OF SUPPLY VOLTAGE (1mW/comparator at +5V)
- LOW INPUT BIAS CURRENT: 25nA TYP
- LOW INPUT OFFSET CURRENT: ±5nA TYP
- LOW INPUT OFFSET VOLTAGE: ±1mV TYP
- INPUT COMMON-MODE VOLTAGE RANGE INCLUDES GROUND
- LOW OUTPUT SATURATION VOLTAGE: 250mV TYP. (Io = 4mA)
- DIFFERENTIAL INPUT VOLTAGE RANGE EQUAL TO THE SUPPLY VOLTAGE
- TTL, DTL, ECL, MOS, CMOS COMPATIBLE OUTPUTS

DESCRIPTION

These devices consist of two independent low voltage comparators designed specifically to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible.

These comparators also have a unique characteristic in that the input common-mode voltage range includes ground even though operated from a single power supply voltage.

PIN CONNECTIONS (top view)
SCHEMATIC DIAGRAM (1/2 LM193)

ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CC}$</td>
<td>Supply Voltage</td>
<td>±18 or ±36</td>
<td>V</td>
</tr>
<tr>
<td>$V_{dd}$</td>
<td>Differential Input Voltage</td>
<td>±36</td>
<td>V</td>
</tr>
<tr>
<td>$V_{i}$</td>
<td>Input Voltage</td>
<td>-0.3 to +36</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Output Short-circuit to Ground</td>
<td>Infinite</td>
<td></td>
</tr>
<tr>
<td>$P_d$</td>
<td>Power Dissipation $^2$</td>
<td>DIP8: 1250</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SO8: 710</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TSSOP8: 625</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mini SO8: 580</td>
<td></td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature Range</td>
<td>-65 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

1. Short-circuits from the output to $V_{CC}^+$ can cause excessive heating and eventual destruction. The maximum output current is approximately 20mA independent of the magnitude of $V_{CC}^+$.
2. $P_d$ is calculated with $T_{amb} = +25^\circ$C, $T_j = +150^\circ$C and $R_{thj}$:
   - 100°C/W for DIP8 package
   - 150°C/W for SO8 package
   - 350°C/W for TSSOP8 package
   - 215°C/W for Mini SO8 package

OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{com}$</td>
<td>Common Mode Input Voltage Range</td>
<td>0 to $V_{CC}^+$ - 1.5</td>
<td>V</td>
</tr>
<tr>
<td>$T_{oper}$</td>
<td>Operating Free-Air Temperature range</td>
<td>LM193: -55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LM283: -40 to +125</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LM383: 0 to +70</td>
<td></td>
</tr>
</tbody>
</table>
# ELECTRICAL CHARACTERISTICS

$V_{CC} = +5V$, $V_{CC} = 0V$, $T_{amb} = +25^\circ C$ (unless otherwise specified)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{io}$</td>
<td>Input Offset Voltage - note 1) $T_{amb} = +25^\circ C$, $T_{min} \leq T_{amb} \leq T_{max}$</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>mV</td>
</tr>
<tr>
<td>$I_{io}$</td>
<td>Input Bias Current - note 2) $T_{amb} = +25^\circ C$, $T_{min} \leq T_{amb} \leq T_{max}$</td>
<td>25</td>
<td>250</td>
<td>400</td>
<td>nA</td>
</tr>
<tr>
<td>$I_{io}$</td>
<td>Input Offset Current $T_{amb} = +25^\circ C$, $T_{min} \leq T_{amb} \leq T_{max}$</td>
<td>5</td>
<td>50</td>
<td>150</td>
<td>nA</td>
</tr>
<tr>
<td>$A_{vd}$</td>
<td>Large Signal Voltage Gain $V_{CC} = 15V$, $R_{L} = 15k\Omega$, $V_{O} = 1V$ to $11V$</td>
<td>60</td>
<td>200</td>
<td></td>
<td>V/mV</td>
</tr>
<tr>
<td>$I_{cc}$</td>
<td>Supply Current (all comparators) $V_{CC} = 5V$, no load $V_{CC} = 30V$, no load</td>
<td>0.4</td>
<td>1</td>
<td>2.5</td>
<td>mA</td>
</tr>
<tr>
<td>$V_{cm}$</td>
<td>Input Common Mode Voltage Range - note 3) $T_{amb} = +25^\circ C$, $T_{min} \leq T_{amb} \leq T_{max}$</td>
<td>0</td>
<td>0</td>
<td>$V_{CC} \pm 1.5$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{id}$</td>
<td>Differential Input Voltage -note 4) $V_{CC}$</td>
<td>0</td>
<td></td>
<td>$V_{CC}$</td>
<td>V</td>
</tr>
<tr>
<td>$I_{sink}$</td>
<td>Output Sink Current $V_{DD} = 1V$, $V_{O} = 1.5V$</td>
<td>6</td>
<td>16</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$V_{OL}$</td>
<td>Low Level Output Voltage $V_{id} = -1V$, $I_{sink} = 4mA$ $T_{amb} = +25^\circ C$, $T_{min} \leq T_{amb} \leq T_{max}$</td>
<td>250</td>
<td>400</td>
<td>700</td>
<td>mV</td>
</tr>
<tr>
<td>$I_{OH}$</td>
<td>High Level Output Current ($V_{id} = 1V$) $V_{id} = 1V$, $V_{CC} = V_{O} = 30V$ $T_{amb} = +25^\circ C$, $T_{min} \leq T_{amb} \leq T_{max}$</td>
<td>0.1</td>
<td>1</td>
<td></td>
<td>nA/\mu A</td>
</tr>
<tr>
<td>$t_{re}$</td>
<td>Response Time - note 5) $R_{L} = 5.1k\Omega$ to $V_{CC}^+$</td>
<td>1.3</td>
<td></td>
<td></td>
<td>\mu s</td>
</tr>
<tr>
<td>$t_{rel}$</td>
<td>Large Signal Response Time $V_{i} = TTL$, $V_{ref} = +1.14V$, $R_{L} = 5.1k\Omega$ to $V_{CC}^+$</td>
<td>300</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

1. At output switch point, $V_{O} = 14V$, $R_{L} = 0$ with $V_{CC}^+$ from 5V to 30V, and over the full common-mode range (0V to $V_{CC}^+ - 1.5V$).
2. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output, and/or loading characteristics on the resistor of input lines.
3. The input common-mode voltage of either input signal voltage should not be allowed to go beyond by more than 0.3V. The upper end of the common-mode voltage range is $V_{CC}^+ - 1.5V$, but other or both inputs can go to 30V without damage.
4. Positive excursions of input voltage may exceed the power supply level. As long as the output voltage remains within the common-mode range, the comparator will provide a proper output state. The low input voltage state must not be less than 3.3V (or 0.3V below the negative power supply, if desired).
5. The response time specified is for a 100mV input step with 5mV overdrive. For larger overdrive signals 300ns can be obtained.
BC546; BC547
NPN general purpose transistors
NPN general purpose transistors  

**FEATURES**
- Low current (max. 100 mA)
- Low voltage (max. 65 V).

**APPLICATIONS**
- General purpose switching and amplification.

**DESCRIPTION**
NPN transistor in a TO-92, SOT54 plastic package. PNP complements: BC556 and BC557.

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**LIMITING VALUES**
In accordance with the Absolute Maximum Rating System (IEC 134).

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_{CEO}</td>
<td>collector-base voltage</td>
<td>open emitter</td>
<td>–</td>
<td>80</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BC546</td>
<td></td>
<td>–</td>
<td>50</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BC547</td>
<td></td>
<td>–</td>
<td>50</td>
<td>V</td>
</tr>
<tr>
<td>V_{CEO}</td>
<td>collector-emitter voltage</td>
<td>open base</td>
<td>–</td>
<td>65</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BC546</td>
<td></td>
<td>–</td>
<td>45</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BC547</td>
<td></td>
<td>–</td>
<td>45</td>
<td>V</td>
</tr>
<tr>
<td>V_{CEO}</td>
<td>emitter-base voltage</td>
<td>open collector</td>
<td>–</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BC546</td>
<td></td>
<td>–</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BC547</td>
<td></td>
<td>–</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>I_c</td>
<td>collector current (DC)</td>
<td></td>
<td>–</td>
<td>100</td>
<td>mA</td>
</tr>
<tr>
<td>I_{CM}</td>
<td>peak collector current</td>
<td></td>
<td>–</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>I_{BM}</td>
<td>peak base current</td>
<td></td>
<td>–</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>P_{tot}</td>
<td>total power dissipation</td>
<td>T_{amb} ≤ 25 °C, note 1</td>
<td>–</td>
<td>500</td>
<td>mW</td>
</tr>
<tr>
<td>T_{STG}</td>
<td>storage temperature</td>
<td></td>
<td>–65</td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>T_f</td>
<td>junction temperature</td>
<td></td>
<td>–</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>T_{amb}</td>
<td>operating ambient temperature</td>
<td></td>
<td>–65</td>
<td>+150</td>
<td>°C</td>
</tr>
</tbody>
</table>
NPN general purpose transistors

**THERMAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th a}$</td>
<td>thermal resistance from junction to ambient</td>
<td>note 1</td>
<td>0.25</td>
<td>K/mW</td>
</tr>
</tbody>
</table>

**Note**

1. Transistor mounted on an FR4 printed-circuit board.

**CHARACTERISTICS**

$T_J = 25 \, {^\circ}C$ unless otherwise specified.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{CBO}$</td>
<td>collector cut-off current</td>
<td>$I_C = 0$, $V_{CE} = 30 , V$</td>
<td>–</td>
<td>–</td>
<td>15</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 0$, $V_{CE} = 30 , V$, $T_J = 150 , ^\circ C$</td>
<td>–</td>
<td>–</td>
<td>5</td>
<td>µA</td>
</tr>
<tr>
<td>$I_{EBO}$</td>
<td>emitter cut-off current</td>
<td>$I_C = 0$, $V_{BE} = 5 , V$</td>
<td>–</td>
<td>–</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>$H_{FE}$</td>
<td>DC current gain</td>
<td></td>
<td>–</td>
<td>90</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC546A</td>
<td>–</td>
<td>150</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC546B; BC547B</td>
<td>–</td>
<td>270</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC547C</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DC current gain</td>
<td>$I_C = 2 , mA$, $V_{CE} = 5 , V$; see Figs 2, 3 and 4</td>
<td>110</td>
<td>180</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC546A</td>
<td>200</td>
<td>290</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC546B; BC547B</td>
<td>420</td>
<td>520</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC547C</td>
<td>110</td>
<td>–</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC547</td>
<td>110</td>
<td>–</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>$V_{CE(sat)}$</td>
<td>collector-emitter saturation voltage</td>
<td>$I_C = 10 , mA$, $I_B = 0.5 , mA$</td>
<td>–</td>
<td>50</td>
<td>250</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 100 , mA$, $I_B = 5 , mA$</td>
<td>–</td>
<td>200</td>
<td>600</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{BE(sat)}$</td>
<td>base-emitter saturation voltage</td>
<td>$I_C = 10 , mA$, $I_B = 0.5 , mA$; note 1</td>
<td>–</td>
<td>700</td>
<td>–</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 100 , mA$, $I_B = 5 , mA$; note 1</td>
<td>–</td>
<td>900</td>
<td>–</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{BE}$</td>
<td>base-emitter voltage</td>
<td>$I_C = 2 , mA$, $V_{CE} = 5 , V$; note 2</td>
<td>580</td>
<td>680</td>
<td>700</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 10 , mA$, $V_{CE} = 5 , V$</td>
<td>–</td>
<td>–</td>
<td>770</td>
<td>mV</td>
</tr>
<tr>
<td>$C_C$</td>
<td>collector capacitance</td>
<td>$I_C = I_B = 0$, $V_{CE} = 10 , V$; $f = 1 , MHz$</td>
<td>–</td>
<td>1.5</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>$C_E$</td>
<td>emitter capacitance</td>
<td>$I_C = I_B = 0$, $V_{CE} = 0.5 , V$; $f = 1 , MHz$</td>
<td>–</td>
<td>11</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>$f_T$</td>
<td>transition frequency</td>
<td>$I_C = 10 , mA$, $V_{CE} = 5 , V$; $f = 100 , MHz$</td>
<td>100</td>
<td>–</td>
<td>–</td>
<td>MHz</td>
</tr>
<tr>
<td>$F$</td>
<td>noise figure</td>
<td>$I_C = 200 , µA$, $V_{CE} = 5 , V$, $R_{D} = 2 , kΩ$, $f = 1 , kHz$, $B = 200 , Hz$</td>
<td>–</td>
<td>2</td>
<td>10</td>
<td>dB</td>
</tr>
</tbody>
</table>
NPN general purpose transistors

Fig. 2 DC current gain: typical values.

BC546; BC547
6. Datasheet LM 7806

**1.5A Positive Voltage Regulator**

**Description**

The Bay Linear LM78XX is an integrated linear positive regulator with three terminals. The LM78XX offers several fixed output voltages, making them useful in wide range of applications. When used as a zener diode-resistor combination replacement, the LM78XX usually results in an effective output impedance improvement of two orders of magnitude, lower quiescent current.

The LM78XX is available in the TO-222, TO-220 & TO-263 packages.

**Features**

- Output Current of 1.5A
- Output Voltage Tolerance of ±5%
- Internal thermal overload protection
- Internal Short-Circuit Limited
- No External Component
- Output Voltage 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, 21V
- Offer in plastic TO-222, TO-220 & TO-263
- Direct Replacement for LM78XX

**Applications**

- Post regulator for switching DC/DC converter
- Bias supply for analog circuits

**Packaging Information**

**Ordering Information**

<table>
<thead>
<tr>
<th>Device</th>
<th>Operating Voltage</th>
<th>Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM7805</td>
<td>7 to 20</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7806</td>
<td>8 to 20</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7807</td>
<td>10.5 to 13</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7809</td>
<td>11.5 to 14</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7810</td>
<td>15.5 to 15</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7812</td>
<td>14.5 to 17</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7815</td>
<td>17.5 to 20</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7818</td>
<td>20.5 to 23</td>
<td>0 to 125 °C</td>
</tr>
<tr>
<td>LM7824</td>
<td>28.5 to 39</td>
<td>0 to 125 °C</td>
</tr>
</tbody>
</table>

TO-220 (T)
TO-263 (S)
TO-252 (D)
### Absolute Maximum Rating

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LM7824, LM7827</th>
<th>All Others</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>40</td>
<td>35</td>
<td>V</td>
</tr>
<tr>
<td>Operating Free-Air Case Virtual Junction Temp.</td>
<td>0 to 150</td>
<td>0 to 150</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-65 to 150</td>
<td>260</td>
<td>°C</td>
</tr>
<tr>
<td>Lead temperature 1.6 mm from case for sec.</td>
<td>-65 to 150</td>
<td>260</td>
<td>°C</td>
</tr>
</tbody>
</table>

### Electrical Characteristics (LM7805)

(V<sub>i</sub>=10V, I<sub>L</sub>=500mA, 0°C ≤ T<sub>j</sub>≤125°C, unless otherwise specified. (Note 1))

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage</td>
<td>V&lt;sub&gt;O&lt;/sub&gt;</td>
<td>T=25°C</td>
<td>4.3</td>
<td>5.0</td>
<td>5.2</td>
<td>V</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>ΔV&lt;sub&gt;O&lt;/sub&gt;</td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=7V to 25V, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>3</td>
<td>100</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=8V to 13V, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>1</td>
<td>50</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>ΔV&lt;sub&gt;O&lt;/sub&gt;</td>
<td>I&lt;sub&gt;L&lt;/sub&gt;=5mA to 1.5A, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>15</td>
<td>100</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I&lt;sub&gt;L&lt;/sub&gt;=250mA to 750mA, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>5</td>
<td>50</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Ripple Rejection</td>
<td>RR</td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=8V to 18V, f=120Hz</td>
<td>63</td>
<td>78</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Output Noise Voltage</td>
<td>V&lt;sub&gt;N&lt;/sub&gt;</td>
<td>f=10Hz to 100Hz, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>40</td>
<td></td>
<td></td>
<td>µV</td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>V&lt;sub&gt;O&lt;/sub&gt;</td>
<td>T=25°C</td>
<td>2.0</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td></td>
<td></td>
<td>4.2</td>
<td>8</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Quiescent Current Change</td>
<td>ΔI&lt;sub&gt;O&lt;/sub&gt;</td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=7V to 25V, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>1.3</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I&lt;sub&gt;L&lt;/sub&gt;=5mA to 1A, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>0.5</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>

### Electrical Characteristics (LM7806)

(V<sub>i</sub>=11V, I<sub>L</sub>=500mA, 0°C ≤ T<sub>j</sub>≤125°C, unless otherwise specified. (Note 1))

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage</td>
<td>V&lt;sub&gt;O&lt;/sub&gt;</td>
<td>T=25°C</td>
<td>5.75</td>
<td>6.0</td>
<td>6.25</td>
<td>V</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>ΔV&lt;sub&gt;O&lt;/sub&gt;</td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=8V to 25V, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>5</td>
<td>120</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=9V to 25V, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>1.5</td>
<td>60</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>ΔV&lt;sub&gt;O&lt;/sub&gt;</td>
<td>I&lt;sub&gt;L&lt;/sub&gt;=5mA to 1.5A, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>14</td>
<td>120</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I&lt;sub&gt;L&lt;/sub&gt;=250mA to 750mA, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>4</td>
<td>60</td>
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<td>mV</td>
</tr>
<tr>
<td>Ripple Rejection</td>
<td>RR</td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=9V to 19V, f=120Hz</td>
<td>59</td>
<td>75</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Output Noise Voltage</td>
<td>V&lt;sub&gt;N&lt;/sub&gt;</td>
<td>f=10Hz to 100Hz, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>45</td>
<td></td>
<td></td>
<td>µV</td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>V&lt;sub&gt;O&lt;/sub&gt;</td>
<td>T=25°C</td>
<td>2.0</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td></td>
<td></td>
<td>4.3</td>
<td>8</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Quiescent Current Change</td>
<td>ΔI&lt;sub&gt;O&lt;/sub&gt;</td>
<td>V&lt;sub&gt;i&lt;/sub&gt;=8V to 25V, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>1.3</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I&lt;sub&gt;L&lt;/sub&gt;=5mA to 1A, T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>0.5</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>
7. Skema Rangkaian Lengkap