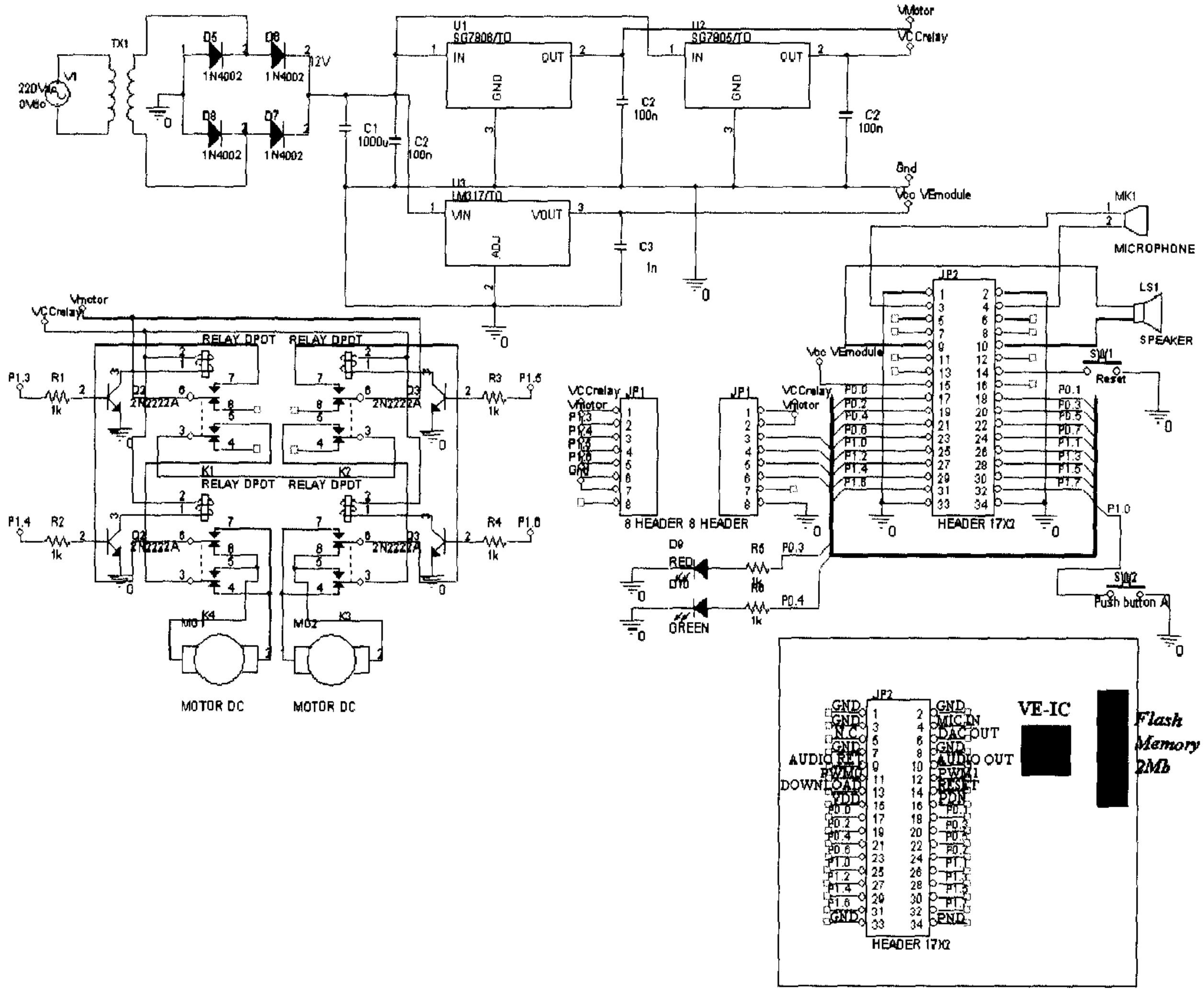
LAMPIRAN

GAMBAR RANGKAIAN KESELURUHAN



```
//--------------------------------------------------------------------------
// File        : cobaskr.vec
// Project     : SKRIPSI Yulius
// Release     : 0.0
// Date        : 1/16/05
// Copyright   : (c) 2005 by Yulius all right reserved
//--------------------------------------------------------------------------

TEMPLATE SD_Templates[7];       // allocate space in flash for 6 templates

extern  SENTENCES SNfileku;     // start of the speech table

#define SEN_SATU4               1
#define SEN_DUA1                2
#define SEN_TIGA3               3
#define SEN_EMPAT2              4
#define SEN_LIMA2               5
#define SEN_ENAM2               6
#define SEN_TUJUH2              7
#define SEN_ULANG2              8
#define SEN_SEBUTKAN_KATA       9
#define SEN_BEEP                10

#include <ve.veh>               // perintah-perintah umum dalam Voice Extreme


const uint8 length  = 2;        // 0 = short; 1 = medium; 2 = long duration

const uint16 conf  = 130;       // Confidence level threshold, 0 being the

                                // best score and 255 being the worst score

uint8 result;                   // Declare an 8-bit variable called result

uint8 msg;

uint8 tries = 3;

uint8 word = 0;uint8 j;

uint8 ctr=0; // Use this as an index to the current template


main()

{
```

```
ConfigureIO (0, 3, 3); // Konfigurasi port P0.3 sebagai output

ConfigureIO (0, 4, 3); // Konfigurasi port P0.4 sebagai output

ConfigureIO (1, 3, 3); // Konfigurasi port P1.3 sebagai output

ConfigureIO (1, 4, 3); // Konfigurasi port P1.4 sebagai output

ConfigureIO (1, 5, 3); // Konfigurasi port P1.5 sebagai output

ConfigureIO (1, 6, 3); // Konfigurasi port P1.6 sebagai output

WritePort1(0x00);

WritePort0(0x00);

//-----------------------------------------------------------------------

// Melakukan Training Process

ctr=0;
j=1;
msg = j;          // indikator untuk kata yang diambil
while (FOREVER)

{

SenTalk(msg, &SNfileku);  // mengucapkan kata "Masukkan kata

                          //  ke(tergantung nilai msg)"

                                                  // berdasarkan sentence table
dari file "fileku"

WritePort0(0x08);         // indikator lampu 1 menyala tanda siap

                                                  // menerima inputan kata

result = PatGen(STANDARD);  // membuat template dari kata yang diucapkan

                  // Template akan disimpan

                  // di UNKNOWN buffer

WritePort0(0x00);             // Pengambilan pola selesai dilakukan
```

```
if (result == 0)          // Melanjutkan proses jika tidak ada kesalahan pada PatGen

{

 if (word == 0)

 {

  PutTemplate(UNKNOWN, ctr, SD_Templates); // Menyimpan ucapan pertama

                          // ke dalam flash memori

  msg = SEN_ULANG2;                 // memberi nilai pada msg untuk memanggil


    // perintah ulangi pada sentence table

  word = 1;

 }

 else

 {   // memanggil template ke-(sesuai nilai ctr) ke KNOWN buffer

   GetTemplate(KNOWN, ctr, SD_Templates);

    // Membandingkan & menyimpan hasil rata-rata dari UNKNOWN & KNOWN
      template

    // ke dalam UNKNOWN buffer

   result = TrainSD(UNKNOWN, KNOWN, UNKNOWN);

   if (result == 0)          // jika hasilnya cocok

   {

     PutTemplate(UNKNOWN, ctr, SD_Templates); // menyimpan hasil rata-rata

     msg=j;                    // template ke flash
                          if (ctr == 6)
    {
              j=1;
     msg=j;
```

```
        ctr=0;
        break;                  // keluar dari While loop
        }

                        else
                        {
                         j++;
                         msg=j;
                         ctr++;         // Melanjutkan ke template berikutnya
                         word=0;
                        }
       }

       else                     // Jika template tidak sesuai

       {

        msg=j;     // Proses training diulang

        word = 0;

       }

     }

   }

   else

    msg = SEN_ULANG2;

 // While loop selesai
}
// Training selesai

//----------------------------------------------------------------------

 SenTalk(SEN_BEEP, &SNfileku);

 SenTalk(SEN_BEEP, &SNfileku);         // Bunyi beep dua kali tanda training sudah
selesai

 ctr=0;
 while (FOREVER)
 {
```

```
if (ButtonAPressed)

{
  SenTalk(SEN_BEEP, &SNfileku);

  WritePort0(0x10);                    // siap memerima input suara

 result = PatGen(STANDARD);      // membuat template dari kata yang diucapkan

        WritePort0(0x00);                    // PatGen selesai

        if (result == 0)
        {
         while (FOREVER)

      {
    MaskTemplate(0, 6, SD_Templates);   // Menyembunyikan template terakhir

     SetSDPerformance(5);                    // Set untuk tingkat keakuratan level 5

   result = RecogSD(ctr, SD_Templates);  // Mengenali pola suara dan dibandingkan

                              // dengan pola yang ada pada buffer UNKNOWN

          if (result == 0)              // jika kata dikenali maka melakukan
            {
             if (ctr==1)
            {
            WritePort1(0x78);  // Mengaktifkan port P1.3 - P1.6 motor maju
            }
            else if (ctr==2)
            {
            WritePort1(0x28);      // Mengaktifkan port P1.3 dan 1.5 motor mundur
            }
            else if (ctr==3)
            {
            WritePort1(0x18);            // Mengaktifkan port P1.3 dan P1.4 motor
            DelayMilliSeconds(800);
            WritePort1(0x78);            // putar kekanan
            }
            else if (ctr==4)
            {
            WritePort1(0x60);            // Mengaktifkan port P1.5 dan P1.6 motor
            DelayMilliSeconds(800);
                        WritePort1(0x78);            // putar kekiri
            }
```

```
        else if (ctr==5)
        {
        WritePort1(0x00);                    // Motor berhenti
        }
        else if (ctr==6)
        {
        WritePort1(0x38);
        DelayMilliSeconds(1600); // Mengaktifkan port P1.3, P1.5 dan P1.6
        WritePort1(0x00);
        }
        else if (ctr==7)
        {
        SenTalk(SEN_BEEP, &SNfileku);   // menghasilkan bunyi BIP

        }
                    ctr=0;
                    break;
       }
       else
       {
              ctr++;
              if (ctr>7)
              {
              SenTalk(SEN_BEEP, &SNfileku);   // menghasilkan bunyi BIP
              SenTalk(SEN_BEEP, &SNfileku);   // menghasilkan bunyi BIP
              ctr=0;

              break;          // keluar dari while loop
              }
        }
    }
   }
  }
 }
}
```

```
;-----------------------------------------------------------------------
; File        : File.vea
; Project     : Skripsiku
; RELEASE     : 0.0
; Date        : 1/17/05
; Copyright   : (c) 2005 by Yulius all right reserved
;-----------------------------------------------------------------------

        extern  VPFileskr

        extern  VPsidemo3

        public SNFileku

        include "sentable.inc" ; Definitions of sentence tokens

;-----------------------------------------------------------------------
_SNfileku segment "CDATA"

SNfileku :
        db 2                            ;jumlah Speech Table file yang digunakan
ada 2
        dt VPfileskr              ;Speech Table pertama kodenya 0
        dt VPsidemo3              ;Speech Table kedua kodenya 1

        db 10                           ;jumlah baris yang akan dibuat pada
Sentence Table 9

s1:

        SpeechTable 0             ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, 2, EOM       ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata==pertama

        SpeechTable 0             ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, 3, EOM       ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata==kedua

        SpeechTable 0             ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, 4, EOM       ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata==ketiga
```

```
        SpeechTable 0                   ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, 5, EOM             ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata==keempat

        SpeechTable 0                   ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, 6, EOM             ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata==kelima

        SpeechTable 0                   ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, 7, EOM             ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata==keenam

        SpeechTable 0                   ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, 8, EOM             ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata==ketujuh

        SpeechTable 0                   ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 9, EOM                                ;kemudian disusun menjadi Ulangi==kata

        SpeechTable 0                   ;Mengambil data pada Speech Table pertama
(Fileskr.veh)
        db 0, 12, 1, EOM                ;kemudian disusun menjadi masukkan==jeda
waktu(75ms)==kata

        SpeechTable 1                   ;Mengambil data pada Speech Table kedua
(sidemo.veh)
        db 27, EOM                      ;kemudian dihasilkan bunyi BIP BIP

End
```

```
//----------------------------------------------------------------------
// File     : fileku.veh
// Project  : Voice Extreme
// Purpose  : Sentence Table Header File
// Dibuat oleh Yulius Darmawan 17/01/2005
//----------------------------------------------------------------------

extern  SENTENCES  SNFileku;


#define SEN_SATU4            1
#define SEN_DUA1             2
#define SEN_TIGA3            3
#define SEN_EMPAT2           4
#define SEN_LIMA2            5
#define SEN_ENAM2            6
#define SEN_TUJUH2           7
#define SEN_ULANG2           8
#define SEN_SEBUTKAN_KATA         9
#define SEN_BEEP             10
```

SENSORY®

Voice Extreme™ IC
Speech Recognition Controller

Data sheet

Description

The Voice Extreme™ IC (VE-IC), from the Interactive Speech™ family of products, is an 8-bit microcontroller designed specifically for speech applications in consumer electronic products.

Combined with a 2MB external flash memory, the VE-IC offers the flexibility of a microcontroller with advanced speech technology, including high-quality speech recognition, speech and music synthesis, speaker verification, and voice record and playback. Products can use one or all of the VE-IC features in a single application.

The VE-IC supports Sensory Speech™ 6, the latest speech recognition technology from Sensory, which includes a number of new techniques that significantly improve recognition performance over previous versions. Using sophisticated neural network technology, on-chip speech recognition algorithms reach an accuracy of greater than 97% for speaker-independent recognition and greater than 99% for speaker-dependent recognition.

The VE-IC can be purchased in DIE or TQFP packages, or fully assembled as a part of the *VE Module*. A low-cost development system, the *VE Toolkit*, contains all software and hardware to create voice activated products.

Features

Full Range of Sensory Speech™ 6 Capabilities

- Speaker-independent speech recognition
- Speaker-dependent speech recognition
- High quality speech synthesis and sound effects
- Speaker verification
- Three-voice music synthesis
- Voice record & playback

Integrated Single-Chip Solution

- 4 MIPS 8-bit microcontroller
- On-chip A/D and D/A converters, pre-amplifier, and AGC
- 32kHz clock for time keeping (DIE package only)
- Secondary Timer 2
- 14 I/O lines
- RS-232 serial interface (uses three I/O)
- 16-bit external memory bus
- 24x24 Multiplier for rapid recognition processing

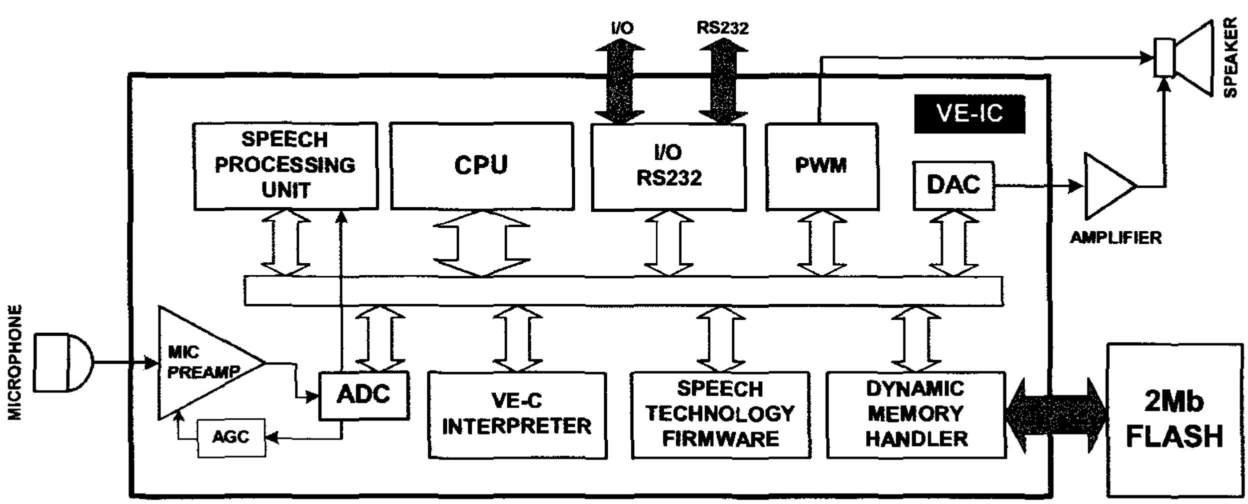
Low Power Requirements

- 2.85 – 5.25V operation
- ~10mA operating current at 3V
- Power down mode; <5 μA standby current

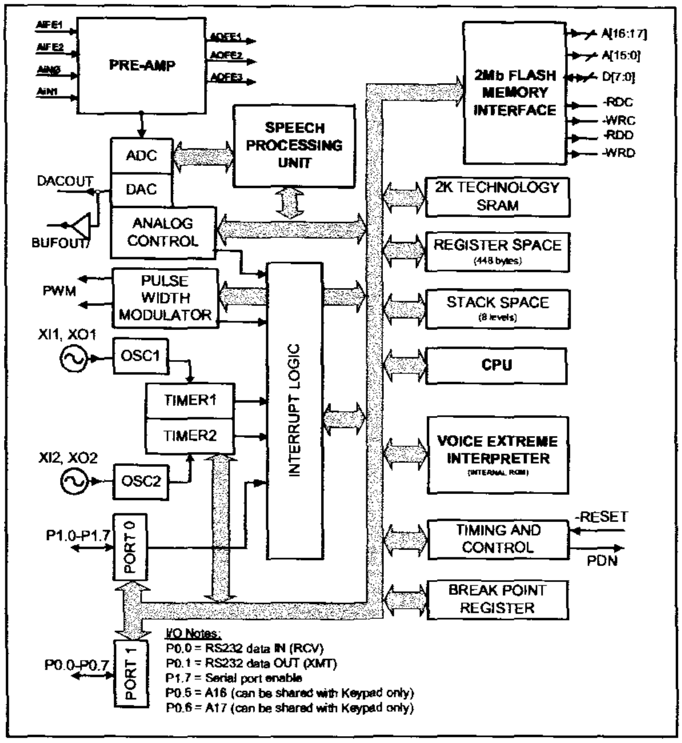
The Voice Extreme™ System

- Built-in VE-C Interpreter (a subset of ANSI-C)
- Built-in Dynamic Memory Handler
- Built-in Speech Technology Firmware

Voice Extreme™ IC Block Diagram



VE-IC architecture



The VE-IC is a highly integrated device that combines:

- 8-bit microcontroller
- On-chip VE-C Interpreter
- 2 Mb Flash memory manager
- RAM (2.5 Kbytes)
- A/D converter and D/A converter
- Input amplifier and pulse width modulator

The VE-IC has an external memory interface, with 16-bit addresses and 8-bit data buses, for accessing external 2 Mb Flash memory.

Two bi-directional ports provide 14 general-purpose I/O pins to communicate with external devices (RS232 uses three I\O). The VE-IC has a high frequency (14.32 MHz) oscillator as well as a low frequency (32,768 Hz) oscillator suitable for timekeeping applications (available in Die version). The processor clock can be selected from either source, with a selectable divider value. The device performs speech recognition when running at 14.32 MHz. There are two programmable 8-bit counters / timers, one derived from each oscillator.

Speech recognition

The VE-IC uses a neural network to perform speaker-independent or speaker-dependent speech recognition and uses the external flash memory to store speech recognition information. The VE-IC has several additional speech recognition features as described below.

Continuous Listening

Continuous Listening allows the chip to continuously listen for a specific word. With this feature a product can be used in a normal environment and only "activates" when a specific word, preceded by quiet, is spoken.

Speech and music synthesis

The VE-IC provides high-quality speech synthesis by using a hybrid of a time-domain compression scheme that improves on conventional ADPCM and a customized reuse of sounds. Speech synthesis uses the external flash to store audio sounds for synthesis.

The VE-IC provides high-quality, low-cost three-voice music synthesis which allows multiple, simultaneous instruments for harmonizing; it uses a MIDI-like system to generate music.

Record and playback

The VE-IC can perform audio record and playback at various compression levels depending on the quantity and quality of playback desired. Data rates of under 14,000 bits per second are achievable while maintaining very high quality reproduction. VE-IC also performs silence removal to improve sound quality and reduce memory requirements.

Speaker verification

The VE-IC can also perform text-dependent speaker verification. After a speaker trains the chip on a specific word, the chip is able to identify whether that word is spoken by the original speaker, thus providing biometric security.

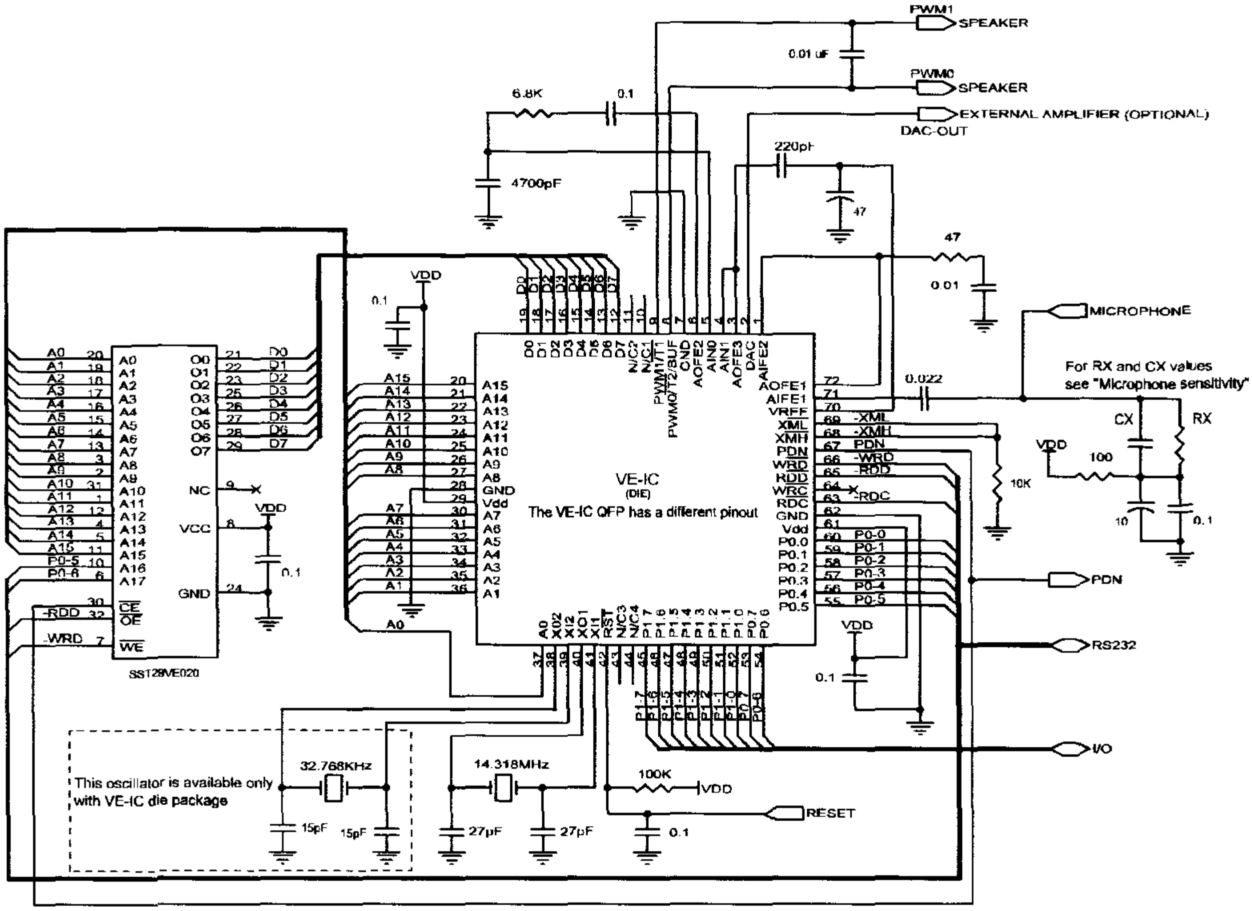
Word spot

Word Spot provides the ability to recognize trigger words embedded in continuous speech; thus the password sequence "Robert Henson" could be recognized if spoken as "My name is Robert John Henson". WS can only be used with the Speaker Dependent technology; thus it always requires a training phase.

Using the VE-IC

Creating applications using the VE-IC requires the development of electronic circuitry, software code, and speech/music data files.
Software code for the VE-IC can be developed using the VE-C Language (a subset of ANSI-C). The Voice Extreme™ IDE offers a friendly environment for developing Voice Extreme™. For more information about the Voice Extreme™ development tools, please contact Sensory or Visit the web site **www.voice-extreme.com**.
The following sample circuit provides an example of how the VE-IC might be used in a consumer electronic product.

Sample Application Circuit (Die)



Microphone Sensitivity

RX determine the microphone sensitivity, by default the microphone gain is pre-set to a level suitable for arms-length user interfaces with a 2.2K resistor at **RX** and 4.7nF capacitor at **CX**. If a different microphone gain is desired, select the values of RX and CX from the table below:

R4	C28	Microphone Note
1K	10nF	Close range or headset
1.5K	6.8nF	
2.2K	4.7nF	
2.7K	3.3nF	Arms length
3.9K	2.7nF	
4.7K	2.2nF	Distance

2Mbit Flash Memory

This memory is required on the VE-IC and all VE applications. Because of the powerful dynamic memory handler of VE system software, this Flash is designed to store the application code, speaker independent weight sets, speech templates, record and playback data, program data, and music data.
These are the 2Mbit flash supported (for further information please refer to manufacturer documentation):

Manufacturer	+5 V_{dd}	+3 V_{dd}
SST	29EE020	29LE020 29LV020
WINBOND	29C020	29V020

4X5 Matrix Keypad Support

The VE-IC supports a 4x5 keypad that can be controlled using functions built into the VE-C language.
When the keypad is scanned, the columns are driven (active low), the rows are sensed (pulled high) and all previous configuration and output values for these pins are saved and restored.
The keypad I/O pinouts are as follows:

	P0.4	P1.4	P0.7	P1.7	P0.3
P0.2	1	2	3	A	E
P1.2	4	5	6	B	F
P0.5	7	8	9	C	G
P1.5	*	0	#	D	H

General Purpose I/O

The VE Module has 14 general-purpose I/O pins. Each line can be programmed as an input with a weak pull-up resistor (~150k ohm), input with a strong pull-up resistor (~10k ohm), input without pull-ups, or as an output.

> **Note:**
> If an application is stand-alone (once you download the program via asynchronous serial I/O), the two serial I/O pins, **P0.0** and **P0.1**, and the serial port enable, **P1.7**, may be used for other purposes.
>
> Since I/O pins **P0.5** and **P0.6** are connected to the address bus of the Flash memory, they can be used only for the matrix keypad; they should not be used under any other circumstances since they are allocated as Flash address lines.

Power

The typical operating current is 10 mA operating at 14.32 MHz and 3V. Lowering clock frequency reduces power consumption, although speech recognition requires a 14.32 MHz clock. Standby current is <5µA in power down mode.

Oscillators

Two independent oscillators in the VE-IC provide a high-frequency clock and a 32kHz time-keeping clock. Both oscillators work with an external crystal, a ceramic resonator or LC.
The oscillator characteristics are:

	Oscillator #1	Oscillator #2
Pins	XI1 and XO1	XI2 and XO2
Frequency	14.32 MHz	32768 Hz
Notes		Available only with DIE package

Clock

The VE-IC uses a fully static core – the processor can be stopped (by removing the clock source) and restarted without causing a reset or losing contents of internal registers. Static operation is guaranteed from DC to 14.32 MHz.

Preamplifier

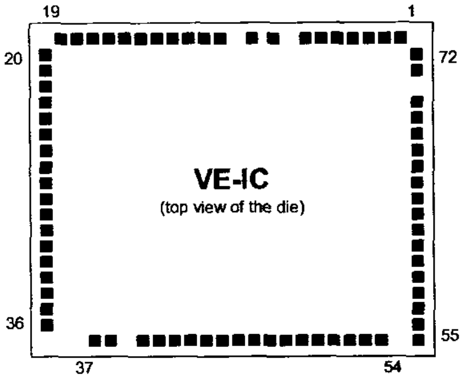
The on-chip preamplifier circuit consists of three stages with a maximum overall gain of about 500. The amplifier includes a Vref input that is used to set the amplifier center voltages and must be driven by a low impedance voltage supplied by an external source. The signal inputs of all stages have an 80 KΩ input impedance to the Vref pad. In a typical design, AOFE1 would be directly coupled to AIFE2, and AOFE2 would be capacitively coupled to AIN0 through an RC lowpass filter to remove DC offset and digital noise. AOFE3 would be bypassed to Vref with a small (220pF) capacitor for additional noise suppression.

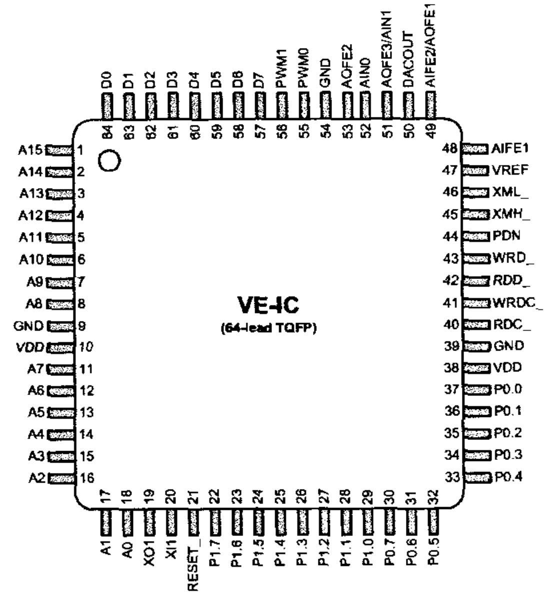
Analog output
The VE-IC offers two separate options for analog output. The DAC (Digital to Analog Converter) output provides a general-purpose 10-bit analog output that may be used for speech output (with the inclusion of an audio amplifier), or other purposes requiring an analog waveform.
For speech applications that require driving a small speaker, the PWM (Pulse-Width Modulator) output can be used instead of the DAC output. The PWM output can directly drive a 32 ohm speaker.

Serial (RS-232) Communication
Serial communication at the *application* level in Voice Extreme™ are always performed at **9600** baud, **8** data bits, **no** parity, **1** stop bit (the download operation runs at 115Kbaud).
If an application is stand-alone (once you download the program via asynchronous serial I/O), the two serial I/O pins, **P0.0** and **P0.1**, and the serial port enable, **P1.7**, may be used for other purposes.

Packaging

The RSC-300/364 can be purchased as unpackaged die or a 64-pin TQFP package.





DIE Pad	Name	QFP Pin	Description	I/O
1	AIFE2	49	Input of 2nd stage of preamplifier	I
2	DACOUT	50	Analog Output (unbuffered).	O
3	AOFE3	51	Output of 3rd stage of preamplifier	O
4	AIN1	51	*Analog In, hi gain* (8X input amplitude of AIN0, same range)	I
5	AIN0	52	Analog In, low gain (range AGND to AVDD/2.)	I
6	AOFE2	53	Output of 2nd stage of preamplifier	O
7	GND	9	Ground	-
8	PWM0	55	Pulse Width Modulator Output 0	O
9	TE1_ or PWM1	56	Test Mode *or Pulse Width Modulator Output1* (multiplexed)	I *or* O
10	NC	-	Not Connected	-
11	NC	-	Not Connected	-
12	D7	57	External Data Bus D7	I/O
13	D6	58	External Data Bus D6	I/O
14	D5	59	External Data Bus D5	I/O
15	D4	60	External Data Bus D4	I/O
16	D3	61	External Data Bus D3	I/O
17	D2	62	External Data Bus D2	I/O
18	D1	63	External Data Bus D1	I/O
19	D0	64	External Data Bus D0	I/O
20	A15	1	External Memory Address Bus A15	O
21	A14	2	External Memory Address Bus A14	O
22	A13	3	External Memory Address Bus A13	O
23	A12	4	External Memory Address Bus A12	O
24	A11	5	External Memory Address Bus A11	O
25	A10	6	External Memory Address Bus A10	O
26	A9	7	External Memory Address Bus A9	O
27	A8	8	External Memory Address Bus A8	O
28	GND	39	*Ground*	-
29	V_{DD}	10	Supply Voltage	-
30	A7	11	External Memory Address Bus A7	O
31	A6	12	External Memory Address Bus A6	O
32	A5	13	External Memory Address Bus A5	O

DIE Pad	Name	QFP Pin	Description	I/O
33	A4	14	External Memory Address Bus A4	O
34	A3	15	External Memory Address Bus A3	O
35	A2	16	External Memory Address Bus A2	O
36	A1	17	External Memory Address Bus A1	O
37	A0	18	External Memory Address Bus A0	O
38	XO2	-	Oscillator 2 output (32768 Hz)	O
39	XI2	-	Oscillator 2 input	I
40	XO1	19	Oscillator 1 output (high frequency)	O
41	XI1	20	Oscillator 1 input	I
42	RESET_	21	Reset	I
43	NC	-	Not Connected	-
44	NC	-	Not Connected	-
45	P1.7	22	RS232 enable or General Purpose I/O	I/O
46	P1.6	23	General Purpose I/O	I/O
47	P1.5	24	General Purpose I/O	I/O
48	P1.4	25	General Purpose I/O	I/O
49	P1.3	26	General Purpose I/O	I/O
50	P1.2	27	General Purpose I/O	I/O
51	P1.1	28	General Purpose I/O	I/O
52	P1.0	29	General Purpose I/O	I/O
53	P0.7	30	General Purpose I/O	I/O
54	P0.6	31	External Memory Address Bus A17 *(see note 3)*	O
55	P0.5	32	External Memory Address Bus A16 *(see note 3)*	O
56	P0.4	33	General Purpose I/O	I/O
57	P0.3	34	General Purpose I/O	I/O
58	P0.2	35	General Purpose I/O	I/O
59	P0.1	36	RS232 output (XMT) or General Purpose I/O	I/O
60	P0.0	37	RS232 input (RCV) or General Purpose I/O	I/O
61	V_{DD}	38	Supply Voltage	-
62	GND	54	Ground	-
63	RDC	40	External Code Read Strobe	O
64	WRC_	41	External Code Write Strobe	O
65	RDD_	42	External Data Read Strobe	O
66	WRD_	43	External Data Write Strobe	O
67	PDN	44	Power Down. Active high when powered down.	O
68	XMH_	45	External Hi-memory enable (low active)	O
69	XML_	46	External Low-memory enable (low active)	O
70	VREF	47	Reference Voltage = Vdd/2 or Vdd/4. Depends on software	-
71	AIFE1	48	Input of 1st stage of preamplifier	
72	AOFE1	49	Output of 1st stage of preamplifier	O

Notes:

1. *Substrate should be connected to VSS*
2. If an application is stand-alone (once you download the program via asynchronous serial I/O), the two serial I/O pins, **P0.0** and **P0.1**, and the serial port enable, **P1.7**, may be used for other purposes.
3. Note that since I/O pins **P0.5** and **P0.6** are connected to the address bus of the Flash memory, they can be used only for the matrix keypad; they should not be used under any other circumstances since they are allocated as Flash address lines.

DC Characteristics

(T_O = 0°C to +70°C, V_{DD} = 2.85V – 5.25V)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
V_{IL}	Input Low Voltage	-0.1		0.75	V	
V_{IH} (Vcc<3.6)	Input High Voltage	0.8*Vdd		Vdd+0.3	V	
V_{IH} (Vcc>3.6)	Input High Voltage	3.0		Vdd+0.3	V	
V_{OL}	Output Low Voltage		0.3	0.1*Vdd	V	I_{OL}= 2 mA
V_{OH}	Output High Voltage (I/O Pins)	0.8*Vdd	0.9*Vdd		V	I_{OL}= -2 mA
I_{IL}	Logical 0 Input Current		<1	10	uA	$V_{ss}<V_{pin}<V_{dd}$
I_{DD1}	Supply Current, Active		10	20	mA	Hi-Z Outputs
I_{DD3}	Supply Current, Powerdown		1	10	uA	Hi-Z Outputs
Rpu	Pull-up resistance P0.0-P1.7 I/O Pins	5,80, Hi-Z	4.5,200, Hi-Z		kΩ	Selected with software

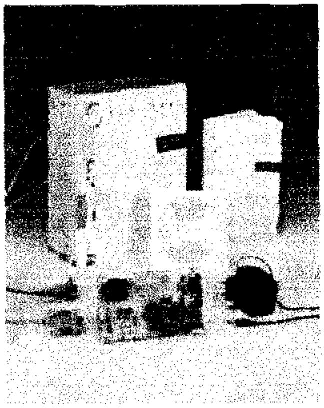
Absolute Maximum Ratings

Any pin to GND:	-0.1V to +6.5V
Operating temperature (T_O):	0°C to +70°C
Soldering temperature:	260°C for 10 sec
Power dissipation:	1 W
Operating Conditions:	0°C to +70°C; V_{DD}=2.85 - 5.25V V_{SS}=0V

WARNING:
Stressing the VE-IC beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.

Ordering Information

Part	Shipping P/N	Marketing P/N	Description
VE-IC Die	65-0087	C300XS1P	Tested, Singulated RSC-300 die in waffle pack
VE-IC QFP	65-0111	C300XV1T	RSC-300 64 pin 10 x 10 x 1.0 mm TQFP



Voice Extreme™ Toolkit

The Voice Extreme™ Toolkit enables quick development of applications using *Sensory Speech*™ technologies.
The Voice Extreme™ Toolkit contains:

- Voice Extreme™ Development Board
- Voice Extreme™ Module
- Power supply
- Serial cable for PC RS-232 connection
- Quick Start Guide
- Software CD containing the Voice Extreme™ IDE, Quick Synthesis™, sample projects, sample data files and documentation

The Interactive Speech™ Product Line

The Interactive Speech line of ICs and software was developed to "bring life to products" through advanced speech recognition and audio technology.
The Interactive Speech Product Line was designed for consumer telephony products and cost-sensitive consumer electronic applications such as home electronics, personal security, and personal communication.
The product line includes award-winning RSC series general-purpose microcontrollers and tools, SC series of speech microcontrollers, plus a line of easy-to-implement chips that can be pin-configured or controlled by an external host microcontroller. Sensory's software technologies run on a variety of microcontrollers and DSPs.

RSC Microcontrollers and Tools

The RSC product line contains low-cost 8-bit speech-optimized microcontrollers designed for use in consumer electronics. All members of the RSC family are fully integrated and include A/D, pre-amplifier, D/A, ROM, and RAM circuitry. The RSC family can perform a full range of speech/audio functions including speech recognition, speaker verification, speech and music synthesis, and voice record/playback. The family is supported by a complete suite of evaluation tools and development kits.

SC Microcontrollers and Tools

The **SC-6x** product line features the highest quality speech synthesis ICs at the lowest data rate in the industry. The line includes a 12.32 MIPS processor for high-quality low data-rate speech compression and MIDI music synthesis, with plenty of power left over for other processor and control functions. Members of the SC-6x line can store as much as 37 minutes of speech on chip and include as much as 64 I/O pins for external interfacing. Integrating this broad range of features onto a single chip enables developers to create products with high quality, long duration speech at very competitive price points.

Application Specific Standard Products (ASSPs)

- ***Voice Direct™ 364*** provides inexpensive speaker-dependent speech recognition and speech synthesis. This easy-to-use, pin-configurable chip requires no custom programming and can recognize up to 60 trained words in slave mode, and 15 words in stand-alone mode. Ideal for speaker-dependent command and control of household consumer products, Voice Direct 364 is part of a complete product line that includes the IC, module, and Voice Direct 364 Speech Recognition Kit.
- ***Voice Extreme™*** simplifies the creation of fully custom speech-enabled products by offering developers the capability of programming the chip in a high-level C-like language. Program code, speech data, and even record and playback information can be stored on a single off-chip Flash memory. Based on Sensory's RSC-364 speech processor, Voice Extreme includes a highly efficient on-chip code interpreter, and is supported by a comprehensive suite of low-cost development tools.

BEST SDK 2001

Software and Technology

- ***Voice Activation™*** micro footprint software provides advanced speech technology on a variety of microcontroller and DSP platforms. A flexible design with a broad range of technologies allows manufacturers to easily integrate speech functionality into consumer electronic products.
- ***Fluent Speech™*** small footprint software recognizes up to 50,000 words; offers Animated Speech with the ability to automate enunciation and articulation; performs text-to-speech synthesis in either male or female voices; provides noise and echo cancellation, performs Wordspotting for natural language usage; offers telephone barge-in; and provides continuous digit recognition.

Important notices

Reasonable efforts have been made to verify the accuracy of information contained herein, however no guarantee can be made of accuracy or applicability. Sensory reserves the right to change any specification or description contained herein.

SENSORY®

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National Semiconductor

May 2003

LM117/LM317A/LM317
3-Terminal Adjustable Regulator

General Description

The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 1.5A over a 1.2V to 37V output range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators. Also, the LM117 is packaged in standard transistor packages which are easily mounted and handled.

In addition to higher performance than fixed regulators, the LM117 series offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output, the LM117 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

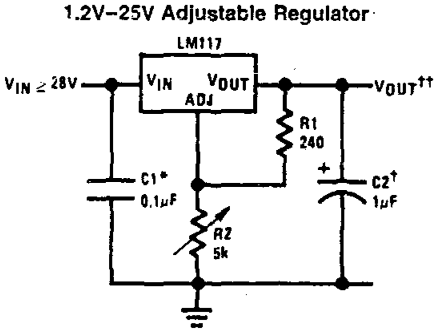
For applications requiring greater output current, see LM150 series (3A) and LM138 series (5A) data sheets. For the negative complement, see LM137 series data sheet

Features

- Guaranteed 1% output voltage tolerance (LM317A)
- Guaranteed max. 0.01%/V line regulation (LM317A)
- Guaranteed max. 0.3% load regulation (LM117)
- Guaranteed 1.5A output current
- Adjustable output down to 1.2V
- Current limit constant with temperature
- P+ Product Enhancement tested
- 80 dB ripple rejection
- Output is short-circuit protected

Typical Applications

1.2V–25V Adjustable Regulator



Full output current not available at high input-output voltages

*Needed if device is more than 6 inches from filter capacitors.

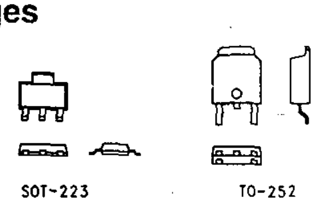
†Optional — improves transient response. Output capacitors in the range of 1μF to 1000μF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

$$^{\dagger\dagger}V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}(R_2)$$

LM117 Series Packages

Part Number Suffix	Package	Design Load Current
K	TO-3	1.5A
H	TO-39	0.5A
T	TO-220	1.5A
E	LCC	0.5A
S	TO-263	1.5A
EMP	SOT-223	1A
MDT	TO-252	0.5A

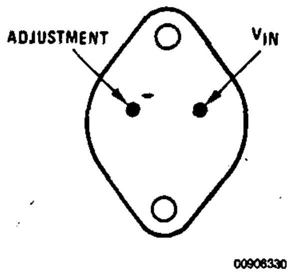
SOT-223 vs. D-Pak (TO-252) Packages



Scale 1:1

Connection Diagrams

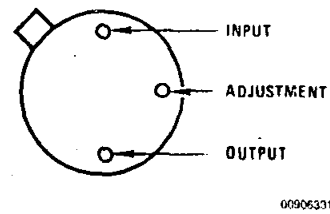
(TO-3)
Metal Can Package



CASE IS OUTPUT

Bottom View
Steel Package
NS Package Number K02A or K02C

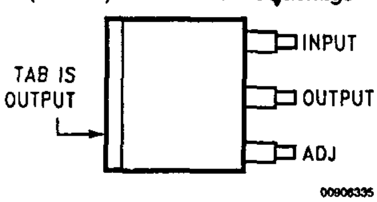
(TO-39)
Metal Can Package



CASE IS OUTPUT

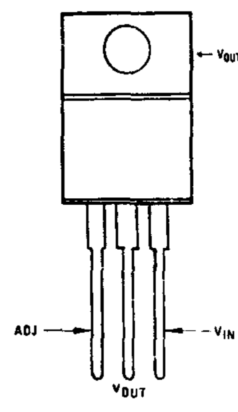
Bottom View
NS Package Number H03A

(TO-263) Surface-Mount Package



Top View

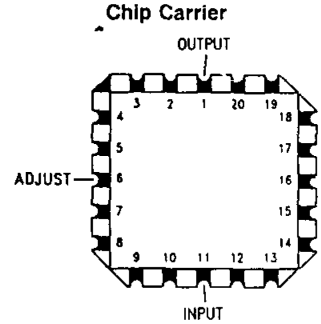
(TO-220)
Plastic Package



Front View
NS Package Number T03B

Side View
NS Package Number TS3B

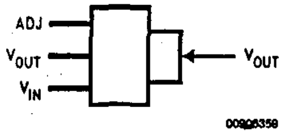
Ceramic Leadless
Chip Carrier



Top View
NS Package Number E20A

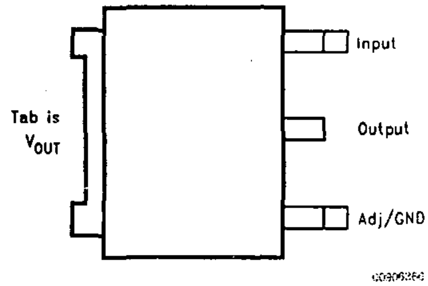
Connection Diagrams (Continued)

4-Lead SOT-223



Front View
NS Package Number MP04A

TO-252 (D-Pak)



Front View
NS Package Number TD03B

Ordering Information

Package	Temperature Range	Part Number	Package Marking	Transport Media	NSC Drawing
Metal Can (TO-3)	$-55^{\circ}C \le T_J \le +150^{\circ}C$	LM117K STEEL	LM117K STEEL P+	50 Per Bag	K02A
	$0^{\circ}C \le T_J \le +125^{\circ}C$	LM317K STEEL	LM317K STEEL P+	50 Per Bag	
	$-55^{\circ}C \le T_J \le +150^{\circ}C$	LM117K/883	LM117K/883	50 Per Bag	K02C
Metal Can (TO-39)	$-55^{\circ}C \le T_J \le +150^{\circ}C$	LM117H	LM117H P+	500 Per Box	H03A
	$-55^{\circ}C \le T_J \le +150^{\circ}C$	LM117H/883	LM117H/883	20 Per Tray	
	$-40^{\circ}C \le T_J \le +125^{\circ}C$	LM317AH	LM317AH P+	500 Per Box	
	$0^{\circ}C \le T_J \le +125^{\circ}C$	LM317H	LM317H P+	500 Per Box	
TO-220 3- Lead	$-40^{\circ}C \le T_J \le +125^{\circ}C$	LM317AT	LM317AT P+	45 Units/Rail	T03B
	$0^{\circ}C \le T_J \le +125^{\circ}C$	LM317T	LM317T P+	45 Units/Rail	
TO-263 3- Lead	$0^{\circ}C \le T_J \le +125^{\circ}C$	LM317S	LM317S P+	45 Units/Rail	TS3B
		LM317SX		500 Units Tape and Reel	
LCC	$-55^{\circ}C \le T_J \le +150^{\circ}C$	LM117E/883	LM117E/883	50 Units/Rail	E20A
SOT-223 4- Lead	$0^{\circ}C \le T_J \le +125^{\circ}C$	LM317EMP	N01A	1k Units Tape and Reel	MP04A
		LM317EMPX		2k Units Tape and Reel	
	$-40^{\circ}C \le T_J \le +125^{\circ}C$	LM317AEMP	N07A	1k Units Tape and Reel	
		LM317AEMPX		2k Units Tape and Reel	
D- Pack 3- Lead	$0^{\circ}C \le T_J \le +125^{\circ}C$	LM317MDT	LM317MDT	75 Units/Rail	TD03B
		LM317MDTX		2.5k Units Tape and Reel	
	$-40^{\circ}C \le T_J \le +125^{\circ}C$	LM317AMDT	LM317AMDT	75 Units/Rail	
		LM317AMDTX		2.5k Units Tape and Reel	

Absolute Maximum Ratings (Note 1)

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

Power Dissipation	Internally Limited
Input-Output Voltage Differential	+40V, −0.3V
Storage Temperature	−65°C to +150°C
Lead Temperature	
Metal Package (Soldering, 10 seconds)	300°C
Plastic Package (Soldering, 4 seconds)	260°C
ESD Tolerance (Note 5)	3 kV

Operating Temperature Range

LM117	$-55°C \le T_J \le +150°C$
LM317A	$-40°C \le T_J \le +125°C$
LM317	$0°C \le T_J \le +125°C$

Preconditioning

Thermal Limit Burn-In	All Devices 100%

Electrical Characteristics (Note 3)

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, $V_{IN} - V_{OUT} = 5V$, and $I_{OUT} = 10$ mA.

Parameter	Conditions	LM117 (Note 2) Min	Typ	Max	Units
Reference Voltage					V
	$3V \le (V_{IN} - V_{OUT}) \le 40V$, $10\text{ mA} \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$	**1.20**	**1.25**	**1.30**	V
Line Regulation	$3V \le (V_{IN} - V_{OUT}) \le 40V$ (Note 4)		0.01	0.02	%/V
			0.02	**0.05**	%/V
Load Regulation	$10\text{ mA} \le I_{OUT} \le I_{MAX}$ (Note 4)		0.1	0.3	%
			0.3	**1**	%
Thermal Regulation	20 ms Pulse		0.03	0.07	%/W
Adjustment Pin Current			**50**	**100**	μA
Adjustment Pin Current Change	$10\text{ mA} \le I_{OUT} \le I_{MAX}$, $3V \le (V_{IN} - V_{OUT}) \le 40V$		**0.2**	**5**	μA
Temperature Stability	$T_{MIN} \le T_J \le T_{MAX}$		**1**		%
Minimum Load Current	$(V_{IN} - V_{OUT}) = 40V$		**3.5**	**5**	mA
Current Limit	$(V_{IN} - V_{OUT}) \le 15V$				
	K Package	**1.5**	**2.2**	**3.4**	A
	H Package	**0.5**	**0.8**	**1.8**	A
	$(V_{IN} - V_{OUT}) = 40V$				
	K Package	0.3	0.4		A
	H Package	0.15	0.2		A
RMS Output Noise, % of V_{OUT}	$10\text{ Hz} \le f \le 10\text{ kHz}$		0.003		%
Ripple Rejection Ratio	$V_{OUT} = 10V$, $f = 120$ Hz, $C_{ADJ} = 0\ \mu F$		65		dB
	$V_{OUT} = 10V$, $f = 120$ Hz, $C_{ADJ} = 10\ \mu F$	**66**	**80**		dB
Long-Term Stability	$T_J = 125°C$, 1000 hrs		0.3	1	%
Thermal Resistance, Junction-to-Case	K Package		2.3	3	°C/W
	H Package		12	15	°C/W
	E Package				°C/W
Thermal Resistance, Junction-to-Ambient (No Heat Sink)	K Package		35		°C/W
	H Package		140		°C/W
	E Package				°C/W

Electrical Characteristics (Note 3)

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, $V_{IN} - V_{OUT} = 5V$, and $I_{OUT} = 10$ mA.

Parameter	Conditions	LM317A			LM317			Units
		Min	Typ	Max	Min	Typ	Max	
Reference Voltage		1.238	1.250	1.262				V
	$3V \le (V_{IN} - V_{OUT}) \le 40V$, $10 mA \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$	**1.225**	**1.250**	**1.270**	**1.20**	**1.25**	**1.30**	V
Line Regulation	$3V \le (V_{IN} - V_{OUT}) \le 40V$ (Note 4)		0.005	0.01		0.01	0.04	%/V
			0.01	**0.02**		**0.02**	**0.07**	%/V
Load Regulation	$10 mA \le I_{OUT} \le I_{MAX}$ (Note 4)		0.1	0.5		0.1	0.5	%
			0.3	**1**		**0.3**	**1.5**	%
Thermal Regulation	20 ms Pulse		0.04	0.07		0.04	0.07	%/W
Adjustment Pin Current			**50**	**100**		**50**	**100**	μA
Adjustment Pin Current Change	$10 mA \le I_{OUT} \le I_{MAX}$ $3V \le (V_{IN} - V_{OUT}) \le 40V$		**0.2**	**5**		**0.2**	**5**	μA
Temperature Stability	$T_{MIN} \le T_J \le T_{MAX}$		**1**			**1**		%
Minimum Load Current	$(V_{IN} - V_{OUT}) = 40V$		**3.5**	**10**		**3.5**	**10**	mA
Current Limit	$(V_{IN} - V_{OUT}) \le 15V$							
	K, T, S Packages	**1.5**	**2.2**	**3.4**	**1.5**	**2.2**	**3.4**	A
	H Package	**0.5**	**0.8**	**1.8**	**0.5**	**0.8**	**1.8**	A
	MP Package	**1.5**	**2.2**	**3.4**	**1.5**	**2.2**	**3.4**	A
	$(V_{IN} - V_{OUT}) = 40V$							
	K, T, S Packages	0.15	0.4		0.15	0.4		A
	H Package	0.075	0.2		0.075	0.2		A
	MP Package	0.55	0.4		0.15	0.4		A
RMS Output Noise, % of V_{OUT}	$10 Hz \le f \le 10 kHz$		0.003			0.003		%
Ripple Rejection Ratio	$V_{OUT} = 10V$, f = 120 Hz, $C_{ADJ} = 0$ μF		65			65		dB
	$V_{OUT} = 10V$, f = 120 Hz, $C_{ADJ} = 10$ μF	**66**	**80**		**66**	**80**		dB
Long-Term Stability	$T_J = 125°C$, 1000 hrs		0.3	1		0.3	1	%
Thermal Resistance, Junction-to-Case	K Package					2.3	3	°C/W
	MDT Package					5		°C/W
	H Package		12	15		12	15	°C/W
	T Package		4	5		4		°C/W
	MP Package		23.5			23.5		°C/W
Thermal Resistance, Junction-to-Ambient (No Heat Sink)	K Package		35			35		°C/W
	MDT Package(Note 6)					92		°C/W
	H Package		140			140		°C/W
	T Package		50			50		°C/W
	S Package (Note 6)		50			50		°C/W

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. The guaranteed specifications apply only for the test conditions listed.

Note 2: Refer to RETS117H drawing for the LM117H, or the RETS117K for the LM117K military specifications.

Note 3: Although power dissipation is internally limited, these specifications are applicable for maximum power dissipations of 2W for the TO-39 and SOT-223 and 20W for the TO-3, TO-220, and TO-263. I_{MAX} is 1.5A for the TO-3, TO-220, and TO-263 packages, 0.5A for the TO-39 package and 1A for the SOT-223 Package. All limits (i.e., the numbers in the Min. and Max. columns) are guaranteed to National's AOQL (Average Outgoing Quality Level).

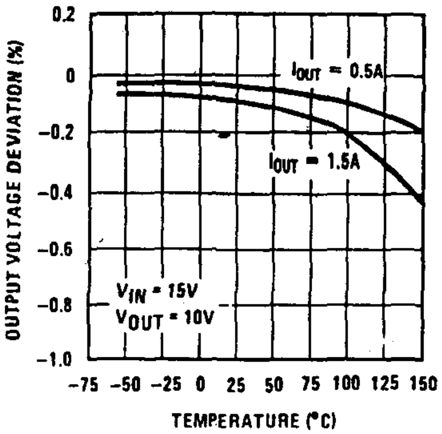
Note 4: Regulation is measured at a constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specifications for thermal regulation.

Note 5: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Note 6: If the TO-263 or TO-252 packages are 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. If the SOT-223 package is used, the thermal resistance can be reduced by increasing the PC board copper area (see applications hints for heatsinking).

Typical Performance Characteristics Output Capacitor = 0µF unless otherwise noted

Load Regulation



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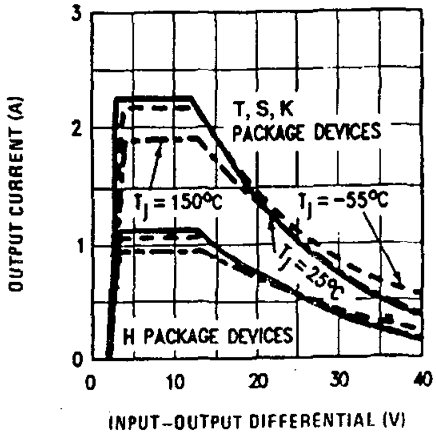
Current Limit



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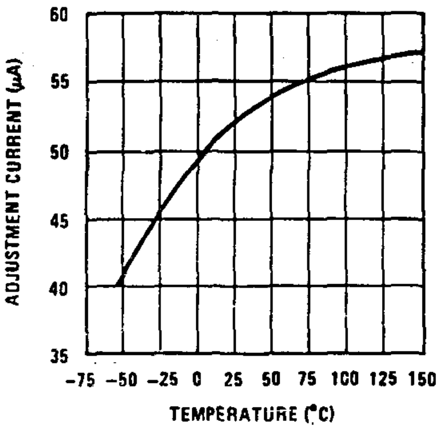
Adjustment Current



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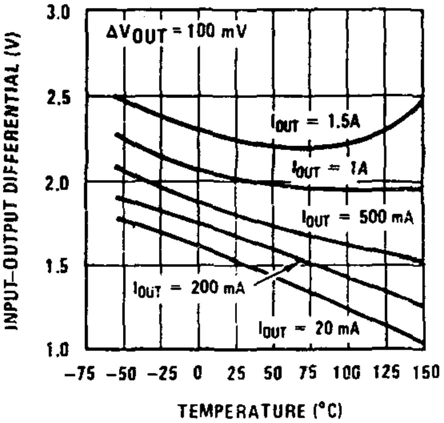
Dropout Voltage



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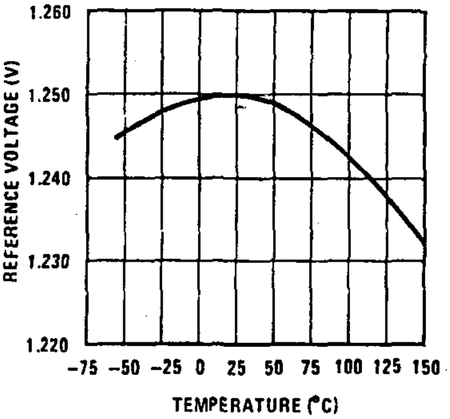
Temperature Stability



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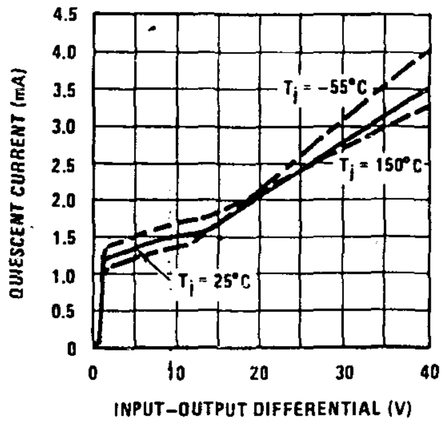
Minimum Operating Current



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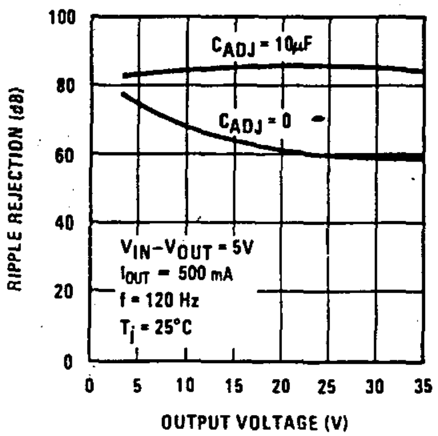
Typical Performance Characteristics Output Capacitor = 0µF unless otherwise noted (Continued)

Ripple Rejection



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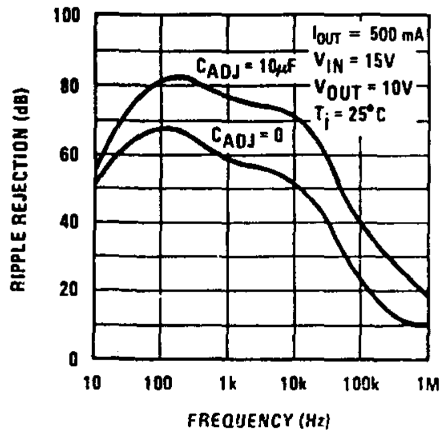
Ripple Rejection



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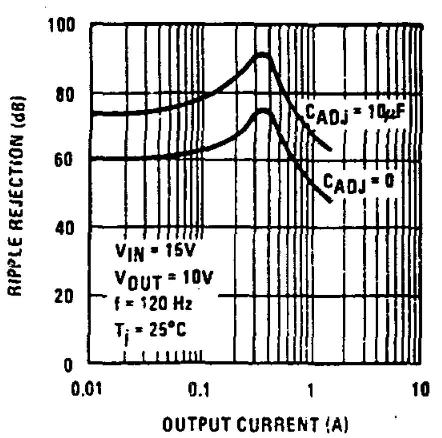
Ripple Rejection



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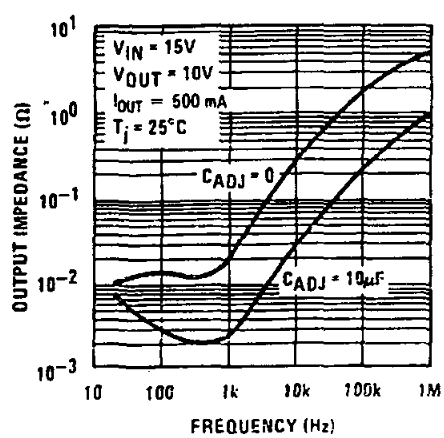
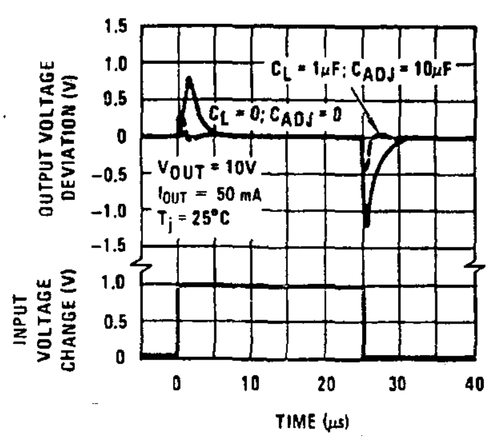
Output Impedance



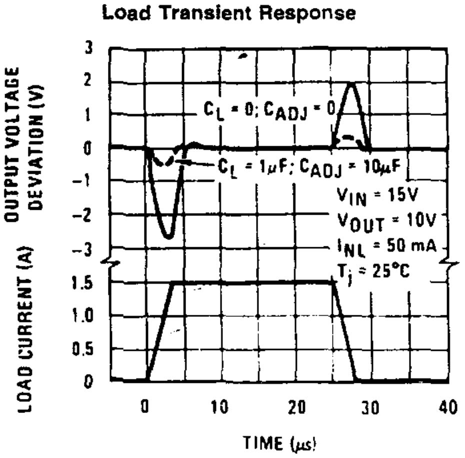
00906346

Line Transient Response



00906347

Load Transient Response



00906348

Application Hints

In operation, the LM117 develops a nominal 1.25V reference voltage, V_{REF}, between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R2, giving an output voltage of

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$

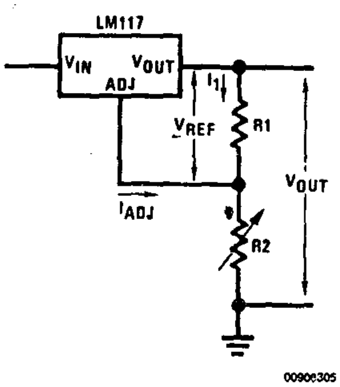


FIGURE 1.

Since the 100µA current from the adjustment terminal represents an error term, the LM117 was designed to minimize I_{ADJ} and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

EXTERNAL CAPACITORS

An input bypass capacitor is recommended. A 0.1µF disc or 1µF solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used but the above values will eliminate the possibility of problems.

The adjustment terminal can be bypassed to ground on the LM117 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10µF bypass capacitor 80dB ripple rejection is obtainable at any output level. Increases over 10µF do not appreciably improve the ripple rejection at frequencies above 120Hz. If the bypass capacitor is used, it is sometimes necessary to include protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device.

In general, the best type of capacitors to use is solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25µF in aluminum electrolytic to equal 1µF solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies; but some types have a large decrease in capacitance at frequencies around 0.5MHz. For this reason, 0.01µF disc may seem to work better than a 0.1µF disc as a bypass.

Although the LM117 is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500 pF and 5000 pF. A 1µF solid tantalum (or 25µF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10µF will merely improve the loop stability and output impedance.

LOAD REGULATION

The LM117 is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal (usually 240Ω) should be tied directly to the output (case) of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 15V regulator with 0.05Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05Ω x I_L. If the set resistor is connected near the load the effective line resistance will be 0.05Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 2 shows the effect of resistance between the regulator and 240Ω set resistor.

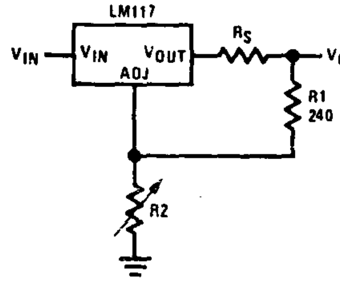


FIGURE 2. Regulator with Line Resistance in Output Lead

With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, with the TO-39 package, care should be taken to minimize the wire length of the output lead. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

PROTECTION DIODES

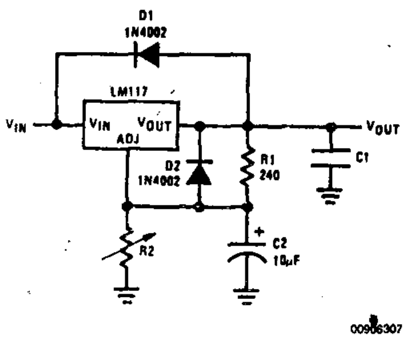
When external capacitors are used with *any* IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10µF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a regulator and the input is shorted, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN}. In the LM117, this discharge path is through a large junction that is able to sustain 15A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25µF or less, there is no need to use diodes.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs

Application Hints (Continued)

when *either* the input or output is shorted. Internal to the LM117 is a 50Ω resistor which limits the peak discharge *current. No* protection is needed for output voltages of 25V or less and 10µF capacitance. *Figure 3* shows an LM117 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



$$V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$

D1 protects against C1

D2 protects against C2

FIGURE 3. Regulator with Protection Diodes

When a value for $\theta_{(H-A)}$ is found using the equation shown, *a heatsink must be selected that has a value that is less than or equal to this number.*

$\theta_{(H-A)}$ is specified numerically by the heatsink manufacturer in the catalog, or shown in a curve that plots temperature rise vs. power dissipation for the heatsink.

HEATSINKING TO-263, SOT-223 AND TO-252 PACKAGE PARTS

The TO-263 ("S"), SOT-223 ("MP") and TO-252 ("DT") packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the package to the plane.

Figure 4 shows for the TO-263 the measured values of $\theta_{(J-A)}$ for different copper area sizes using a typical PCB with 1 ounce copper *and no solder mask over the copper area used for heatsinking.*

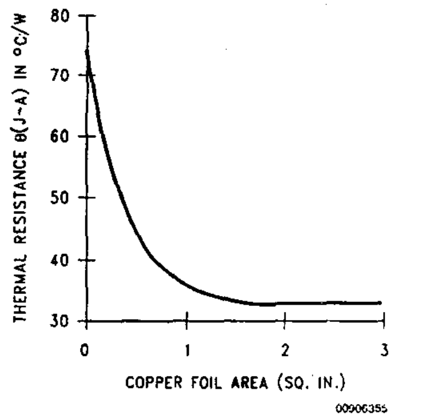


FIGURE 4. $\theta_{(J-A)}$ vs Copper (1 ounce) Area for the TO-263 Package

As shown in the figure, increasing the copper area beyond 1 square inch produces very little improvement. It should also be observed that the minimum value of $\theta_{(J-A)}$ for the TO-263 package mounted to a PCB is 32°C/W.

As a design aid, *Figure 5* shows the maximum allowable power dissipation compared to ambient temperature for the TO-263 device (assuming $\theta_{(J-A)}$ is 35°C/W and the maximum junction temperature is 125°C).

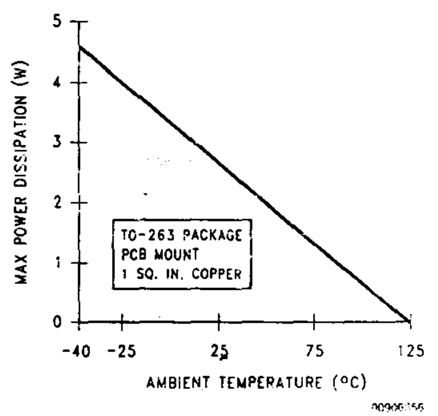


FIGURE 5. Maximum Power Dissipation vs T_{AMB} for the TO-263 Package

Figure 6 and *Figure 7* show the information for the SOT-223 package. *Figure 7* assumes a $\theta_{(J-A)}$ of 74°C/W for 1 ounce copper and 51°C/W for 2 ounce copper and a maximum junction temperature of 125°C.

Application Hints (Continued)

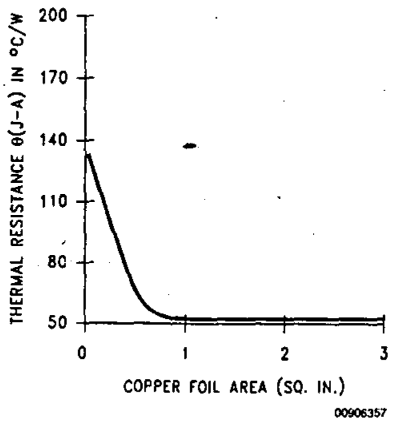


FIGURE 6. ***$\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package***

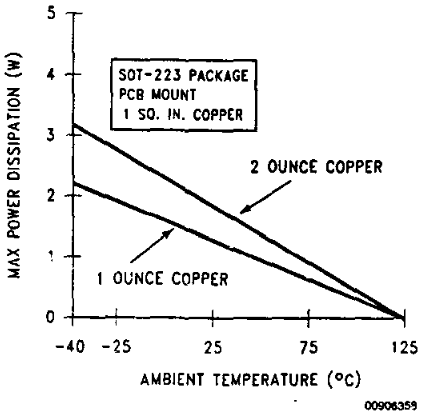


FIGURE 7. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

The LM317 regulators have internal thermal shutdown to protect the device from over-heating. Under all possible operating conditions, the junction temperature of the LM317 must be within the range of 0°C to 125°C. A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. To determine if a heatsink is needed, the power dissipated by the regulator, P_D, must be calculated:

$I_{IN} = I_L + I_G$

$P_D = (V_{IN} - V_{OUT})\ I_L + V_{IN}I_G$

Figure 8 shows the voltage and currents which are present in the circuit.

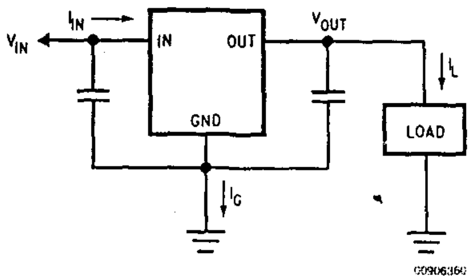


FIGURE 8. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, T_R(max):

$T_R(\max) = T_J(\max) - T_A(\max)$

where T_J(max) is the maximum allowable junction temperature (125°C), and T_A(max) is the maximum ambient temperature which will be encountered in the application.

Using the calculated values for T_R(max) and P_D, the maximum allowable value for the junction-to-ambient thermal resistance (θ_{JA}) can be calculated:

$\theta_{JA} = T_R(\max)/P_D$

If the maximum allowable value for θ_{JA} is found to be ≥92°C/W (Typical Rated Value) for TO-252 package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for θ_{JA} falls below these limits, a heatsink is required.

As a design aid, *Table 1* shows the value of the θ_{JA} of TO-252 for different heatsink area. The copper patterns that we used to measure these θ_{JA}s are shown at the end of the Application Notes Section. *Figure 9* reflects the same test results as what are in the *Table 1*

Figure 10 shows the maximum allowable power dissipation vs. ambient tempeŕature for the TO-252 device. *Figure 11* shows the maximum allowable power dissipation vs. copper area (in^2) for the TO-252 device. Please see AN1028 for power enhancement techniques to be used with SOT-223 and TO-252 packages.

TABLE 1. θ_{JA} Different Heatsink Area

Layout	Copper Area		Thermal Resistance
	Top Side (in^2)*	Bottom Side (in^2)	(θ_{JA}°C/W) TO-252
1	0.0123	0	103
2	0.066	0	87
3	0.3	0	60
4	0.53	0	54
5	0.76	0	52
6	1	0	47
7	0	0.2	84
8	0	0.4	70
9	0	0.6	63

Application Hints (Continued)

TABLE 1. θ_{JA} Different Heatsink Area (Continued)

Layout	Copper Area		Thermal Resistance
10	0	0.8	57
11	0	1	57
12	0.066	0.066	89
13	0.175	0.175	72
14	0.284	0.284	61
15	0.392	0.392	55
16	0.5	0.5	53

Note: Tab of device attached to topside of copper.

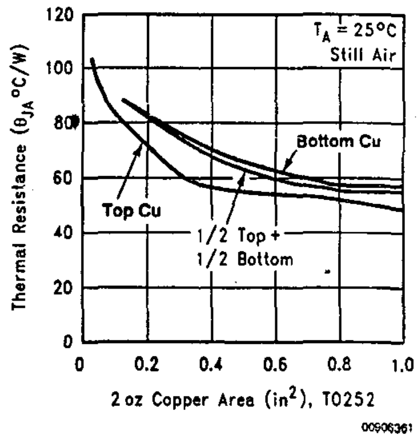


FIGURE 9. θ_{JA} vs 2oz Copper Area for TO-252

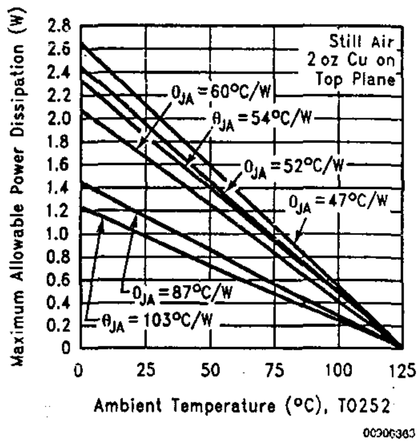


FIGURE 10. Maximum Allowable Power Dissipation vs. Ambient Temperature for TO-252

Application Hints (Continued)

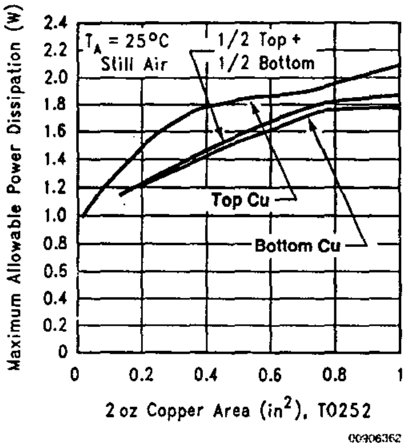


FIGURE 11. Maximum Allowable Power Dissipation vs. 2oz Copper Area for TO-252

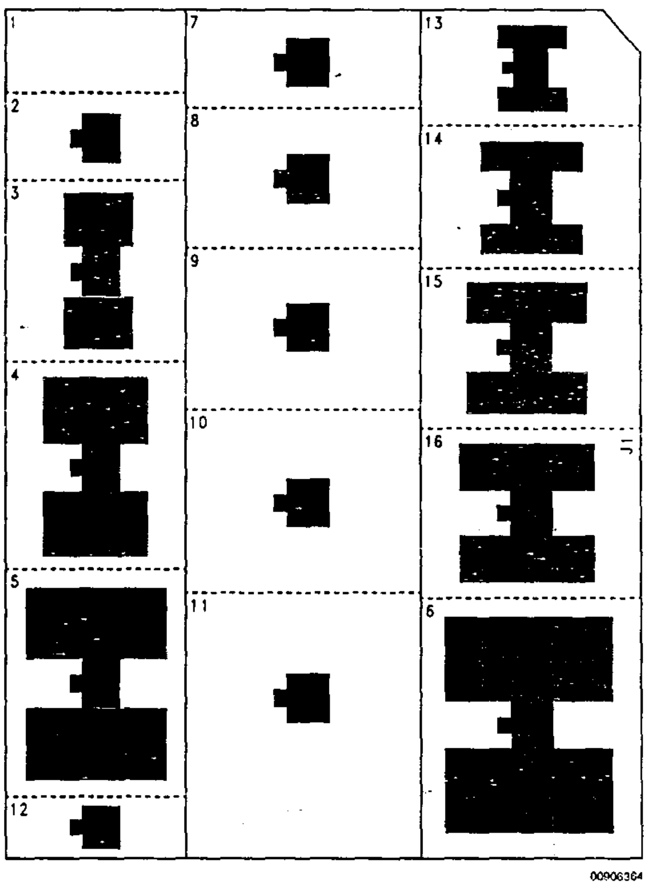


FIGURE 12. Top View of the Thermal Test Pattern in Actual Scale

NPN switching transistors — 2N2222; 2N2222A

FEATURES

- High current (max. 800 mA)
- Low voltage (max. 40 V).

APPLICATIONS

- Linear amplification and switching.

DESCRIPTION

NPN switching transistor in a TO-18 metal package.
PNP complement: 2N2907A.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector, connected to case

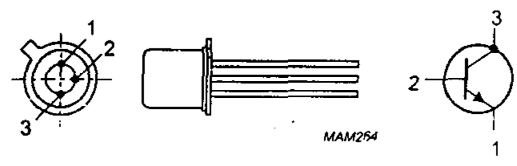


Fig.1 Simplified outline (TO-18) and symbol.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	2N2222		–	60	V
	2N2222A		–	75	V
V_{CEO}	collector-emitter voltage	open base			
	2N2222		–	30	V
	2N2222A		–	40	V
	collector current (DC)		–	800	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	–	500	mW
h_{FE}	DC current gain	I_C = 10 mA; V_{CE} = 10 V	75	–	
f_T	transition frequency	I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz			
	2N2222		250	–	MHz
	2N2222A		300	–	MHz
t_{off}	turn-off time	I_{Con} = 150 mA; I_{Bon} = 15 mA; I_{Boff} = −15 mA	–	250	ns

LIMITING VALUES

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

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	2N2222		–	60	V
	2N2222A		–	75	V
V_{CEO}	collector-emitter voltage	open base			
	2N2222		–	30	V
	2N2222A		–	40	V
V_{EBO}	emitter-base voltage	open collector			
	2N2222		–	5	V
	2N2222A		–	6	V
I_C	collector current (DC)		–	800	mA
I_{CM}	peak collector current		–	800	mA
I_{BM}	peak base current		–	200	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	–	500	mW
		$T_{case} \leq 25$ °C	–	1.2	W
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	200	°C
T_{amb}	operating ambient temperature		–65	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	in free air	350	K/W
$R_{th\ j\text{-}c}$	thermal resistance from junction to case		146	K/W

CHARACTERISTICS

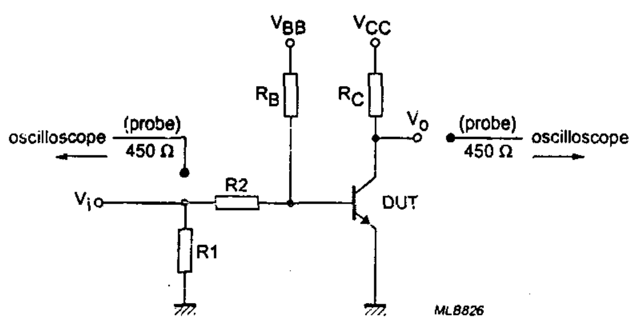
T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{CBO}	collector cut-off current 2N2222	$I_E = 0$; $V_{CB} = 50$ V	–	10	nA
		$I_E = 0$; $V_{CB} = 50$ V; $T_{amb} = 150$ °C	–	10	μA
I_{CBO}	collector cut-off current 2N2222A	$I_E = 0$; $V_{CB} = 60$ V	–	10	nA
		$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	–	10	μA
I_{EBO}	emitter cut-off current	$I_C = 0$; $V_{EB} = 3$ V	–	10	nA
h_{FE}	DC current gain	$I_C = 0.1$ mA; $V_{CE} = 10$ V	35	–	
		$I_C = 1$ mA; $V_{CE} = 10$ V	50	–	
		$I_C = 10$ mA; $V_{CE} = 10$ V	75	–	
		$I_C = 150$ mA; $V_{CE} = 1$ V; note 1	50	–	
		$I_C = 150$ mA; $V_{CE} = 10$ V; note 1	100	300	
h_{FE}	DC current gain 2N2222A	$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	35	–	
h_{FE}	DC current gain 2N2222 2N2222A	$I_C = 500$ mA; $V_{CE} = 10$ V; note 1	 30 40	 – –	
V_{CEsat}	collector-emitter saturation voltage 2N2222	$I_C = 150$ mA; $I_B = 15$ mA; note 1	–	400	mV
		$I_C = 500$ mA; $I_B = 50$ mA; note 1	–	1.6	V
V_{CEsat}	collector-emitter saturation voltage 2N2222A	$I_C = 150$ mA; $I_B = 15$ mA; note 1	–	300	mV
		$I_C = 500$ mA; $I_B = 50$ mA; note 1	–	1	V
V_{BEsat}	base-emitter saturation voltage 2N2222	$I_C = 150$ mA; $I_B = 15$ mA; note 1	–	1.3	V
		$I_C = 500$ mA; $I_B = 50$ mA; note 1	–	2.6	V
V_{BEsat}	base-emitter saturation voltage 2N2222A	$I_C = 150$ mA; $I_B = 15$ mA; note 1	0.6	1.2	V
		$I_C = 500$ mA; $I_B = 50$ mA; note 1	–	2	V
C_c	collector capacitance	$I_E = i_e = 0$; $V_{CB} = 10$ V; f = 1 MHz	–	8	pF
C_e	emitter capacitance 2N2222A	$I_C = i_c = 0$; $V_{EB} = 500$ mV; f = 1 MHz	–	25	pF
f_T	transition frequency 2N2222 2N2222A	$I_C = 20$ mA; $V_{CE} = 20$ V; f = 100 MHz	 250 300	 – –	 MHz MHz
F	noise figure 2N2222A	$I_C = 200$ μA; $V_{CE} = 5$ V; $R_S = 2$ kΩ; f = 1 kHz; B = 200 Hz	–	4	dB

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
Switching times (between 10% and 90% levels); see Fig.2					
t_{on}	turn-on time	I_{Con} = 150 mA; I_{Bon} = 15 mA; I_{Boff} = −15 mA	–	35	ns
t_d	delay time		–	10	ns
t_r	rise time		–	25	ns
t_{off}	turn-off time		–	250	ns
t_s	storage time		–	200	ns
t_f	fall time		–	60	ns

Note

1. Pulse test: $t_p \leq 300$ µs; $\delta \leq 0.02$.

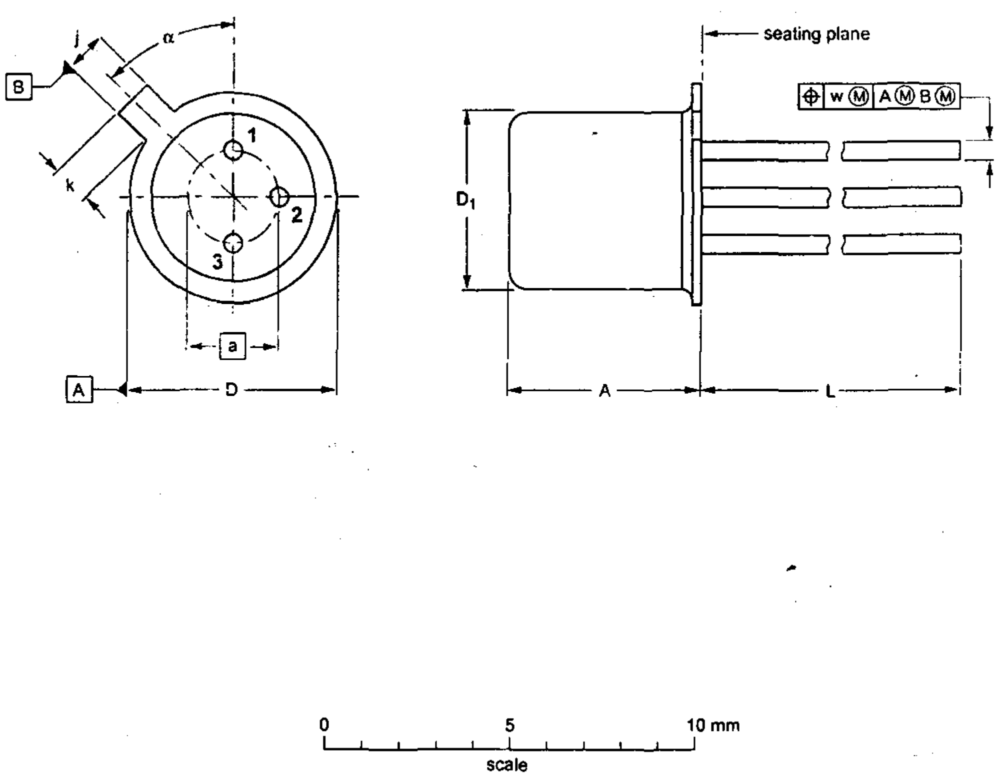


V_i = 9.5 V; T = 500 µs; t_p = 10 µs; $t_r = t_f \leq 3$ ns.
$R1$ = 68 Ω; $R2$ = 325 Ω; R_B = 325 Ω; R_C = 160 Ω.
V_{BB} = −3.5 V; V_{CC} = 29.5 V.
Oscilloscope input impedance Z_i = 50 Ω.

Fig.2 Test circuit for switching times.

PACKAGE OUTLINE

Metal-can cylindrical single-ended package; 3 leads **SOT18/13**



DIMENSIONS (millimetre dimensions are derived from the original inch dimensions)

UNIT	A	a	b	D	D_1	j	k	L	w	α
mm	5.31 4.74	2.54	0.47 0.41	5.45 5.30	4.70 4.55	1.03 0.94	1.1 0.9	15.0 12.7	0.40	45°

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT18/13	B11/C7 type 3	TO-18				97-04-18

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

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