โปรแกรมการทำงานของระบบเตือนภัยผ่านทางโทรศัพท์เคลื่อนที่ด้วยการส่งข้อความสั้น

```
define BIT(x) (0x01 << (x))
#define bit_get(p,m) ((p) & (m))
#define outp( val, port ) ( port ) = ( val )
#define inp( port ) ( port )
#define sbi( port, bit ) ( port ) |= ( 1 << (bit) )
#define cbi( port, bit ) ( port ) &= ~( 1 << (bit) )
/*
MODEL :  2406    GRPS ,SMS , GSM
MODEL : 2501  Same as 2406 But Built in  GPS
*/
#define MODEL 2406
/*
    GPRS_ENABLE   :  SET 1 This Enable GPRS
                     IF Set 0  for Disable It
*/
#define GPRS_ENABLE 0

#define G_OnOFF_DDR DDRB
#define G_OnOFF_PORT PORTB
#define G_OnOFF_PIN 4
#define OUTPUT_DDR DDRD
#define OUTPUT_PORT PORTD
#define OUTPUT_PIN_O1 4
#define OUTPUT_PIN_O2 5
#define OUTPUT_PIN_O3 6    // used
#define OUTPUT_PIN_O4 7    //used
```

```
#define OUTPUT_DDR_O5 DDRC
#define OUTPUT_PORT_O5 PORTC
#define OUTPUT_PIN_O5 7
#define INPUT_PIN_1 PINC.7

#define SoundOn() sbi(OUTPUT_PORT,OUTPUT_PIN_O4)
#define SoundOff() cbi(OUTPUT_PORT,OUTPUT_PIN_O4)

#define LightOn() sbi(OUTPUT_PORT,OUTPUT_PIN_O3)
#define LightOff() cbi(OUTPUT_PORT,OUTPUT_PIN_O3)

#define LED_DDR DDRB
#define LED_PORT PORTB
#define LED_PIN_1 5      //used
#define LED_PIN_2 6     //used

#define LED1_On() sbi(LED_PORT,LED_PIN_1)
#define LED2_On() sbi(LED_PORT,LED_PIN_2)
#define LED1_Off() cbi(LED_PORT,LED_PIN_1)
#define LED2_Off() cbi(LED_PORT,LED_PIN_2)

#define SW_DDR DDRC
#define SW_PIN PINC
#define SW_PIN_1 PINC.2
#define  SW_OnOff SW_PIN_1
#define SW_PIN_2 PINC.3
#define SW_Alert SW_PIN_2
#define SW_PIN_3 PINC.4
#define SW_PIN_4 PINC.5
```

```
#define ModuleGpsOff() sbi( G_OnOFF_PORT,G_OnOFF_PIN);
#define ModuleGpsOn() cbi( G_OnOFF_PORT,G_OnOFF_PIN);

#define ALERT 1
#define IDLE 0

#define ON 0
#define OFF 1

bit INPUT_PIN_1_CHK;
bit SW_PIN_4_CHK;
bit SW_PIN_3_CHK;

unsigned  char refreshTime;

unsigned   int N1,N2,E1,E2,ad1,ad2,ad3,ad4,ad5,ad6,ad7,ad8;

unsigned char hour=0,minu=0,sec=0,year=0,month=0,day=0;
 eeprom unsigned long int firstindex=0,lastindex=0;
 eeprom char *tew="000000000#0";
 eeprom char *ee_phonenumber1="000000000#0";
 eeprom char *ee_phonenumber2="000000000#0";
 eeprom char *ee_phonenumber3="000000000#0";
 eeprom char *ee_phonenumber4="000000000#0";
 eeprom char *ee_phonenumber5="000000000#0";
 unsigned char level,phonenumber[9]="00000000";
 eeprom char memOutput=0x00;
```

```
 eeprom unsigned char APN=2;
 eeprom char cycle=1;
 unsigned int timer_count,i;
 unsigned char sendSuccess=0;
unsigned char ON_OFF_CHECK;   // เก็บสถานะ ปิด เปิด
 #include <mega32.h>
#include <string.h>
#define ADC_VREF_TYPE 0x00
 #define portDelay 50


 bit  OUTPUT_PIN_O1_CHK=1;
 bit  OUTPUT_PIN_O2_CHK=1;
 bit  OUTPUT_PIN_O3_CHK=1;

// Standard Input/Output functions
  #asm
   .equ __i2c_port=0x18 ;PORTB
   .equ __sda_bit=1
   .equ __scl_bit=0
#endasm
 #include <ds1307.h>
#include <stdio.h>
#include<delay.h>
#include<m_string.c>
#include <logger.c>
#include <writepackage.c>
#include<gps_gprs.c>
#include<sms.c>
```

```
 char door_detect=0;

 interrupt [TIM1_OVF] void timer1_ovf_isr(void){
timer_count++;
        if(timer_count>=130){   timer_count=0;
                   if(sendSuccess==0){  write_datalog();  }
               //    WDTCR=0x0F;                         // Enable Watch Dog Timer
      }
}

interrupt [TIM0_OVF] void timer0_ovf_isr(void){
timer_count++;
        if(timer_count>=50)  {
      //          GPS_refresh() ;
               timer_count=0;
        }
}

  void main(void){
        {
//refreshTime=refTmm;
refreshTime=1;
//cycle=0;
//firstindex=262090;lastindex=262090;
//APN=1;
 PORTA=0x00;
DDRA=0b00000000;
PORTB=0xFF;
DDRB=0xFF;
```

```
PORTC=0x00;
DDRC=0x00;
PORTD=0x00;
DDRD=0xFF;

//   init mechine
sbi( G_OnOFF_DDR,G_OnOFF_PIN);  // OUTPUT  G_ON/OFF   pin
ModuleGpsOff()   //  Off Module
sbi( OUTPUT_DDR,OUTPUT_PIN_O1);
sbi( OUTPUT_DDR,OUTPUT_PIN_O2);
sbi( OUTPUT_DDR,OUTPUT_PIN_O3);
sbi( OUTPUT_DDR,OUTPUT_PIN_O4);

cbi( OUTPUT_DDR_O5,OUTPUT_PIN_O5);

sbi(LED_DDR,LED_PIN_1);
sbi(LED_DDR,LED_PIN_2);
cbi(SW_DDR,SW_PIN_1);
cbi(SW_DDR,SW_PIN_2);
cbi(SW_DDR,SW_PIN_3);
cbi(SW_DDR,SW_PIN_4);

/*
if(bit_get(memOutput,BIT(1))){  sbi( OUTPUT_PORT,OUTPUT_PIN_O1);}
else {  cbi( OUTPUT_PORT,OUTPUT_PIN_O1); }

if(bit_get(memOutput,BIT(2))){  sbi( OUTPUT_PORT,OUTPUT_PIN_O2);}
else {  cbi( OUTPUT_PORT,OUTPUT_PIN_O2); }
```

```
if(bit_get(memOutput,BIT(3))){  sbi( OUTPUT_PORT,OUTPUT_PIN_O3);}
else {  cbi( OUTPUT_PORT,OUTPUT_PIN_O3); }

if(bit_get(memOutput,BIT(4))){  sbi( OUTPUT_PORT,OUTPUT_PIN_O4);}
else {  cbi( OUTPUT_PORT,OUTPUT_PIN_O4); }
  */
sbi( OUTPUT_PORT,OUTPUT_PIN_O1);
sbi( OUTPUT_PORT,OUTPUT_PIN_O2);
sbi( OUTPUT_PORT,OUTPUT_PIN_O3);

 //
UCSRA=0x00;
UCSRB=0x18;
UCSRC=0x86;
UBRRH=0x00;
UBRRL=0x33;

ACSR=0x80;
SFIOR=0x00;

 TCCR0=0x05;
TCNT0=0x00;

 // Timer(s)/Counter(s) Interrupt(s) initialization
TIMSK=0x05;
ADMUX=ADC_VREF_TYPE;
ADCSRA=0x87;
        }
delay_ms(1000);
```

```
//___________________________________________________
{/************** I2C init *******************/
 i2c_init();
rtc_init(0,0,0);
/**************  *******************/}
waitModuleInit();
 clearUARTBuffer();
  printf(">>%d\r\n",ad1);
                ADC_refresh();
    //   while(1){

                   printf("%d,",SW_PIN_4);
                   printf("%d,",SW_PIN_3);
                   printf("%d,",INPUT_PIN_1);
                                          printf("%d,",      SW_PIN_3&& SW_PIN_4&& INPUT_PIN_1
);
                   printf("\r\n----------\r\n") ;
                   delay_ms(500);
         //      }
 /************** End Wait  System  *******************/
                                       ///URL );
printf("connect\r\n");
  TCCR0=0x00;
  #if MODEL == 2501
  GPS_refresh();
  #endif
  #asm("sei");
 #if GPRS_ENABLE ==1
GPRS_detectAPN();
```

```
GPRS_Init();
#endif
TCCR0=0x00;
PORTC.4=1;

 INPUT_PIN_1_CHK = IDLE;
 SW_PIN_4_CHK = IDLE;
 SW_PIN_3_CHK= IDLE;

while (1){
 char  minTemp;
 int procount;
   clearUARTBuffer();

                   TCCR1B=0x03;
                   TCCR0=0x00;
                              LED2_Off();
                              LED1_Off();
                     while(1)
                     {           ADC_refresh();
  #ifdef debug
  printf("loop\r\n");
  #endif
                                    if(SW_PIN_3_CHK ||(!SW_PIN_4_CHK) || INPUT_PIN_1_CHK){
                                                LED2_On();
                                    }else { LED2_Off(); }
 #ifdef debug
 printf("go loop2\r\n");
 #endif
```

```
                if(SW_OnOff ==OFF){
                    LED1_Off();
#ifdef debug
printf("SW OFF\r\n");
#endif
                    while(SW_OnOff==OFF) ;  // รอเปิด SW
                    SMS_send("Power On","+66817352163");
                    delay_ms(2000);
                }

            LED1_On();
#ifdef debug
 printf("go loop2\r\n");
#endif
            if(procount++>=1000){
                    sms_readreply();
                    procount=0;
            }

        //          if(ad2<50){SMS_send("ALERT6","+66817352163");
do{}while(ad2<50);delay_ms(500);}
        //          else
if(ad3<50){SMS_send("ALERT4","+66817352163");do{}while(ad3<50);delay_ms(500);}
        //          else
if(ad4<50){SMS_send("ALERT2","+66817352163");do{}while(ad4<50);delay_ms(500);}
        //          else
if(ad1<50){SMS_send("ALERT3","+66817352163");do{}while(ad1<50);delay_ms(500);}
            if(INPUT_PIN_1 == ON){
                if(INPUT_PIN_1_CHK==IDLE){
```

```
                    INPUT_PIN_1_CHK= ALERT;
                                    SMS_send("ALERT3\r\n","+66817352163");
                                    delay_ms(3000);
                  }
              }else if(INPUT_PIN_1 == OFF){
                  if(INPUT_PIN_1_CHK==ALERT){
                    INPUT_PIN_1_CHK = IDLE;
                                     SMS_send("UN ALERT3\r\n","+66817352163");
                                     delay_ms(3000);
                  }
              }
#ifdef debug
printf("go loop3\r\n");
#endif
              if(SW_PIN_4 ==OFF){
               door_detect=1;
                    if(SW_PIN_4_CHK==ALERT){
                      SW_PIN_4_CHK=IDLE;

                                     SMS_send("ALERT2\r\n","+66817352163");
                                     delay_ms(3000);
                    }
              }else if(SW_PIN_4 ==ON){
                    if(SW_PIN_4_CHK==IDLE){
                      SW_PIN_4_CHK=ALERT;
                     //  printf("aler2\r\n");
                      delay_ms(1000);
                                   if (door_detect==1){
                                     SMS_send("UN ALERT2\r\n","+66817352163");
```

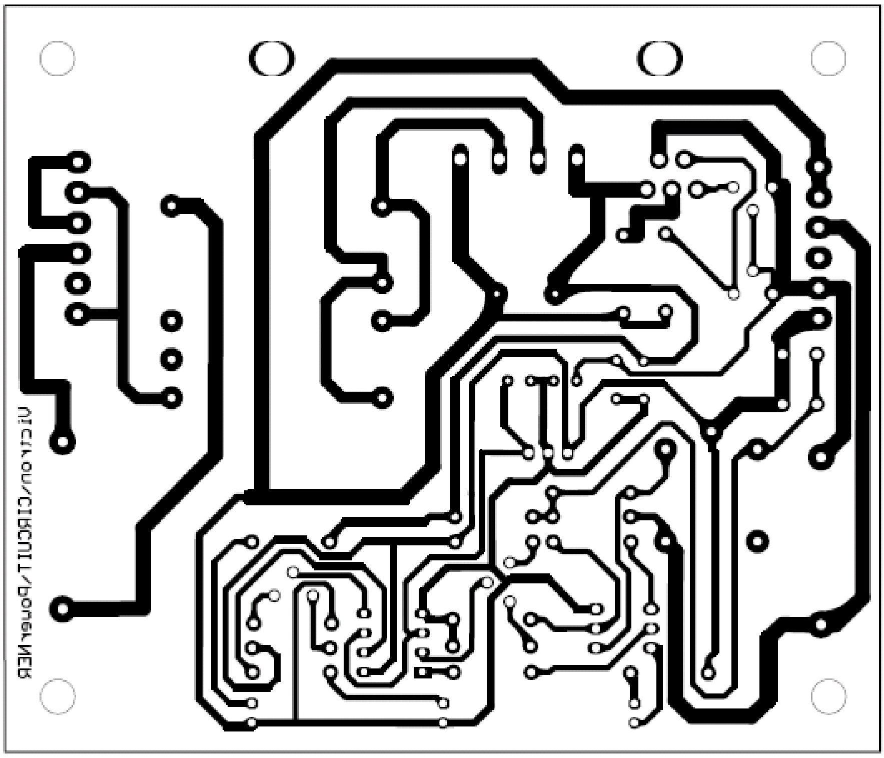
```
                                        delay_ms(3000);
                                    }
                        }
                }
  #ifdef debug
printf("go loop4\r\n");
  #endif
                if(SW_PIN_3 ==ON){
                        if(SW_PIN_3_CHK==IDLE){
                           SW_PIN_3_CHK=ALERT;

                                        SMS_send("ALERT1\r\n","+66817352163");
                                        delay_ms(3000);
                        }

                }else if(SW_PIN_3 ==OFF){
                        if (SW_PIN_3_CHK==ALERT){
                            SW_PIN_3_CHK=IDLE;
                                        SMS_send("Un ALERT1\r\n","+66817352163");
                                        delay_ms(3000);
                        }
                }
#ifdef debug
printf("go loop5\r\n");
 #endif
                /*
                else if(SW_OnOff==0) {
                    ON_OFF_CHECK = ON_OFF_CHECK ^ 0x01;   // เปลี่ยนสถานะการ
เปิดปิด
```

```
                    if( bit_get(ON_OFF_CHECK,BIT(0))){
                     LightOn();
                      SoundOn();
                          delay_ms(400);
                      LightOff();
                      SoundOff();
                          delay_ms(400);
                      LightOn();
                      SoundOn();
                          delay_ms(400);
                      LightOff();
                      SoundOff();
                          delay_ms(400);
//                   LED2_On();
//                   LED1_On();
                      GPRS_COMMAND("AT+CMGD=1,0\r",2);
                    LightOff();
                    SoundOff();
                      delay_ms(1000);
                 }
             }
             */
             /*
         if( bit_get(ON_OFF_CHECK,BIT(0))){
//              LED2_On();
//              LED1_On();
             for(firstindex=1;firstindex<=100;firstindex++){
                 if( bit_get(ON_OFF_CHECK,BIT(0))){
                    if(SW_OnOff==0) {
```

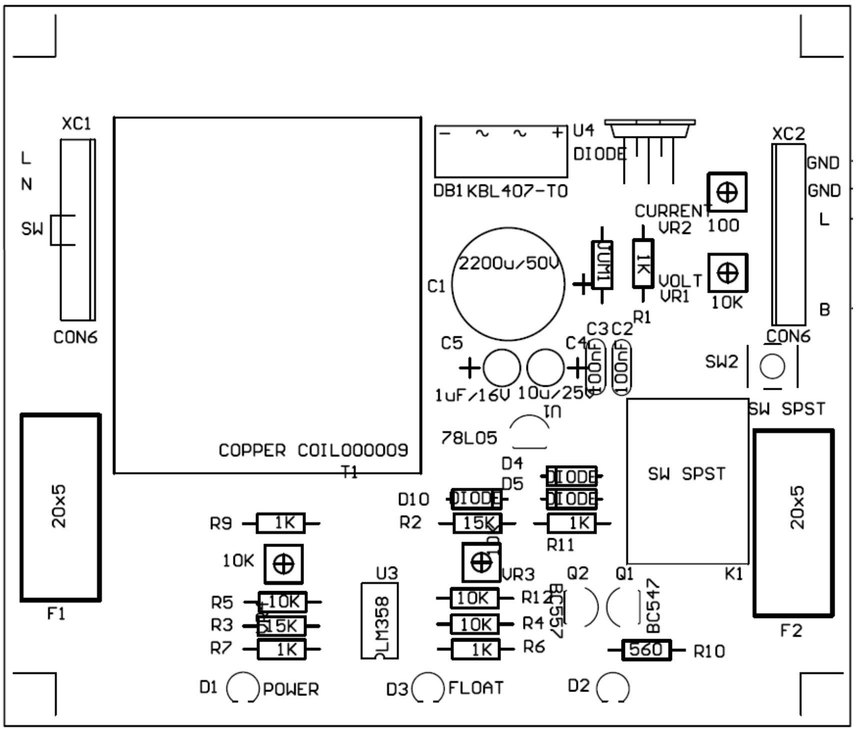
```
                LED2_Off();
                ON_OFF_CHECK = ON_OFF_CHECK ^ 0x01;
              }
             delay_us(20);
            }
        }
        sms_readreply();
        LED1_Off();
        for(firstindex=1;firstindex<=100;firstindex++){
              if( bit_get(ON_OFF_CHECK,BIT(0))){
                if(SW_OnOff==0) {
                LED2_Off();
                      ON_OFF_CHECK = ON_OFF_CHECK ^ 0x01;
                }
                delay_us(20);
             }
          }
}
/*
else if(SW_Alert ==ON){  // เมื่อเกิด Event  แจ้งเตือน
   delay_ms(200);
printf("!!!!!");
SMS_send("ALERT","+66817352163");  //  ส่งข้อมูลการแจ้งเตือนไปที่เบอร์
xxxx
   delay_ms(200);
SoundOn();
      do{ // วนเปิดปิด ไฟ จนกว่าจะมีการ  ดับ  Alarm
         LightOn();
              delay_ms(500);
```

```
                    LightOff();
                          delay_ms(500);
                }while(SW_Alert ==1);
                delay_ms(3000);
         }
          else{
             //    LED2_Off();
             //    LED1_Off();
          }
          */
       }
       }
 /*******************  Wireless ***************************/
}
```

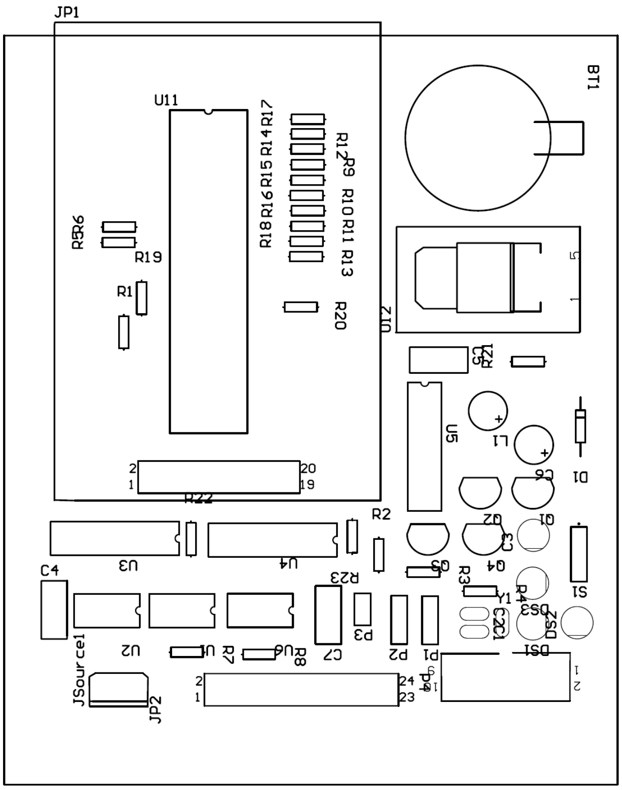
ลายวงจรและการลงอุปกรณ์



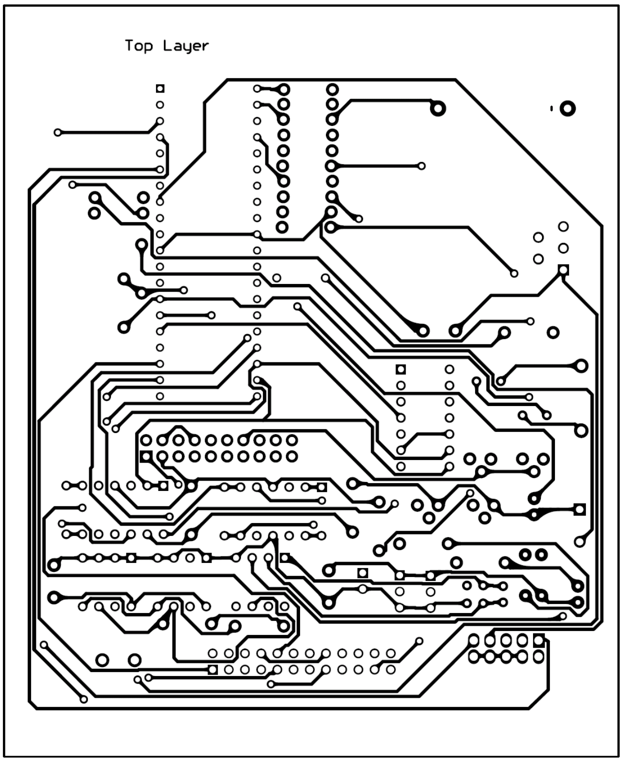
ลายวงจรเพาเวอร์ซัพพลาย



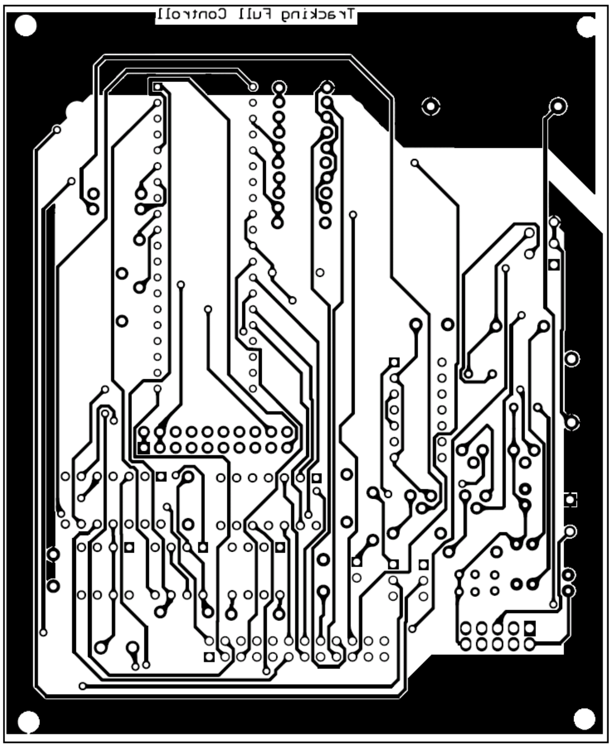
วงจรพิมพ์ด้านบนเพื่อการประกอบลงอุปกรณ์



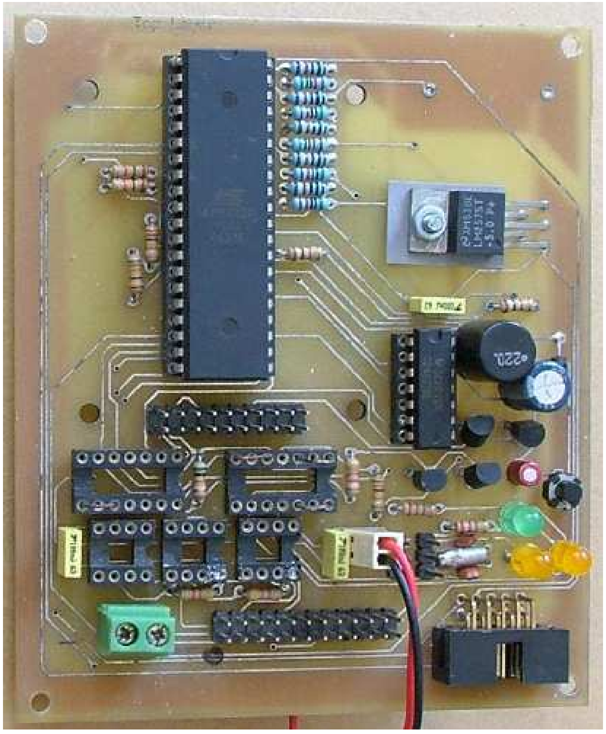
วงจรด้านบนลงตัวอุปกรณ์



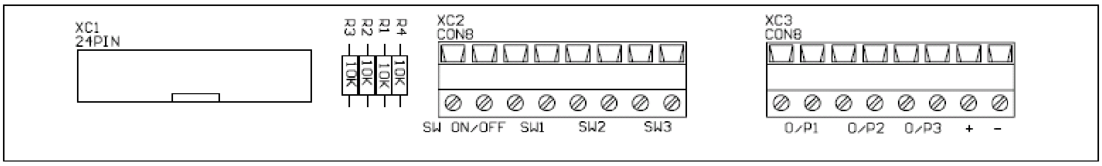
แผ่นวงจรควบคุมลายวงจรด้านบน



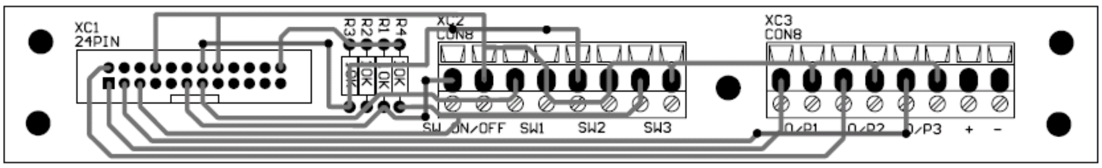
แผ่นลายวงจรควบคุมลายด้านล่าง



การลงอุปกรณ์ลงแผ่นวงจรควบคุมเรียบร้อย



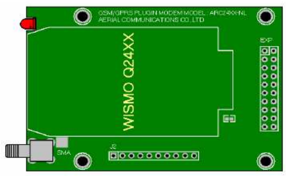
แผ่นวงจร Input Sensor

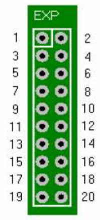


แผ่นวงจร Input Sensor

แผ่นวงจรเชื่อมต่อโมดูล Wavecom รุ่น WISMO Q2406 (เข้ากับ ไมโครคอนโทรลเลอร์)

GSM/GPRS PLUGIN MODEM
MODEL : ARC24XX-NL
PIN Description





EXP CONNECTOR (20PIN)

Pin Number	Assignment	I/O	I/O Type	Description
1	BOOT			Reserved use by Aerial (Pull down with 100KOhm)
2	RESET	I	CMOS	Reset GSM Module(Active High)
3	TX	I	GPI/O	RS232-Transmit
4	RTS	I	GPI/O	RS232-Request to send
5	RI	O	GPI/O	RS232-Ring Indicator
6	DCD	O	GPI/O	RS232-Data Carrier Detect
7	RX	O	GPI/O	RS232- Receive
8	CTS	O	GPI/O	RS232-Clear to send
9	SPK_P	O	Analog	Speaker Positive Output
10	SPK_N	O	Analog	Speaker Negative Output
11	MIC_P	I	Analog	Microphone Positive Input
12	MIC_N	I	Analog	Microphone Negative Input
13	PWR	I	CMOS	Power On/Off Module (Logic High > 1 sec)
14	VCC MODULE	O	Supply	Digital Output (Use for check module in power on state)
15	DTR	I	GPI/O	RS232-DTR
16	DSR	O	GPI/O	RS232-DSR
17	+5V	I	Supply	Power Supply Input (High Current)
18	+5V	I	Supply	Power Supply Input (High Current)
19	GND		Supply	
20	GND		Supply	

โมดูล Wavecom รุ่น WISMO Q2406

คุณสมบัติของ Wavecom **รุ่น** WISMO Q2406 Series GSM900/1800 GPRS Class10

- ใช้ได้สองระบบคือ GSM/GPRS modem (EGSM900/1800 MHz or EGSM900/1900 MHz)
- พลังงานเอาต์พุต

  Class 4 (2W @ 900 MHz)

  Class 1 (1W @ 1800/1900 MHz)
- แรงดันอินพุต :5v-32v
- กระแสอินพุต

  ในขณะไม่ได้งาน 5mA, ในขณะใช้งาน 140mA ของระบบ GSM900 ที่ 12V

  ในขณะไม่ได้งาน 5mA, ในขณะใช้งาน 100mA ของระบบ GSM1800/1900 ที่ 12V
- ช่วงของอุณหภูมิ

  ในขณะปฏิบัติงาน 20 องศาซี ถึง + 55 องศาซี

  ในขณะบันทึกการใช้งาน 25 องศาซี ถึง + 70 องศาซี
- ขนาด : 98 x 54 x 25 mm
- น้ำหนัก : 130g

คุณสมบัติด้านเสียงของ Wavecom Fastrack GSM Modem

- การใช้โทรศัพท์
- การเรียกสายฉุกเฉิน
- เต็มอัตรา, สูงกว่าเต็มอัตรา และครึ่งอัตรา (FR/EFR/HR)
- ฟังก์ชั่นความถี่หลายคู่เสียง (DTMF)
- หัวต่อสายอากาศ SMA
- ช่องใส่ SIM แบบเลื่อน (3V/5V SIM interface)

AT Command ในการติดต่อกับโทรศัพท์มือถือ

AT Command คือชุดของคำสั่งที่ใช้ในการควบคุมโทรศัพท์มือถือ และคำสั่ง AT Command ที่ใช้ในโครงงานนี้คือ

คำสั่งที่ใช้ในการตรวจสอบสภาวะการติดต่อกับมือถือ

รูปแบบคำสั่ง

AT<CR>

โดยถ้าติดต่อได้สำเร็จมือถือจะตอบ OK

คำสั่งควบคุมการโทร

คำสั่งโทรออก

รูปแบบคำสั่ง

ATD+66XXXXXXXX<CR>

โดย X คือหมายเลขที่ต้องการโทรออก

โทรศัพท์ตอบกลับมา

OK แสดงว่า มีการโทรออกได้

คำสั่งรับสายเรียกเข้า

รูปแบบคำสั่ง

ATA<CR>

โทรศัพท์ตอบกลับมา

OK แสดงว่า มีการรับสายที่โทรเข้ามาแล้ว

คำสั่งวางสาย หรือยกเลิกการโทร

รูปแบบคำสั่ง

ATH<CR>

โทรศัพท์ตอบกลับมา

OK แสดงว่า มีการรับสายที่โทรเข้ามาแล้ว

คำสั่งที่ใช้ในการเปิดใช้ระบบ GPRS

คำสั่งเปิดใช้งาน MODEM

รูปแบบคำสั่ง

AT + WOPEN = < index ><CR>

โดย < Index > คือ 0 และ 1

; 0 คือ ไม่ใช้งานและ 1 คือ ใช้งาน

คำสั่งการขอเปิดการติดต่อ GPRS

รูปแบบคำสั่ง

AT+CGATT =< mode><CR>

ให้ตั้งค่า AT+CGATT =1

; 0 คือ ไม่ใช้งานและ 1 คือ ใช้งาน

คำสั่งติดต่อกับศูนย์บริการ

รูปแบบคำสั่ง

AT#APNSERV="WWW.DTAC.TH"<CR>

โดย เป็นการขอใช้ระบบ GPRS กับศูนย์บริการ

คำสั่งเปิดการติดต่อ

รูปแบบคำสั่ง

AT#CONNECTIONSTART<CR>

โดย เป็นการเริ่มเปิดการติดต่อระบบ GPRS

คำสั่งเชื่อมต่อกลับเครือข่าย

รูปแบบคำสั่ง

AT#TCPSERV="XXX.XXX.XXX.XXX"<CR>

โดย เป็นการเชื่อมต่อกลับเครือข่ายผ่านทาง IP Address

คำสั่งติดต่อผ่านพอร์ต

รูปแบบคำสั่ง

AT#TCPPORT="3000"<CR>

โดย เป็นการส่งข้อมูลผ่านทางพอร์ต 3000 ของเครื่อง Sever

คำสั่งเปิดการส่งข้อมูล/ปิดการส่งข้อมูล

รูปแบบคำสั่ง

AT#OTCP<CR>

โดย เป็นการเริ่มส่งข้อมูลผ่านระบบ GPRS

คำสั่งปิดการส่งข้อมูล

รูปแบบคำสั่ง

Ctrl+C

โดย เป็นการหยุดส่งข้อมูลผ่านระบบ GPRS

คำสั่งหยุดการติดต่อกับระบบเครือข่าย

รูปแบบคำสั่ง

AT#CONNECTIONSTOP<CR>

โดย เป็นการหยุดการติดต่อกับระบบเครือข่าย

คำสั่ง SMS

คำสั่งเลือกรูปแบบข้อความ

รูปแบบคำสั่ง

AT + CMGF = < index ><CR>

โดย < Index > คือ 0 และ 1

; 0 คือ โหมด PDU และ 1 คือ โหมด text

คำสั่งแสดงข้อความที่เข้ามาใหม่

รูปแบบคำสั่ง

AT+CNMI=<mode>, <mt>, <bm>, <ds>, <bfr><CR>

ให้ตั้งค่า AT+CNMI=2, 1, 2, 0, 0 กด Enter

โทรศัพท์ตอบกลับมา

OK แสดงว่า ตั้งค่าไว้แล้ว

คำสั่งอ่านข้อความ

รูปแบบคำสั่ง

AT+CMGR = < index ><CR>

โดย < Index > คือ แทน sms ที่เท่าไร

คำสั่งแสดงข้อความ

รูปแบบคำสั่ง

AT+CMGL = < stat ><CR>

โดย ค่า < Stat > มีค่าดังตาราง ค่า Startคำสั่งส่งข้อความ

แบ่งเป็น 2 แบบคือ

1. โหมด Text

รูปแบบคำสั่ง

AT+CMGS="+66XXXXXXXX"<CR>

ข้อความที่จะส่ง, <ctrl-Z>

2. โหมด PDU

รูปแบบคำสั่ง

AT+CMGS=<length><CR>

<pdu><ctrl-Z>

โดย <Length> เป็นความยาวของข้อมูลที่จะส่งคือ

ความยาวของส่วน(Header + ความยาวของส่วนที่เป็น PDU Code-3)/2

และ <pdu> คือ Header + PDU Code

คำสั่งลบข้อความ

รูปแบบคำสั่ง

AT+CMGD = < index ><CR>

โดย < Index > คือ แทน sms ที่เท่าไร

คำสั่งแสดงสถานีเครือข่าย

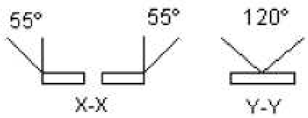
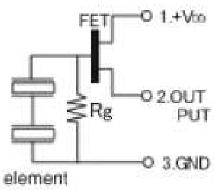
รูปแบบคำสั่ง

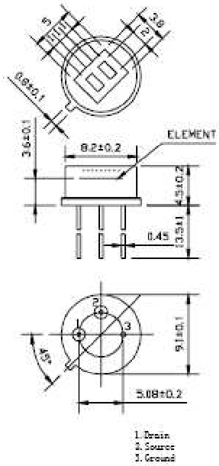
AT+CSCB=0, 50<CR>

โดยถ้าติดต่อได้สำเร็จมือถือจะตอบ OK และแสดงชื่อสถานี

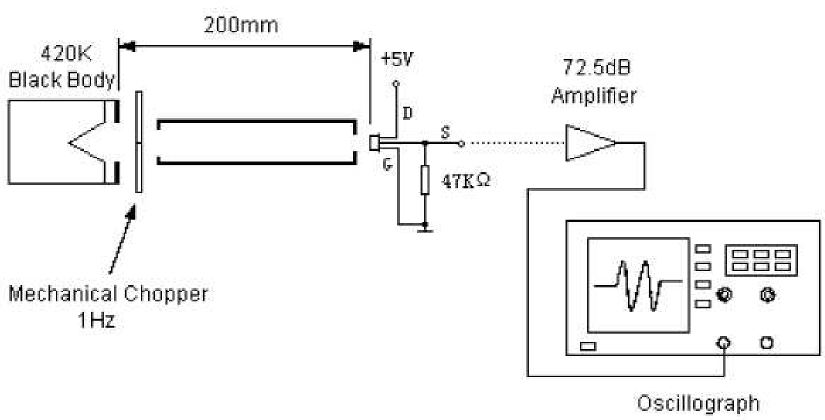
Data Sheet ของอุปกรณ์ต่าง ๆ ที่ใช้ในระบบ

■ Standard Specifications and Dimensions

Recommended Model	D203B
Encapsulation Type	TO-5
IR Receiving Electrode	2×1mm, 2 elements
Window Size	5×3.8mm
Spectral Response	5-14μm
Transmittance	≥75%
Signal Output [Vp-p]	≥3500mV
Sensitivity	≥3300V/W
Detectivity (D*)	≥1.4 ×10^{8} cmHz$^{1/2}$/W
Noise[Vp-p]	<70mV
Output Balance	<10%
Offset Voltage	0.3-1.2V
Supply Voltage	3-15V
Operating Temp.	-30-70℃
Storage Temp.	-40-80℃
Field of View Equivalent Circuit	
Equivalent Circuit	

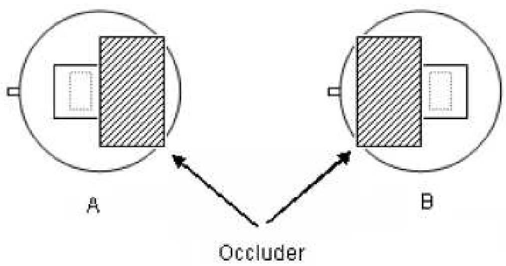


Test Method



Test conditions

- Ambient temperature 25°C
- Black-body temperature 420K(147°C)
- Modulating frequency 1 Hz, 0.3-3.5Hz △f,
- 72.5 dB Amplifier

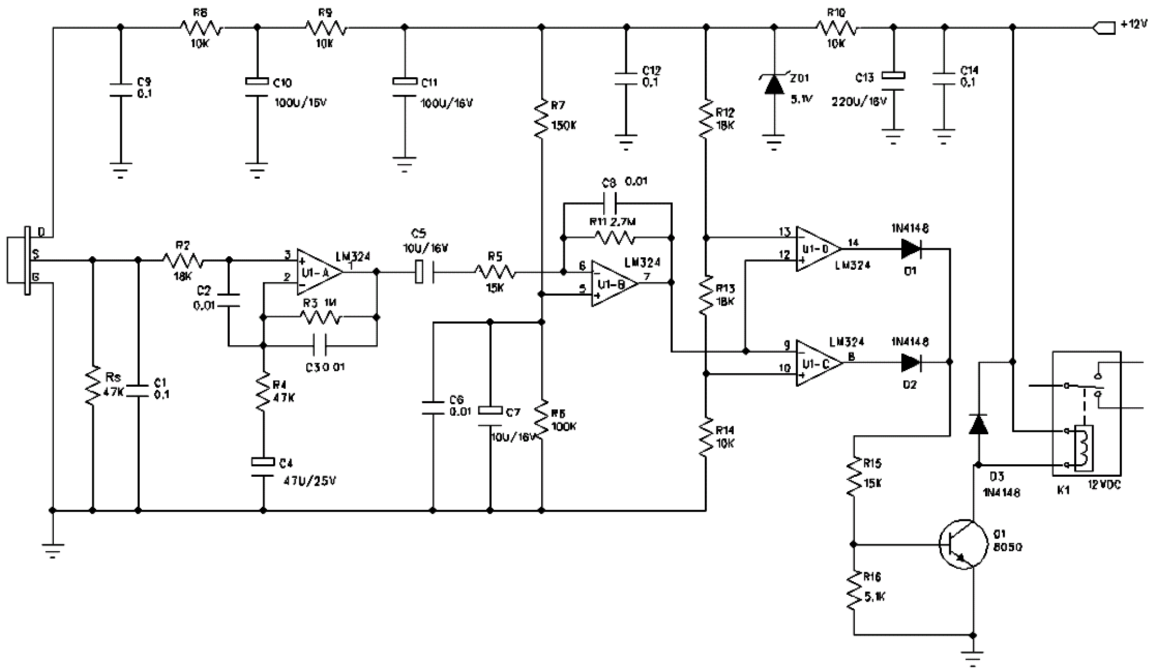


The sensitivity balance of dual element sensor is calculated through testing the sensitivity (single signal output voltage) of each element and using the following formula:

Balance = $|V_A - V_B|/(V_A + V_B) \times 100\%$

V_A = Sensitivity of side A (mVp-p)

V_B = Sensitivity of side B (mVp-p)



Notice:

U1A-D:LM324

Vdd:12V DC

Rs=47KΩ @ on an offset voltage

K30. PIR DETECTOR USING MOVEMENT IC & PCB MOUNTED LENS

Making a movement detector using a high-gain op-amp circuit has never been easy. It is interesting to see how magazine articles present the subject; they always imply that the project is easy. The problem is that as the gain of the circuit is increased the slightest line voltage luctuation will false trigger the unit. This arises when you try to run the op-amp circuit from the same power supply which operates the siren, or even an LED which comes on when the unit is triggered. It is still a black art to juggle the position of voltage regulators & special op-amps, capacitors & components to minimise this problem. So both for the hobbyist and commercial user there is a real attraction to have the movement detector circuit all contained in one IC. Heimann were first to put the complete electronics of a movement detector into one IC. But it was too expensive for commercial use and has been discontinued. The 20 pin DIP IC supplied here is the result of a recent American - Hong Kong Chinese venture to do the same thing more cheaply. Our tests on this IC show it to be very good & easy to use.

And the choice of an efficient lens system is also important. The purpose of the fresnel lens is to break up the area under observation into optical zones so that a heat source moving from one optical zone to another will generate a heat wave on the surface of the PIR detector. It is no use having an excellent electronic circuit if the IR optical system is not very good. A lower gain circuit with an excellent lens system is far better than an excellent circuit & poor lens system. (Many cheap commercial detectors follow this philosophy.) And herein lies the problem for the hobbyist: it has always been difficult for the hobbyist to construct a curved mounting to hold the large plastic-sheet Fresnel lenses which give the most sensitive IR optics onto the PIR sensor. The physics of a creeping burglar at 25 yards (or meters) simply demands a focal length of 4 to 5cm for the lens/sensor system in order for the motion to be reliably detected. The PCB-mounted lens supplied in this Kit is a good compromise. It will reliably detect motion in the 3 to 4 meters (yards) range.

The technology of PIR sensors is now well known and has been published in most hobby magazines sometime within the last 5 years. Dual sensor PIR detectors are now the most widely used motion detectors. The other technologies (mainly ultrasonic) suffer too much from false triggering or are too expensive.

The kit is constructed on a single-sided printed circuit board (PCB). It has a silk screen overlay on top to aid construction. On the bottom there is a solder mask to help in soldering.

ASSEMBLY

Before you do anything. The RE200B PIR (passive infra red) sensor, the LDR (light dependent resistor) and the plastic PCB-mounted Fresnel lens are all to be mounted on the **BACK**, copper side of the PCB. They do not go on the top of the PCB where all the other components go. This is so that the unit can be easily placed in a box with the lens poking out a hole in the box but with the electronics on the top of the PCB inside the box for easy access. Mount these 3 components last as described below.

Also consider at this time the position of the 2 LED's. You may want to put 1 or both of them also on the bottom of the PCB depending on how you want to use the Kit.

First Thing. Place all the components in a container and check them off against the Component list. Do not touch the surface of the PIR detector. It is generally easiest to solder the lowest height components first - the resistors, switches and IC socket. Make sure you get the electrolytic capacitors, the LED's and the diode in the correct way. For the LED's the short leg and the flat on the plastic case is the cathode and corresponds to the bar on the overlay. Do not mix up the 78L05 with the 2 BC547's. They all come in a TO-92 package. Note that C5 is a low-leakage electrolytic capacitor.

The three trimpots & 3 terminal blocks should be the last items to solder into placeon the top. Now we will describe how best to assemble the LDR and PIR sensor.

LDR, Lens & PIR Sensor. These 3 components go on the copper side - the bottom side - of the PCB. First the LDR. Put it through the two holes from the copper side and support it about 1/8" to 1/4" (4 to 8 mm) above the surface. Solder it into place. Cut off the legs.

PIR. This also is mounted on the copper side. The top overlay gives an X-ray view of how to mount it. The 3 legs can only fit into the PCB one way from the bottom so there should not be a problem. The notch on the sensor should be directly underneath the notch as printed on the overlay. Now unlike the LDR the 3 legs have to be spread out on the top of the PCB and inserted into their espective holes & soldered. Follow the link tracks: D-D, G-G, S-S.

Lens. Finally the plastic lens should be snapped into place on the bottom side to cover the sensor & LDR.

CIRCUIT DESCRIPTION

Important Note. Due to the sensitive electronics in the movement IC and the PIR sensor there is a warm-up period of about a minute required when you turn the detector on before it will work. Also changes to settings (in particular the daylight level) require about 90 seconds to take effect. Remember that the fast digital world does not apply to these modern analog devices.

The heart of the circuit is the motion detection IC. Electrical signals from the PIR sensor have a very low frequency (0.1 to 10Hz) and bandwidth. The IC is optimised for this. The operating voltage of the KC778B itself is 4 - 15V. But with the 78L05 regulator voltage input should be in the 9V to 12V range. There are three sensitivity controls built into the circuit. They can be seen in the schematic diagram on the next page.

- sensitivity is controlled at pin 2 by trimpot P1. When this pin equals the sensor drain potential at pin 7 (about 0.5V) sensitivity is at a minimum.

K30. PIR DETECTOR USING MOVEMENT IC & PCB MOUNTED LENS

When pin 2 is connected to ground (about 0.125V) sensitivity is at a maximum.

- daylight sensitivity using trimpot P2 and the LDR. Maybe you want the sensor to be inactive during the daytime and only active at night. (For example, if it is connected to a night light.) If you do not want this feature then tie pin 12 to Vcc and leave pin 11 unconnected.

- pulse on-time trimpot P3. This adjusts the output pulse from between 1.5 seconds upwards. For the minimum time delay you can directly connect pins 18 & 19 with no external capacitor or resistor. The output signal turns on LED2 and the signal is available from the Output terminal block to be connected to any device you choose - bell, buzzer, siren, relay etc. A protection diode D1 has been placed across the output to short circuit any back emf from relays connected across the Output.

Pin 17 is also connected to an LED, LED1. This IC output always goes on when the sensor & IC detect movement. But this trigger may result in an Output signal. For example, when the Output from the unit is off during the daytime. Also there is an inbuilt latency period of about 1.5 seconds in the Output pulse when triggered. This latency period is essential to smooth out the multiple trigger pulses actually sensed by the detector (as shown by LED1.) LED1 can of course be removed if it is not wanted. There is an internal 500R resistor on pin 17 so a current limiting resistor is not required.

Exit Delay. The Toggle terminal Block has been configured to give the user an exit delay of about 30 seconds in which time the detector will not operate. This can be used to test that the detector is working or give you time to leave the room after you have turned it on. See pin 15 below.

Further Pin Details

Pin 3 Offset Filter. Connects to an external 10uF capacitor & holds the average value of the switched capacitor bypass filter output. Motion is detected when the difference between this average and the actual filter output is greater than the sensitivity setting.

Pin 4 Anti-Alias. Connects to external 0.1uF providing low-pass filtering of the PIR signal input signal blocking input signals at and above the switching frequency of the switched capacitor bypass filter.

Pin 5 DC Cap. Connects to an external 10uF and holds the average source potential. The difference between this average & the actual source potential is amplified & coupled to the switched capacitor bypass filter. It should be a low-leakage or tantalum capacitor.

Pin 6 Vreg. This is supposed to be a voltage regulator pin. However, we found it did not work as advertised & we used an external voltage regulator.

Pin 7 Drain Reference. The potential is power supply independent. The potential can be divided down by an external pot to supply the sensitivity adjust to pin 2.

Pin 8 Source. PIR input. It is sensitive and should be as short a length as possible. There should be a ground plane on the PCB under the sensor.

Pin 9 is Analog ground and Pin 10 is Digital Ground

Pin 13 Gain Select. When unconnected gain is 68db. When connected to ground gain is 62db. We have left it unconnected here.

Pin 14 On/Auto/Off. Unconnected the IC works automatically. Connected to ground the IC will turn off unconditionally. Connected to Vcc it will turn on unconditionally.

Pin 15 Toggle. Unconnected the IC works automatically. Connected to ground the IC state will turn change its state and remain in the new state unconditionally as long as the pin is connected to ground. We have configured this feature to give a delay. If there is a conflict between pins 14 & 15 the off state is the default.

Pin 16 Output. Can direct drive triac, optocoupler or small relay. Output impedence is 35R allowing it to direct drive a small (100R coil resistance) relay.

Pin 20 Frequency Reference. 160Hz is used to drive the internally switched capacitor, bandpass filter & timing delays. It is connected externally through a 60K resistor to Vcc and a 0.1uF capacitor to Gnd.

There are more specifications at

http://www.kitsrus.com/gif/comic_p1.gif
http://www.kitsrus.com/gif/comic_p1.gif

PIR Sensor. The dual element PIR detector RE200B from Nippon Ceramic has a field of view from 125° to 138° (axis dependent.) It has greater than 70% transmission in the infra-red 700 to 1400 nm range. Each element generates a DC voltage proportional to the heat 'seen'. The two elements are connected in series opposition so that any common input is cancelled out. This is important for two reasons; it makes the sensor immune to changes in ambient temperature. Second, it allows the differential signal to be greatly amplified. Operating voltage from 3-10V.

There are some specifications at

http://www.kitsrus.com/ jpg/pir_1.jpg
http://www.kitsrus.com/ jpg/pir_2.jpg

LDR spec see: http://www.kitsrus.com/projects/cds.pdf

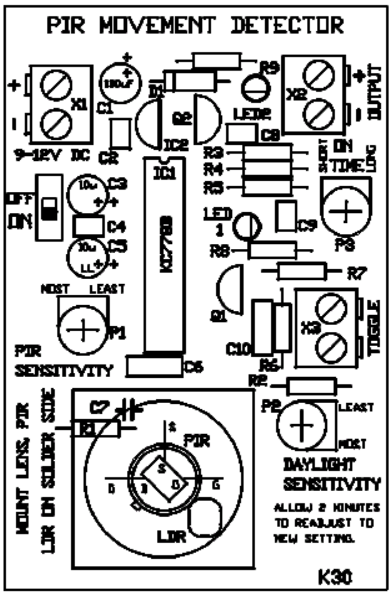
Fresnel Lens spec see:
http://www.kitsrus.com/ projects/fresnel.pdf

WHAT TO DO IF IT DOES NOT WORK

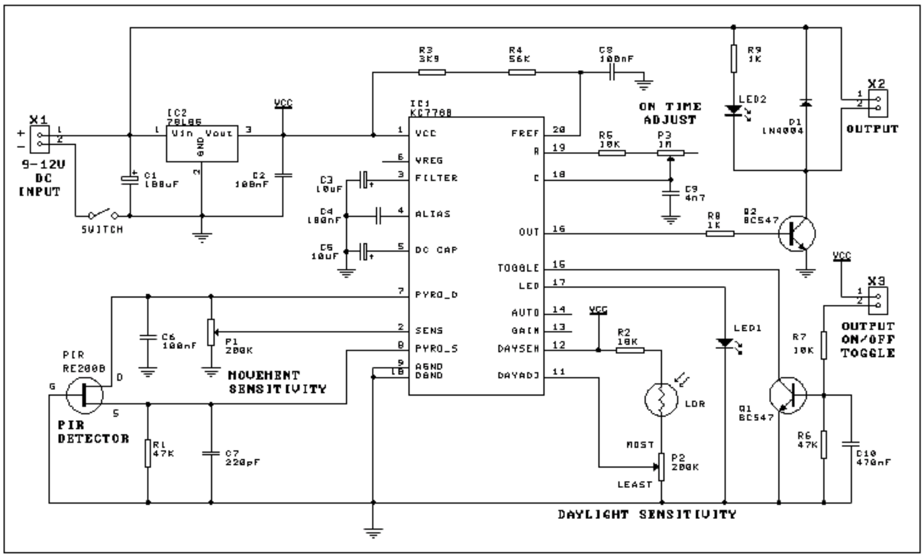
Did you remember to allow about a minute for the Kit to warm-up before it will work. Poor soldering is the most

K30. PIR DETECTOR USING MOVEMENT IC & PCB MOUNTED LENS

likely reason that the circuit does not work. Check all solder joints carefully under a good light. Next check that all components are in their correct position on the PCB. Check especially the orientation of the LEDs, electrolytic capacitors, transistors, voltage regulator and the IC. Are the PIR sensor & LDR on the bottom of the board?



COMPONENTS		
Resistors 5% carbon film:		
1K brown black red	R8 R9	2
3K9 orange white red	R3	1
10K brown black orange	R2 R5 R7	3
47K yellow violet orange	R1 R6	2
56K green blue orange	R4 1	
200K Koa trimpot 204	P1 P2	2
1M Koa trimpot 105	P3	1
10uF mini elcap	C3	1
10uF Low leakage elcap	C5	1
100uF mini elcap	C1	1
100nF monoblock 104	C2 C4 C6 C8	4
220pF ceramic 221	C7	1
4n7 ceramic 472	C9	1
470nF monoblock	C10	1
KC778B Movement	IC1	1
20 pin IC socket		1
BC547 transistor	Q1 Q2	2
78L05	IC2	1
1N4004 diode	D1	1
2 pole terminal blocks		3
3mm LED		2
RE200B PIR sensor		1
Light Dependent Resistor LDR		1
PCB-mounted Fresnel Lens		1
Kit 30 PCB		1
SPDT PCB-mounted switch		1



Features

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories
  - 32K 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
  - 1024 Bytes EEPROM
    Endurance: 100,000 Write/Erase Cycles
  - 2K Byte Internal SRAM
  - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- 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 in TQFP Package Only
    2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
  - Byte-oriented 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, and 44-pad QFN/MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega32L
  - 4.5 - 5.5V for ATmega32
- Speed Grades
  - 0 - 8 MHz for ATmega32L
  - 0 - 16 MHz for ATmega32
- Power Consumption at 1 MHz, 3V, 25°C for ATmega32L
  - Active: 1.1 mA
  - Idle Mode: 0.35 mA
  - Power-down Mode: < 1 µA

8-bit AVR® Microcontroller with 32K Bytes In-System Programmable Flash

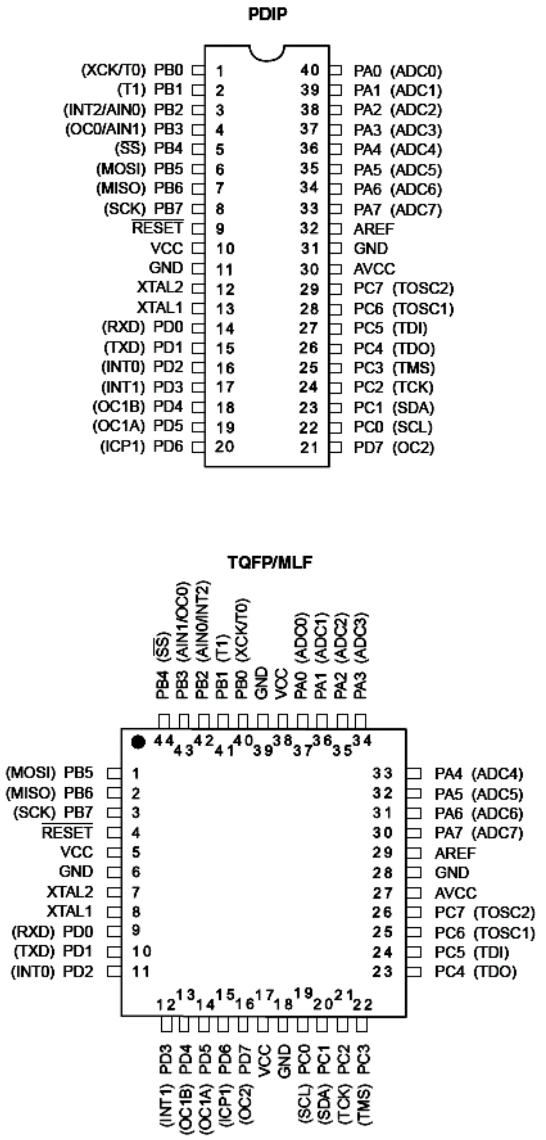
ATmega32
ATmega32L

Summary

2503HS–AVR–03/05

Pin Configurations

Figure 1. Pinout ATmega32

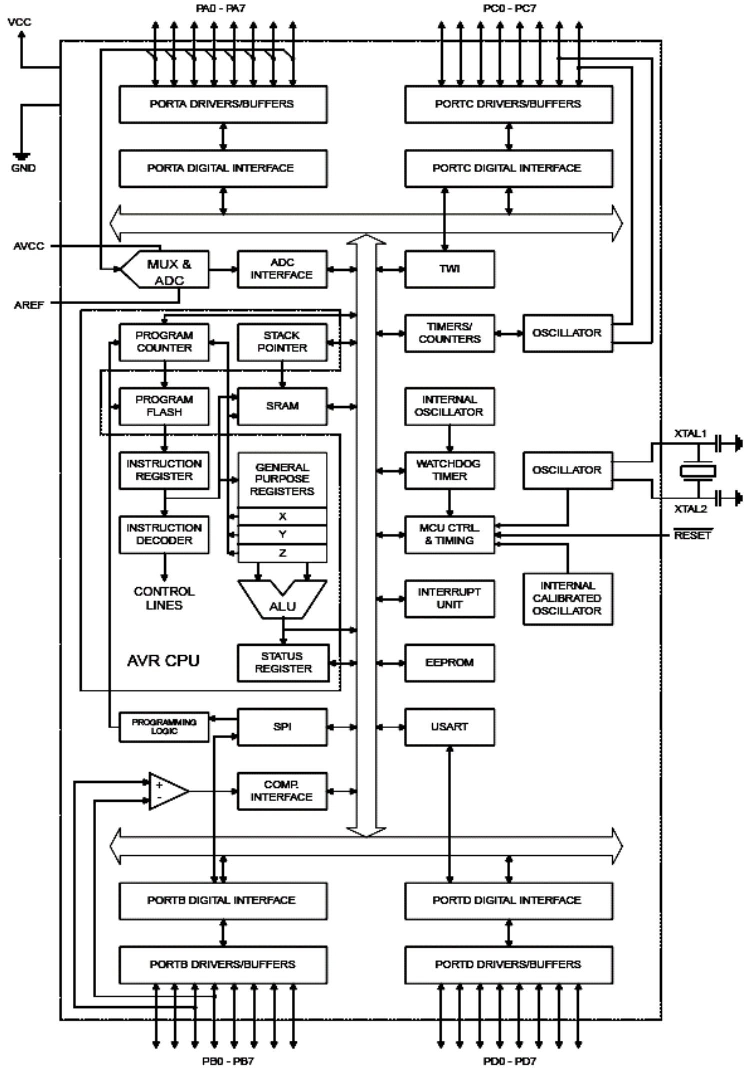


Overview

The ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

Figure 2. Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega32 provides the following features: 32K bytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 1024 bytes EEPROM, 2K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for Boundary-scan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the USART, Two-wire interface, A/D Converter, SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next External Interrupt or Hardware Reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run.

The device is manufactured using Atmel's high density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega32 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega32 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

Pin Descriptions

VCC

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 ATmega32 as listed on page 55.

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. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs.

The TD0 pin is tri-stated unless TAP states that shift out data are entered.

Port C also serves the functions of the JTAG interface and other special features of the ATmega32 as listed on page 58.

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 ATmega32 as listed on page 60.

$\overline{\text{RESET}}$

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 35. 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.

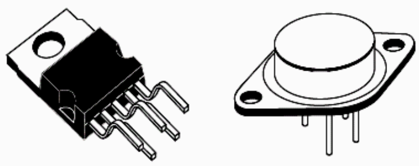
Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
$3F ($5F)	SREG	I	T	H	S	V	N	Z	C	8
$3E ($5E)	SPH	–	–	–	–	SP11	SP10	SP9	SP8	10
$3D ($5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	10
$3C ($5C)	OCR0	Timer/Counter0 Output Compare Register								80
$3B ($5B)	GICR	INT1	INT0	INT2	–	–	–	IVSEL	IVCE	45, 65
$3A ($5A)	GIFR	INTF1	INTF0	INTF2	–	–	–	–	–	66
$39 ($59)	TIMSK	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0	80, 110, 128
$38 ($58)	TIFR	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0	81, 111, 128
$37 ($57)	SPMCR	SPMIE	RWWSB	–	RWWSRE	BLBSET	PGWRT	PGERS	SPMEN	246
$36 ($56)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE	175
$35 ($55)	MCUCR	SE	SM2	SM1	SM0	ISC11	ISC10	ISC01	ISC00	30, 64
$34 ($54)	MCUCSR	JTD	ISC2	–	JTRF	WDRF	BORF	EXTRF	PORF	38, 65, 226
$33 ($53)	TCCR0	FOC0	WGM00	COM01	COM00	WGM01	CS02	CS01	CS00	78
$32 ($52)	TCNT0	Timer/Counter0 (8 Bits)								80
$31[1] ($51)[1]	OSCCAL	Oscillator Calibration Register								28
	OCDR	On-Chip Debug Register								222
$30 ($50)	SFIOR	ADTS2	ADTS1	ADTS0	–	ACME	PUD	PSR2	PSR10	54,83,129,196,216
$2F ($4F)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	FOC1A	FOC1B	WGM11	WGM10	105
$2E ($4E)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	108
$2D ($4D)	TCNT1H	Timer/Counter1 – Counter Register High Byte								109
$2C ($4C)	TCNT1L	Timer/Counter1 – Counter Register Low Byte								109
$2B ($4B)	OCR1AH	Timer/Counter1 – Output Compare Register A High Byte								109
$2A ($4A)	OCR1AL	Timer/Counter1 – Output Compare Register A Low Byte								109
$29 ($49)	OCR1BH	Timer/Counter1 – Output Compare Register B High Byte								109
$28 ($48)	OCR1BL	Timer/Counter1 – Output Compare Register B Low Byte								109
$27 ($47)	ICR1H	Timer/Counter1 – Input Capture Register High Byte								110
$26 ($46)	ICR1L	Timer/Counter1 – Input Capture Register Low Byte								110
$25 ($45)	TCCR2	FOC2	WGM20	COM21	COM20	WGM21	CS22	CS21	CS20	123
$24 ($44)	TCNT2	Timer/Counter2 (8 Bits)								125
$23 ($43)	OCR2	Timer/Counter2 Output Compare Register								125
$22 ($42)	ASSR	–	–	–	–	AS2	TCN2UB	OCR2UB	TCR2UB	126
$21 ($41)	WDTCR	–	–	–	WDTOE	WDE	WDP2	WDP1	WDP0	40
$20[2] ($40)[2]	UBRRH	URSEL	–	–	–	UBRR[11:8]				162
	UCSRC	URSEL	UMSEL	UPM1	UPM0	USBS	UCSZ1	UCSZ0	UCPOL	160
$1F ($3F)	EEARH	–	–	–	–	–	–	EEAR9	EEAR8	17
$1E ($3E)	EEARL	EEPROM Address Register Low Byte								17
$1D ($3D)	EEDR	EEPROM Data Register								17
$1C ($3C)	EECR	–	–	–	–	EERIE	EEMWE	EEWE	EERE	17
$1B ($3B)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	62
$1A ($3A)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	62
$19 ($39)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	62
$18 ($38)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	62
$17 ($37)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	62
$16 ($36)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	63
$15 ($35)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	63
$14 ($34)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	63
$13 ($33)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	63
$12 ($32)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	63
$11 ($31)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	63
$10 ($30)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	63
$0F ($2F)	SPDR	SPI Data Register								136
$0E ($2E)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X	136
$0D ($2D)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	134
$0C ($2C)	UDR	USART I/O Data Register								157
$0B ($2B)	UCSRA	RXC	TXC	UDRE	FE	DOR	PE	U2X	MPCM	158
$0A ($2A)	UCSRB	RXCIE	TXCIE	UDRIE	RXEN	TXEN	UCSZ2	RXB8	TXB8	159
$09 ($29)	UBRRL	USART Baud Rate Register Low Byte								162
$08 ($28)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	197
$07 ($27)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0	212
$06 ($26)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	214
$05 ($25)	ADCH	ADC Data Register High Byte								215
$04 ($24)	ADCL	ADC Data Register Low Byte								215
$03 ($23)	TWDR	Two-wire Serial Interface Data Register								177
$02 ($22)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	177

L200

ADJUSTABLE VOLTAGE AND CURRENT REGULATOR

- ADJUSTABLE OUTPUT CURRENT UP TO 2 A (GUARANTEED UP TO T_j = 150 °C)
- ADJUSTABLE OUTPUT VOLTAGE DOWN TO 2.85 V
- INPUT OVERVOLTAGE PROTECTION (UP TO 60 V, 10 ms)
- SHORT CIRCUIT PROTECTION
- OUTPUT TRANSISTOR S.O.A. PROTECTION
- THERMAL OVERLOAD PROTECTION
- LOW BIAS CURRENT ON REGULATION PIN
- LOW STANDBY CURRENT DRAIN



Pentawatt® **TO-3 (4 lead)**

DESCRIPTION

The L200 is a monolithic integrated circuit for voltage and current programmable regulation. It is available in Pentawatt® package or 4-lead TO-3 metal case. Current limiting, power limiting, thermal shutdown and input overvoltage protection (up to 60 V) make the L200 virtually blow-out proof.

The L200 can be used to replace fixed voltage regulators when high output voltage precision is required and eliminates the need to stock a range of fixed voltage regulators.

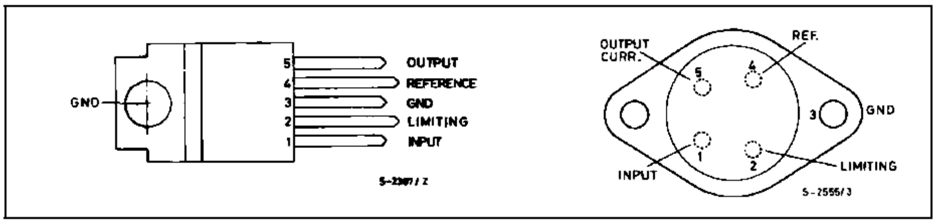
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	40	V
V_i	Peak Input Voltage (10 ms)	60	V
$\Delta V_{i\text{-}o}$	Dropout Voltage	32	V
I_o	Output Current	internally limited	
P_{tot}	Power Dissipation	internally limited	
T_{stg}	Storage Temperature	-55 to 150	°C
T_{op}	Operating Junction Temperature for L200C	-25 to 150	°C
	for L200	-55 to 150	°C

THERMAL DATA

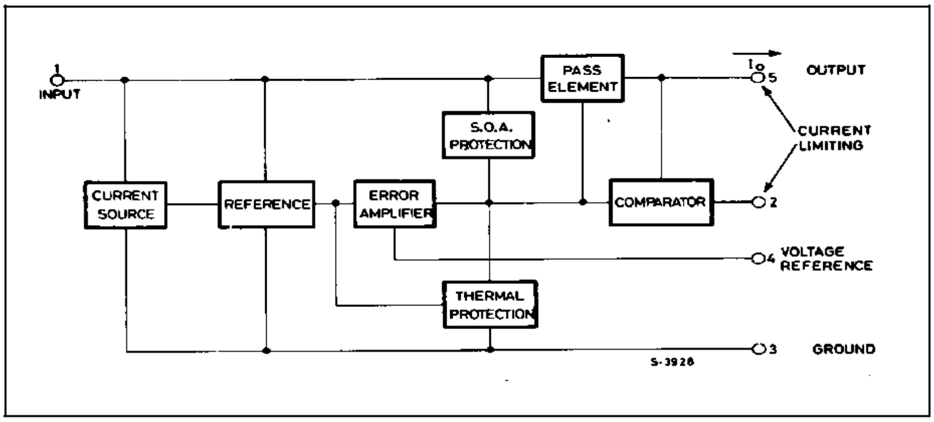
			TO-3	Pentawatt®
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max	4 °C/W	3 °C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max	35 °C/W	50 °C/W

CONNECTION DIAGRAMS AND ORDER CODES (top views)



Type	Pentawatt®	TO-3
L200		L200 T
L200 C	L200 CH L200 CV	L200 CT

BLOCK DIAGRAM



APPLICATION CIRCUITS

Figure 1. Programmable Voltage Regulator with Current Limiting

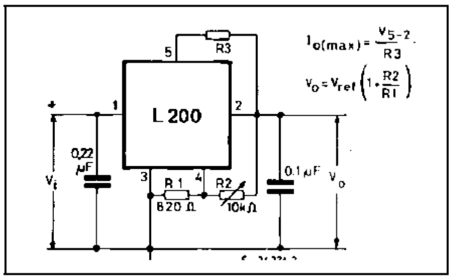
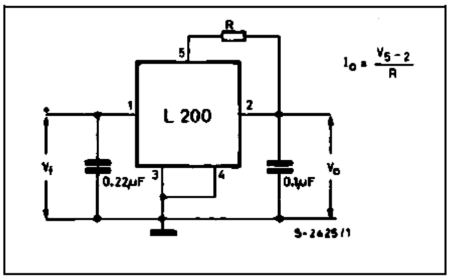
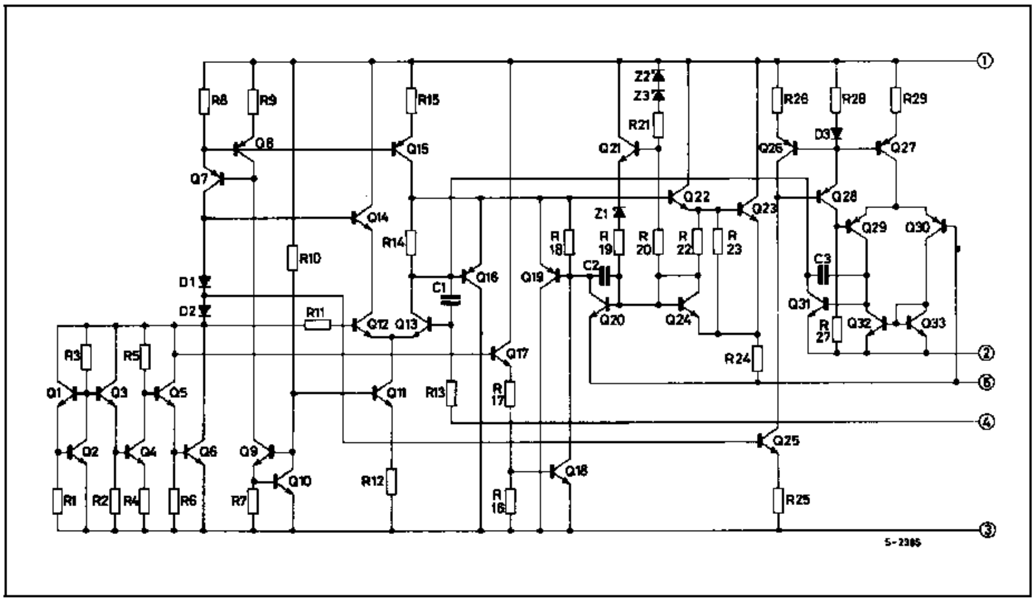


Figure 2. Programmable Current Regulator.



SCHEMATIC DIAGRAM



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

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
VOLTAGE REGULATION LOOP						
I_d	Quiescent drain Current (pin 3)	V_i = 20 V		4.2	9.2	mA
e_N	Output Noise Voltage	Vo = Vref I_o = 10 mA B = 1 MHz		80		µV
V_o	Output Voltage Range	I_o = 10 mA	2.85		36	V
$\frac{\Delta V_o}{V_o}$	Voltage Load Regulation (note 1)	ΔI_o = 2 A ΔI_o = 1.5 A		0.15 0.1	1 0.9	% %
$\frac{\Delta V_i}{\Delta V_o}$	Line Regulation	V_0 = 5 V V_i = 8 to 18 V	48	60		dB
SVR	Supply Voltage Rejection	V_0 = 5 V I_o = 500 mA ΔV_i = 10 V_{pp} f = 100 Hz (note 2)	48	60		dB
$\Delta V_{i\text{-}o}$	Droupout Voltage between Pins 1 and 5	I_o = 1.5 A ΔV_0 ≤ 2%		2	2.5	V
V_{ref}	Reference Voltage (pin 4)	V_i = 20 V I_o = 10 mA	2.64	2.77	2.86	V

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
ΔV_{ref}	Average Temperature Coefficient of Reference Voltage	V_i = 20 V Io = 10mA for Tj = - 25 to 125 °C for Tj = 125 to 150 °C		 -0.25 -1.5		 mV/°C mV/°C
I_4	Bias Current and Pin 4			3	10	µA
$\frac{\Delta I_4}{\Delta T \bullet I_4}$	Average Temperature Coefficient (pin 4)			-0.5		%/°C
Z_o	Output Impedance	V_i = 10 V $V_o = V_{ref}$ I_o = 0.5 A f = 100 Hz		1.5		mΩ

CURRENT REGULATION LOOP

V_{SC}	Current Limit Sense Voltage between Pins 5 and 2	V_i = 10 V $V_o = V_{ref}$ I_5 = 100 mA	0.38	0.45	0.52	V
$\frac{\Delta V_{SC}}{\Delta T \bullet V_{SC}}$	Average Temperature Coefficient of V_{SC}			0.03		%/°C
$\frac{\Delta I_o}{I_o}$	Current Load Regulation	Vi = 10 V ΔVo = 3V I_o = 0.5 A I_o = 1A I_o = 1.5 A		 1.4 1 0.9		 % % %
I_{SC}	Peak Short Circuit Current	$V_i - V_0$ = 14 V (pins 2 and 5 short circuited)			3.6	A

Note 1: A load step of 2 A can be applied provited that input-output differential voltage is lower than 20 V (see Figure 3).
Note 2: The same performance can be maintained at higher output levels if a bypassing capacitor is provited between pins 2 and 4.

Figure 3. Typical Safe Operating Area Protection.

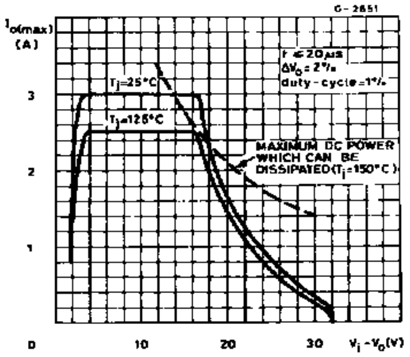


Figure 4. Quiescent Current vs. Supply Voltage.

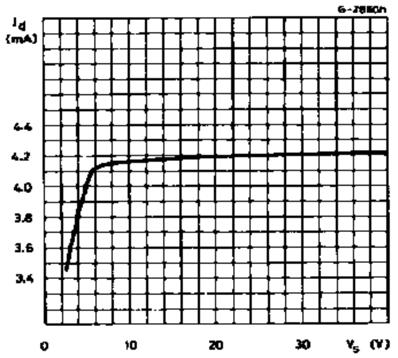


Figure 17. Load Transient Reponse

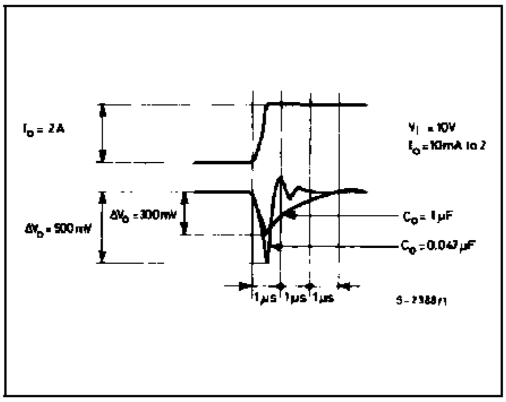
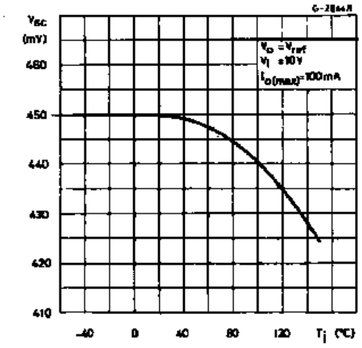


Figure 18. Current Limit Sense Voltage vs. Junction Temperature.



APPLICATIONS CIRCUITS

Figure 19. - Programmable Voltage Regulator

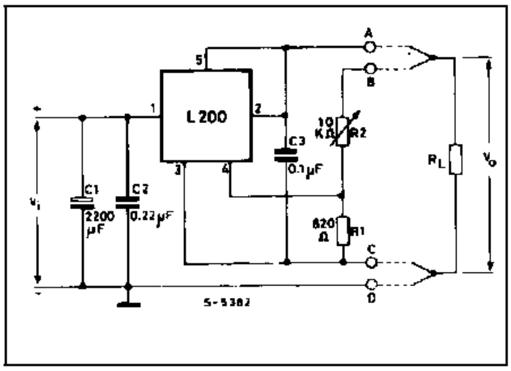


Figure 20. - P.C. Board and Components Layout of Figure 19.

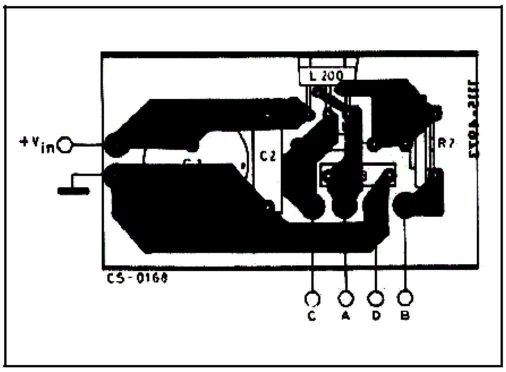


Figure 21. - High Current Voltage Regulator with Short Circuit Protection.

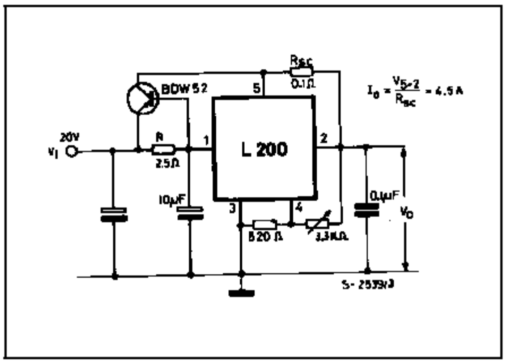


Figure 22. - Digitally Selected Regulator with Inhibit.

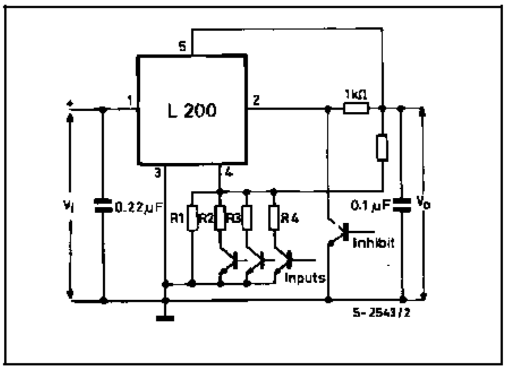
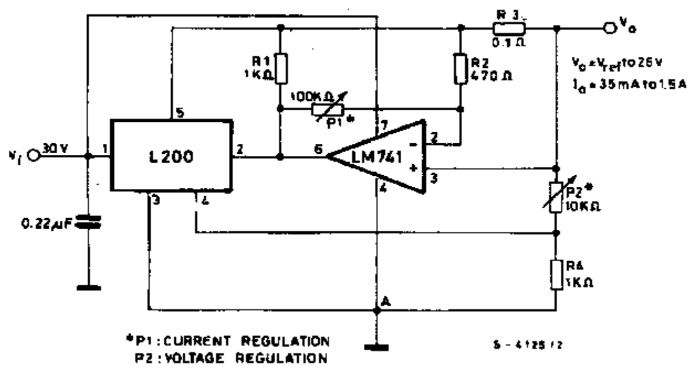


Figure 23. Programmable Voltage and Current Regulator.



Note: Connecting point A to a negative voltage (for example - 3V/10 mA) it is possible to extend the output voltage range down to 0 V and obtain the current limiting down to this level (output short-circuit condition).

Figure 24. High Current Regulator with NPN Pass Transistor.

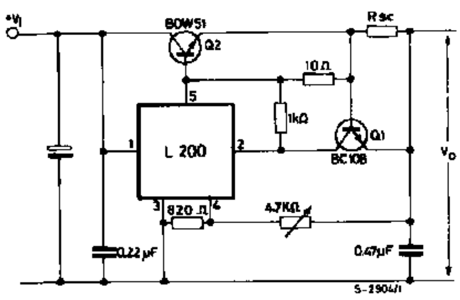
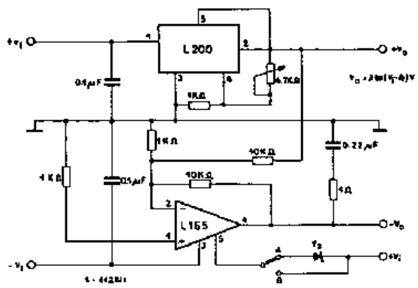


Figure 25. High Current Tracking Regualtor.



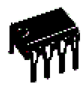
A : for ±18≤ V_i ≤±32

Note – V_z must be chosen in order to verify $2V_i - V_z \leq 36$ V

LM158,A-LM258,A
LM358,A

LOW POWER DUAL OPERATIONAL AMPLIFIERS

- INTERNALLY FREQUENCY COMPENSATED
- LARGE DC VOLTAGE GAIN: 100dB
- WIDE BANDWIDTH (unity gain): 1.1MHz (temperature compensated)
- VERY LOW SUPPLY CURRENT/OP (500µA) ESSENTIALLY INDEPENDENT OF SUPPLY VOLTAGE
- LOW INPUT BIAS CURRENT: 20nA (temperature compensated)
- LOW INPUT OFFSET VOLTAGE: 2mV
- LOW INPUT OFFSET CURRENT: 2nA
- INPUT COMMON-MODE VOLTAGE RANGE INCLUDES GROUND
- DIFFERENTIAL INPUT VOLTAGE RANGE EQUAL TO THE POWER SUPPLY VOLTAGE
- LARGE OUTPUT VOLTAGE SWING 0V TO (Vcc - 1.5V)



N
DIP8
(Plastic Package)

D & S
SO8 & miniSO8
(Plastic Micropackage)

P
TSSOP8
(Thin Shrink Small Outline Package)

DESCRIPTION

These circuits consist of two independent, high gain, internally frequency compensated which were designed specifically to operate from a single power supply over a wide range of voltages. The low power supply drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op-amp circuits which now can be more easily implemented in single power supply systems. For example, these circuits can be directly supplied with the standard +5V which is used in logic systems and will easily provide the required interface electronics without requiring any additional power supply.

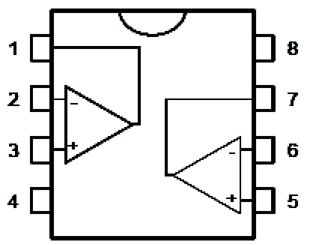
Inthe linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.

ORDER CODE

Part Number	Temperature Range	Package			
		N	S	D	P
LM158,A	-55°C, +125°C	•		•	•
LM258,A	-40°C, +105°C	•		•	•
LM358,A	0°C, +70°C	•	•	•	•
Example : LM258N					

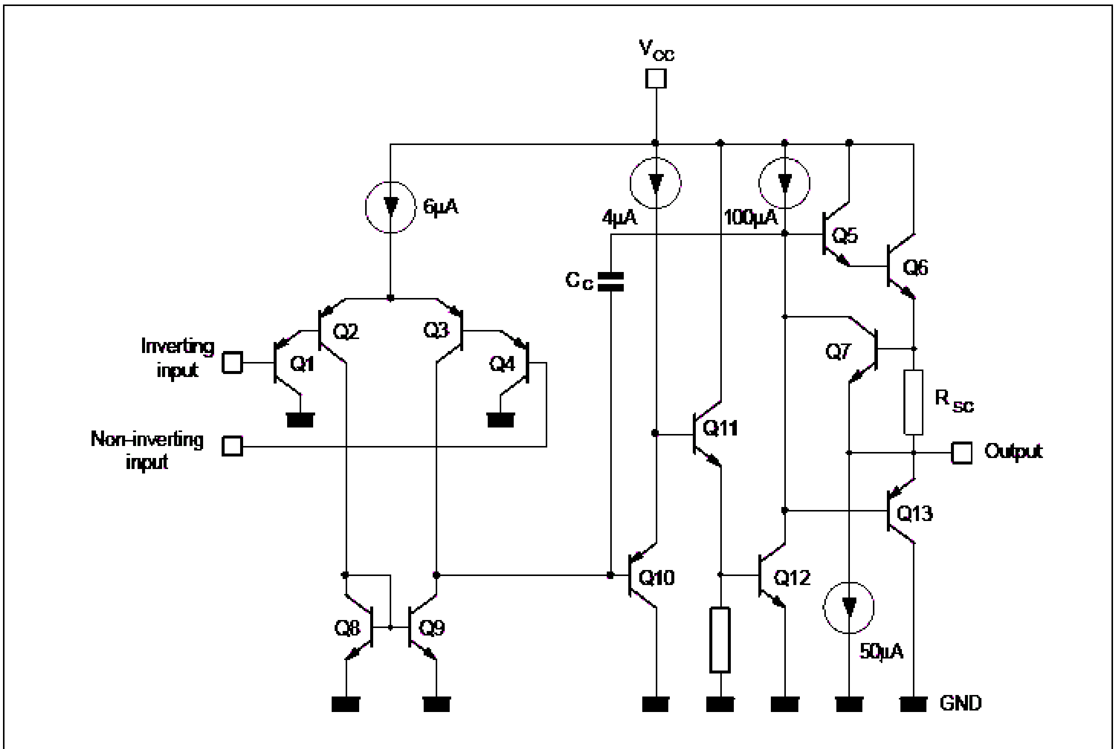
N = Dual in Line Package (DIP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)
S = Small Outline Package (miniSO) only available in Tape & Reel (DT)
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape &Reel (PT)

PIN CONNECTIONS (top view)



1 - Output 1
2 - Inverting input
3 - Non-inverting input
4 - V_{CC}^-
5 - Non-inverting input 2
6 - Inverting input 2
7 - Output 2
8 - V_{CC}^+

SCHEMATIC DIAGRAM (1/2 LM158)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	LM158,A	LM258,A	LM358,A	Unit
V_{CC}	Supply voltage	+32			V
V_i	Input Voltage	-0.3 to +32			V
V_{id}	Differential Input Voltage	+32			V
P_{tot}	Power Dissipation 1)	500			mW
	Output Short-circuit Duration 2)	Infinite			
I_{in}	Input Current 3)	50			mA
T_{oper}	Opearting Free-air Temperature Range	-55 to +125	-40 to +105	0 to +70	°C
T_{stg}	Storage Temperature Range	-65 to +150			°C

1. Power dissipation must be considered to ensure maximum junction temperature (Tj) is not exceeded.
2. Short-circuits from the output to V_{CC} can cause excessive heating if V_{CC} > 15V. The maximum output current is approximately 40mA independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuit on all amplifiers.
3. This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diodes clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. this transistor action can cause the output voltages of the Op-amps to go to the V_{CC} voltage level (or to ground for a large overdrive) for the time duration than an input is driven negative.
This is not destructive and normal output will set up again for input voltage higher than -0.3V.

ELECTRICAL CHARACTERISTICS

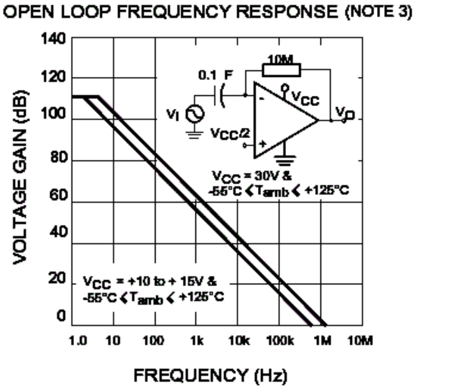
V_{CC}^{+} = +5V, V_{CC}^{-} = Ground, V_o = 1.4V, T_{amb} = +25°C (unless otherwise specified)

Symbol	Parameter	LM158A-LM258A LM358A			LM158-LM258 LM358			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{io}	Input Offset Voltage - note 1) T_{amb} = +25°C LM158, LM258 LM158A $T_{min} \le T_{amb} \le T_{max}$ LM158, LM258		1	3 2 4		2	7 5 9 7	mV
I_{io}	Input Offset Current T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		2	10 30		2	30 40	nA
I_{ib}	Input Bias Current - note 2) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		20	50 100		20	150 200	nA
A_{vd}	Large Signal Voltage Gain V_{CC} = +15V, R_L = 2kΩ, V_o = 1.4V to 11.4V T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	50 25	100		50 25	100		V/mV
SVR	Supply Voltage Rejection Ratio ($R_s \le$ 10kΩ) V_{CC}^{+} = 5V to 30V T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	65 65	100		65 65	100		dB
I_{CC}	Supply Current, all Amp, no load $T_{min} \le T_{amb} \le T_{max}$ V_{CC} = +5V $T_{min} \le T_{amb} \le T_{max}$ V_{CC} = +30V		0.7	1.2 1		0.7	1.2 2	mA
V_{icm}	Input Common Mode Voltage Range V_{CC} = +30V - note 3) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	0 0		V_{CC}^{+} -1.5 V_{CC}^{+} -2	0 0		V_{CC}^{+} -1.5 V_{CC}^{+} -2	V
CMR	Common Mode Rejection Ratio ($R_s \le$ 10kΩ) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	70 60	85		70 60	85		dB
I_{source}	Output Current Source V_{CC} = +15V, V_o = +2V, V_{id} = +1V	20	40	60	20	40	60	mA
I_{sink}	Output Sink Current (V_{id} = -1V) V_{CC} = +15V, V_o = +2V V_{CC} = +15V, V_o = +0.2V	10 12	20 50		10 12	20 50		mA µA
V_{OPP}	Output Voltage Swing (R_L = 2kΩ) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	0 0		V_{CC}^{+} -1.5 V_{CC}^{+} -2	0 0		V_{CC}^{+} -1.5 V_{CC}^{+} -2	

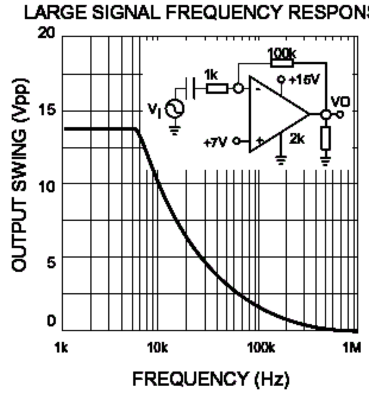
Symbol	Parameter	LM158A-LM258A LM358A			LM158-LM258 LM358			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{OH}	High Level Output Voltage ($V_{CC}^+ = 30V$) $T_{amb} = +25°C$ $R_L = 2k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$ $T_{amb} = +25°C$ $R_L = 10k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$	26 26 27 27	27 28		26 26 27 27	27 28		V
V_{OL}	Low Level Output Voltage ($R_L = 10k\Omega$) $T_{amb} = +25°C$ $T_{min} \leq T_{amb} \leq T_{max}$		5	20 20		5	20 20	mV
SR	Slew Rate $V_{CC} = 15V$, $V_i = 0.5$ to $3V$, $R_L = 2k\Omega$, $C_L = 100pF$, unity Gain	0.3	0.6		0.3	0.6		V/µs
GBP	Gain Bandwidth Product $V_{CC} = 30V$, $f = 100kHz$, $V_{in} = 10mV$, $R_L = 2k\Omega$, $C_L = 100pF$	0.7	1.1		0.7	1.1		MHz
THD	Total Harmonic Distortion $f = 1kHz$, $A_v = 20dB$, $R_L = 2k\Omega$, $V_o = 2V_{pp}$, $C_L = 100pF$, $V_O = 2Vpp$		0.02			0.02		%
e_n	Equivalent Input Noise Voltage $f = 1kHz$, $R_s = 100\Omega$, $V_{CC} = 30V$		55			55		$\frac{nV}{\sqrt{Hz}}$
DV_{io}	Input Offset Voltage Drift		7	15		7	30	µV/°C
DI_{lio}	Input Offset Current Drift		10	200		10	300	pA/°C
V_{o1}/V_{o2}	Channel Separation - note 4) $1kHz \leq f \leq 20kHZ$		120			120		dB

1. $V_o = 1.4V$, $R_s = 0\Omega$, $5V < V_{CC}^+ < 30V$, $0 < V_{ic} < V_{CC}^+ - 1.5V$
2. The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
3. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V_{CC}^+ - 1.5V$, but either or both inputs can go to +32V without damage.
4. Due to the proximity of external components insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequences.

OPEN LOOP FREQUENCY RESPONSE (NOTE 3)



LARGE SIGNAL FREQUENCY RESPONSE



National Semiconductor

May 1999

LM1575/LM2575/LM2575HV Series SIMPLE SWITCHER® 1A Step-Down Voltage Regulator

LM1575/LM2575/LM2575HV Series SIMPLE SWITCHER 1A Step-Down Voltage Regulator

General Description

The LM2575 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 1A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V, 15V, and an adjustable output version.

Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation and a fixed-frequency oscillator.

The LM2575 series offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially reduces the size of the heat sink, and in many cases no heat sink is required.

A standard series of inductors optimized for use with the LM2575 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a guaranteed ±4% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency. External shutdown is included, featuring 50 µA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

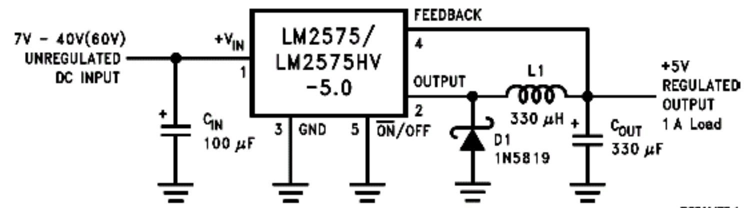
Features

- 3.3V, 5V, 12V, 15V, and adjustable output versions
- Adjustable version output voltage range, 1.23V to 37V (57V for HV version) ±4% max over line and load conditions
- Guaranteed 1A output current
- Wide input voltage range, 40V up to 60V for HV version
- Requires only 4 external components
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection
- P+ Product Enhancement tested

Applications

- Simple high-efficiency step-down (buck) regulator
- Efficient pre-regualtor for linear regulators
- On-card switching regulators
- Positive to negative converter (Buck-Boost)

Typical Application (Fixed Output Voltage Versions)



DS011475-1

Note: Pin numbers are for the TO-220 package.

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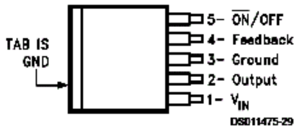
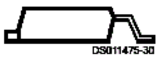
Connection Diagrams (XX indicates output voltage option. See Ordering Information table for complete part number.) (Continued)

TO-263(S)
5-Lead Surface-Mount Package



Top View



Side View
LM2575S-XX or LM2575HVS-XX
See NS Package Number TS5B

Ordering Information

Package Type	NSC Package Number	Standard Voltage Rating (40V)	High Voltage Rating (60V)	Temperature Range
5-Lead TO-220 Straight Leads	T05A	LM2575T-3.3 LM2575T-5.0 LM2575T-12 LM2575T-15 LM2575T-ADJ	LM2575HVT-3.3 LM2575HVT-5.0 LM2575HVT-12 LM2575HVT-15 LM2575HVT-ADJ	
5-Lead TO-220 Bent and Staggered Leads	T05D	LM2575T-3.3 Flow LB03 LM2575T-5.0 Flow LB03 LM2575T-12 Flow LB03 LM2575T-15 Flow LB03 LM2575T-ADJ Flow LB03	LM2575HVT-3.3 Flow LB03 LM2575HVT-5.0 Flow LB03 LM2575HVT-12 Flow LB03 LM2575HVT-15 Flow LB03 LM2575HVT-ADJ Flow LB03	
16-Pin Molded DIP	N16A	LM2575N-5.0 LM2575N-12 LM2575N-15 LM2575N-ADJ	LM2575HVN-5.0 LM2575HVN-12 LM2575HVN-15 LM2575HVN-ADJ	$-40°C \le T_J \le +125°C$
24-Pin Surface Mount	M24B	LM2575M-5.0 LM2575M-12 LM2575M-15 LM2575M-ADJ	LM2575HVM-5.0 LM2575HVM-12 LM2575HVM-15 LM2575HVM-ADJ	
5-Lead TO-236 Surface Mount	TS5B	LM2575S-3.3 LM2575S-5.0 LM2575S-12 LM2575S-15 LM2575S-ADJ	LM2575HVS-3.3 LM2575HVS-5.0 LM2575HVS-12 LM2575HVS-15 LM2575HVS-ADJ	
16-Pin Ceramic DIP	J16A	LM1575J-3.3-QML LM1575J-5.0-QML LM1575J-12-QML LM1575J-15-QML LM1575J-ADJ-QML		$-55°C \le T_J \le +150°C$

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Maximum Supply Voltage	
LM1575/LM2575	45V
LM2575HV	63V
$\overline{\text{ON}}$ /OFF Pin Input Voltage	$-0.3V \le V \le +V_{IN}$
Output Voltage to Ground	
(Steady State)	−1V
Power Dissipation	Internally Limited
Storage Temperature Range	−65°C to +150°C
Maximum Junction Temperature	150°C
Minimum ESD Rating	
(C = 100 pF, R = 1.5 kΩ)	2 kV
Lead Temperature	
(Soldering, 10 sec.)	260°C

Operating Ratings

Temperature Range	
LM1575	$-55°C \le T_J \le +150°C$
LM2575/LM2575HV	$-40°C \le T_J \le +125°C$
Supply Voltage	
LM1575/LM2575	40V
LM2575HV	60V

LM1575-3.3, LM2575-3.3, LM2575HV-3.3 Electrical Characteristics

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range** .

Symbol	Parameter	Conditions	Typ	LM1575-3.3 Limit (Note 2)	LM2575-3.3 LM2575HV-3.3 Limit (Note 3)	Units (Limits)
SYSTEM PARAMETERS (Note 4) Test Circuit *Figure 2*						
V_{OUT}	Output Voltage	V_{IN} = 12V, I_{LOAD} = 0.2A	3.3			V
		Circuit of *Figure 2*		3.267	3.234	V(Min)
				3.333	3.366	V(Max)
V_{OUT}	Output Voltage	$4.75V \le V_{IN} \le 40V$, $0.2A \le I_{LOAD} \le 1A$	3.3			V
	LM1575/LM2575	Circuit of *Figure 2*		3.200/**3.168**	3.168/**3.135**	V(Min)
				3.400/**3.432**	3.432/**3.465**	V(Max)
V_{OUT}	Output Voltage	$4.75V \le V_{IN} \le 60V$, $0.2A \le I_{LOAD} \le 1A$	3.3			V
	LM2575HV	Circuit of *Figure 2*		3.200/**3.168**	3.168/**3.135**	V(Min)
				3.416/**3.450**	3.450/**3.482**	V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 1A	75			%

LM1575-5.0, LM2575-5.0, LM2575HV-5.0 Electrical Characteristics

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**.

Symbol	Parameter	Conditions	Typ	LM1575-5.0 Limit (Note 2)	LM2575-5.0 LM2575HV-5.0 Limit (Note 3)	Units (Limits)
SYSTEM PARAMETERS (Note 4) Test Circuit *Figure 2*						
V_{OUT}	Output Voltage	V_{IN} = 12V, I_{LOAD} = 0.2A	5.0			V
		Circuit of *Figure 2*		4.950	4.900	V(Min)
				5.050	5.100	V(Max)
V_{OUT}	Output Voltage	$0.2A \le I_{LOAD} \le 1A$,	5.0			V
	LM1575/LM2575	$8V \le V_{IN} \le 40V$		4.850/**4.800**	4.800/**4.750**	V(Min)
		Circuit of *Figure 2*		5.150/**5.200**	5.200/**5.250**	V(Max)
V_{OUT}	Output Voltage	$0.2A \le I_{LOAD} \le 1A$,	5.0			V
	LM2575HV	$8V \le V_{IN} \le 60V$		4.850/**4.800**	4.800/**4.750**	V(Min)
		Circuit of *Figure 2*		5.175/**5.225**	5.225/**5.275**	V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 1A	77			%

LM1575-12, LM2575-12, LM2575HV-12
Electrical Characteristics

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range** .

Symbol	Parameter	Conditions	Typ	LM1575-12	LM2575-12 LM2575HV-12	Units (Limits)
				Limit (Note 2)	Limit (Note 3)	
SYSTEM PARAMETERS (Note 4) Test Circuit *Figure 2*						
V_{OUT}	Output Voltage	V_{IN} = 25V, I_{LOAD} = 0.2A Circuit of *Figure 2*	12	 11.88 12.12	 11.76 12.24	V V(Min) V(Max)
V_{OUT}	Output Voltage LM1575/LM2575	0.2A ≤ I_{LOAD} ≤ 1A, 15V ≤ V_{IN} ≤ 40V Circuit of *Figure 2*	12	 11.64/**11.52** 12.36/**12.48**	 11.52/**11.40** 12.48/**12.60**	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2575HV	0.2A ≤ I_{LOAD} ≤ 1A, 15V ≤ V_{IN} ≤ 60V Circuit of *Figure 2*	12	 11.64/**11.52** 12.42/**12.54**	 11.52/**11.40** 12.54/**12.66**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 15V, I_{LOAD} = 1A	88			%

LM1575-15, LM2575-15, LM2575HV-15
Electrical Characteristics

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range** .

Symbol	Parameter	Conditions	Typ	LM1575-15	LM2575-15 LM2575HV-15	Units (Limits)
				Limit (Note 2)	Limit (Note 3)	
SYSTEM PARAMETERS (Note 4) Test Circuit *Figure 2*						
V_{OUT}	Output Voltage	V_{IN} = 30V, I_{LOAD} = 0.2A Circuit of *Figure 2*	15	 14.85 15.15	 14.70 15.30	V V(Min) V(Max)
V_{OUT}	Output Voltage LM1575/LM2575	0.2A ≤ I_{LOAD} ≤ 1A, 18V ≤ V_{IN} ≤ 40V Circuit of *Figure 2*	15	 14.55/**14.40** 15.45/**15.60**	 14.40/**14.25** 15.60/**15.75**	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2575HV	0.2A ≤ I_{LOAD} ≤ 1A, 18V ≤ V_{IN} ≤ 60V Circuit of *Figure 2*	15	 14.55/**14.40** 15.525/**15.675**	 14.40/**14.25** 15.68/**15.83**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 18V, I_{LOAD} = 1A	88			%

LM1575-ADJ, LM2575-ADJ, LM2575HV-ADJ
Electrical Characteristics

Specifications with standard type face are for T_J= 25°C, and those with **boldface type** apply over **full Operating Temperature Range**.

Symbol	Parameter	Conditions	Typ	LM1575-ADJ	LM2575-ADJ LM2575HV-ADJ	Units (Limits)
				Limit (Note 2)	Limit (Note 3)	
SYSTEM PARAMETERS (Note 4) Test Circuit *Figure 2*						
V_{OUT}	Feedback Voltage	V_{IN} = 12V, I_{LOAD} = 0.2A V_{OUT} = 5V Circuit of *Figure 2*	1.230	 1.217 1.243	 1.217 1.243	V V(Min) V(Max)

LM1575-ADJ, LM2575-ADJ, LM2575HV-ADJ
Electrical Characteristics (Continued)

Specifications with standard type face are for T_J= 25˚C, and those with **boldface type** apply over **full Operating Temperature Range**.

Symbol	Parameter	Conditions	Typ	LM1575-ADJ	LM2575-ADJ LM2575HV-ADJ	Units (Limits)
				Limit (Note 2)	Limit (Note 3)	
SYSTEM PARAMETERS (Note 4) Test Circuit *Figure 2*						
V_{OUT}	Feedback Voltage LM1575/LM2575	$0.2A \le I_{LOAD} \le 1A$, $8V \le V_{IN} \le 40V$ V_{OUT} = 5V, Circuit of *Figure 2*	1.230	1.205/**1.193** 1.255/**1.267**	1.193/**1.180** 1.267/**1.280**	V V(Min) V(Max)
V_{OUT}	Feedback Voltage LM2575HV	$0.2A \le I_{LOAD} \le 1A$, $8V \le V_{IN} \le 60V$ V_{OUT} = 5V, Circuit of *Figure 2*	1.230	1.205/**1.193** 1.261/**1.273**	1.193/**1.180** 1.273/**1.286**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 1A, V_{OUT} = 5V	77			%

All Output Voltage Versions
Electrical Characteristics

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, V_{IN} = 12V for the 3.3V, 5V, and Adjustable version, V_{IN} = 25V for the 12V version, and V_{IN} = 30V for the 15V version. I_{LOAD} = 200 mA.

Symbol	Parameter	Conditions	Typ	LM1575-XX	LM2575-XX LM2575HV-XX	Units (Limits)
				Limit (Note 2)	Limit (Note 3)	
DEVICE PARAMETERS						
I_b	Feedback Bias Current	V_{OUT} = 5V (Adjustable Version Only)	50	100/**500**	100/**500**	nA
f_O	Oscillator Frequency	(Note 13)	52	47/**43** 58/**62**	47/**42** 58/**63**	kHz kHz(Min) kHz(Max)
V_{SAT}	Saturation Voltage	I_{OUT} = 1A (Note 5)	0.9	1.2/**1.4**	1.2/**1.4**	V V(Max)
DC	Max Duty Cycle (ON)	(Note 6)	98	93	93	% %(Min)
I_{CL}	Current Limit	Peak Current (Notes 5, 13)	2.2	1.7/**1.3** 3.0/**3.2**	1.7/**1.3** 3.0/**3.2**	A A(Min) A(Max)
I_L	Output Leakage Current	(Notes 7, 8) Output = 0V		2	2	mA(Max)
		Output = −1V	7.5			mA
		Output = −1V		30	30	mA(Max)
I_Q	Quiescent Current	(Note 7)	5	10/**12**	10	mA mA(Max)
I_{STBY}	Standby Quiescent Current	$\overline{ON}$ /OFF Pin = 5V (OFF)	50	200/**500**	200	µA µA(Max)
θ_{JA}	Thermal Resistance	T Package, Junction to Ambient (Note 9)	65			
θ_{JA}		T Package, Junction to Ambient (Note 10)	45			˚C/W
θ_{JC}		T Package, Junction to Case	2			
θ_{JA}		N Package, Junction to Ambient (Note 11)	85			
θ_{JA}		M Package, Junction to Ambient (Note 11)	100			
θ_{JA}		S Package, Junction to Ambient (Note 12)	37			

All Output Voltage Versions
Electrical Characteristics (Continued)

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, V_{IN} = 12V for the 3.3V, 5V, and Adjustable version, V_{IN} = 25V for the 12V version, and V_{IN} = 30V for the 15V version. I_{LOAD} = 200 mA.

Symbol	Parameter	Conditions	Typ	LM1575-XX Limit (Note 2)	LM2575-XX LM2575HV-XX Limit (Note 3)	Units (Limits)
$\overline{ON}$ /OFF CONTROL Test Circuit *Figure 2*						
V_{IH}	$\overline{ON}$ /OFF Pin Logic	V_{OUT} = 0V	1.4	2.2/**2.4**	2.2/**2.4**	V(Min)
V_{IL}	Input Level	V_{OUT} = Nominal Output Voltage	1.2	1.0/**0.8**	1.0/**0.8**	V(Max)
I_{IH}	$\overline{ON}$ /OFF Pin Input Current	$\overline{ON}$ /OFF Pin = 5V (OFF)	12	30	30	µA µA(Max)
I_{IL}		$\overline{ON}$ /OFF Pin = 0V (ON)	0	10	10	µA µA(Max)

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: All limits guaranteed at room temperature (standard type face) and at **temperature extremes (bold type face)**. All limts are used to calculate Average Outgoing Quality Level, and all are 100% production tested.

Note 3: All limits guaranteed at room temperature (standard type face) and at **temperature extremes (bold type face)**. All room temperature limits are 100% production tested. All limits at **temperature extremes** are guaranteed via correlation using standard Statistical Quality Control (SQC) methods.

Note 4: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM1575/LM2575 is used as shown in the *Figure 2* test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

Note 5: Output (pin 2) sourcing current. No diode, inductor or capacitor connected to output pin.

Note 6: Feedback (pin 4) removed from output and connected to 0V.

Note 7: Feedback (pin 4) removed from output and connected to +12V for the Adjustable, 3.3V, and 5V versions, and +25V for the 12V and 15V versions, to force the output transistor OFF.

Note 8: V_{IN} = 40V (60V for the high voltage version).

Note 9: Junction to ambient thermal resistance (no external heat sink) for the 5 lead TO-220 package mounted vertically, with ½ inch leads in a socket, or on a PC board with minimum copper area.

Note 10: Junction to ambient thermal resistance (no external heat sink) for the 5 lead TO-220 package mounted vertically, with ½ inch leads soldered to a PC board containing approximately 4 square inches of copper area surrounding the leads.

Note 11: Junction to ambient thermal resistance with approxmiately 1 square inch of pc board copper surrounding the leads. Additional copper area will lower thermal resistance further. See thermal model in Switchers made Simple software.

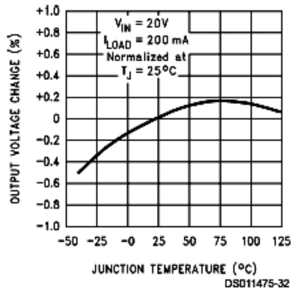
Note 12: If the TO-263 package is used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package: Using 0.5 square inches of copper area, θ_{JA} is 50°C/W; with 1 square inch of copper area, θ_{JA} is 37°C/W; and with 1.6 or more square inches of copper area, θ_{JA} is 32°C/W.

Note 13: The oscillator frequency reduces to approximately 18 kHz in the event of an output short or an overload which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self protection feature lowers the average power dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.

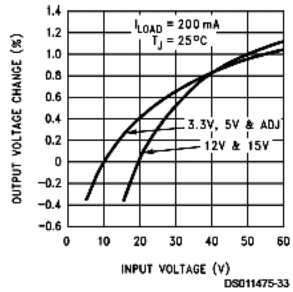
Note 14: Refer to RETS LM1575J for current revision of military RETS/SMD.

Typical Performance Characteristics (Circuit of *Figure 2*)

Normalized Output Voltage



Line Regulation



Dropout Voltage