LIST PROGRAM PENGUJI MCB PADA VB 6.0

Private Sub Apply_Click()
    Timer3.Interval = 1000 / Val(speed_tension.Text)
End Sub

Private Sub connect_Click()
    If MSComm1.PortOpen = False Then
        MSComm1.PortOpen = True
    End Sub

Private Sub DISCONNECT_Click()
    If MSComm1.PortOpen = True Then
        MSComm1.PortOpen = False
    End Sub

Private Sub EXIT_Click()
    End
End Sub

Private Sub Form_Load()
    Timer1.Enabled = False
    Timer2.Enabled = False
    Timer3.Enabled = False
    slewrate.Text = 1
End Sub

Private Sub Print_Click()
    PrintForm
End Sub

Private Sub SEND_Click()
    'If MSComm1.PortOpen = True Then
        MSComm1.Output = Chr(Val(Text3.Text) * 5)
    'Text4.Text = Chr(Text3.Text)
    End Sub

Private Sub speed_Change()
    Timer1.Interval = Val(speed.Text) * 1000
End Sub

Private Sub Start_Click()
    Timer1.Enabled = True
    Timer2.Enabled = True
    Timer3.Enabled = True
End Sub

Private Sub Stop_Click()
    Timer1.Enabled = False
    Timer2.Enabled = False
    Timer3.Enabled = False
End Sub

Private Sub Timer1_Timer()
    MSChart1.Data = (Text1.Text)
    Force.AddItem (Val(Text1.Text))
    Text2.Text = Time
    Time.AddItem (Abs(Time_counter) / 2)
    rtfText.Text = rtfText.Text + "," + Text1.Text + Chr$(13) + Text2.Text
    If (Abs(Time_counter) / 2) > 120 Then
        Timer1.Enabled = False
        Timer2.Enabled = False
        End If
    End Sub

Private Sub Timer2_Timer()
End Sub
```vbnet
Time_counter = Val(Time_counter) + 1

If MSComm1.PortOpen = True Then
    MSComm1.Output = (Chr(Val(bufferslew.Text) * 5)+128)

Text5.Text = (Val(bufferslew.Text) * 50)
Text1.Text = Asc(MSComm1.Input) / 12
End Sub

Private Sub Timer3_Timer()
If Val(bufferslew.Text) < Val(Text3.Text) Then
    bufferslew.Text = Val(bufferslew.Text) + 0.01
End Sub
```
LIST PROGRAM PADA CODEVISION AVR (CLIENT)

#include <mega16.h>
#include <delay.h>

#define RXB8 1
#define TXB8 0
#define UPE 2
#define OVR 3
#define FE 4
#define UDRE 5
#define RXC 7
#define FRAMING_ERROR (1<<FE)
#define PARITY_ERROR (1<<UPE)
#define DATA_OVERRUN (1<<OVR)
#define DATA_REGISTER_EMPTY (1<<UDRE)
#define RX_COMPLETE (1<<RXC)

// USART Receiver interrupt service routine
interrupt [USART_RXC] void
usrat_rx_isr(void)
{
    char status,data;
    status=UCSRA;
data=UDR;
if ((status & (FRAMING_ERROR | PARITY_ERROR | DATA_OVERRUN))==0)
{
    rx_buffer[rx_wr_index]=data;
if (++rx_wr_index == RX_BUFFER_SIZE) rx_wr_index=0;
if (++rx_counter == RX_BUFFER_SIZE)
{
    rx_counter=0;
    rx_buffer_overflow=1;
};
};
PORTC = data;
getchar();
}
#endif

// Get a character from the USART Receiver buffer
#define _ALTERNATE_GETCHAR_
#define _pragma used+
char getchar(void)
{
    char data;
    while (rx_counter==0);
data=rx_buffer[rx_rd_index];
if (++rx_rd_index == RX_BUFFER_SIZE) rx_rd_index=0;
asm("cli")
--rx_counter;
asm("sei")
return data;
}
#pragma used
#endif

// Standard Input/Output functions
#include <stdio.h>

#define ADC_VREF_TYPE 0xC0

// Read the AD conversion result
unsigned int read_adc(unsigned char adc_input)
{
    ADMUX=adc_input;
    (ADC_VREF_TYPE & 0xff);
// Start the AD conversion
ADCSRA|=0x40;
// Wait for the AD conversion to complete
while ((ADCSRA & 0x10) == 0);
ADCSRA |= 0x10;
return ADCW;
}

// Declare your global variables here

void main( void )
{
// Declare your local variables here


// Input/Output Ports initialization
// Port A initialization
// Func7=In Func6=In Func5=In
// Func4=In Func3=In Func2=In
// State7=T State6=T State5=T
// State4=T State3=T State2=T State1=T
// State0=T
PORTA = 0x00;
DDRA = 0x00;

// Port B initialization
// Func7=In Func6=In Func5=In
// Func4=In Func3=In Func2=In
// State7=T State6=T State5=T
// State4=T State3=T State2=T State1=T
// State0=T
PORTB = 0x00;
DDRB = 0x00;

// Port C initialization
// Func7=In Func6=In Func5=In
// Func4=In Func3=In Func2=In
// State7=T State6=T State5=T
// State4=T State3=T State2=T State1=T
// State0=T
PORTC = 0x00;
DDRC = 0xFF;

// Port D initialization
// Func7=In Func6=In Func5=In
// Func4=In Func3=In Func2=In
// State7=T State6=T State5=T
// State4=T State3=T State2=T State1=T
// State0=T
PORTD = 0x00;
DDRD = 0x00;

// Timer/Counter 0 initialization
// Clock source: System Clock
// Clock value: Timer 0 Stopped
// Mode: Normal top=FFFFh
// OC0 output: Discon.
// OC0B output: Discon.
// Noise Canceler: Off
// Input Capture on Falling Edge
// Timer 0 Overflow Interrupt: Off
// Input Capture Interrupt: Off
// Compare A Match Interrupt: Off
// Compare B Match Interrupt: Off
TCCR0A = 0x00;
TCCR0B = 0x00;
TCNT0H = 0x00;
TCNT0L = 0x00;
ICR0H = 0x00;
ICR0L = 0x00;
OCR0AH = 0x00;
OCR0AL = 0x00;
OCR0BH = 0x00;
OCR0BL = 0x00;

// Timer/Counter 1 initialization
// Clock source: System Clock
// Clock value: Timer 2 Stopped
// Mode: Normal top=FFFFh
// OC2 output: Disconected
// ASSR=0x00;
// TCCR2=0x00;
// TCNT2H=0x00;
// TCNT2L=0x00;
// OCR2AH=0x00;
// OCR2AL=0x00;
// OCR2BH=0x00;
// OCR2BL=0x00;

// External Interrupt(s) initialization
// INT0: Off
// INT1: Off
// INT2: Off
MCUCR = 0x00;
MCUCSR = 0x00;

// Timer(s)/Counter(s) Interrupt(s) initialization
TMSK = 0x00;

// USART initialization
// Communication Parameters: 8 Data,
// 1 Stop, No Parity
// USART Receiver: On
// USART Transmitter: On
// USART Mode: Asynchronous
// USART Baud rate: 9600
UCSR = 0x00;
UCSRB = 0x98;
UCSC = 0x86;
UBRRH = 0x00;
UBRRL = 0x47;

// Analog Comparator initialization
// Analog Comparator: Off
// Analog Comparator Input Capture by
// Timer/Counter 1: Off
// ADC initialization
// ADC Clock frequency: 86.400 kHz
// ADC Voltage Reference: Int., cap. on AREF
// ADC Auto Trigger Source: None
ADMUX=ADC_VREF_TYPE & 0xff;
ADCSRA=0x87;

// Global enable interrupts
#asm("sei")

while (1)
{
    // Place your code here
    delay_ms(100);
    putchar((read_adc(0)/4));
}
}
LAMPIRAN C
Datasheet 2N3055, DAC 0802, LM 833, C945, D313

DATASHEET 2N3055
COMPLEMENTARY SILICON POWER TRANSISTORS

...designed for use in general-purpose amplifier and switching applications

FEATURES:
* Power Dissipation: $P_D = 115W$ @ $T_C = 25^\circ C$
* DC Current Gain $\beta = 20 - 70$ @ $I_C = 4.0 A$
* $V_{CE(OV)} = 1.1 V$ (Max.) @ $I_C = 4.0 A, I_E = 400 mA$

MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-Emitter Voltage</td>
<td>$V_{CEO}$</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>Collector-Base Voltage</td>
<td>$V_{CBO}$</td>
<td>70</td>
<td>V</td>
</tr>
<tr>
<td>Collector-Base Voltage</td>
<td>$V_{CEO}$</td>
<td>100</td>
<td>V</td>
</tr>
<tr>
<td>Emitter-Base Voltage</td>
<td>$V_{BEO}$</td>
<td>7.0</td>
<td>V</td>
</tr>
<tr>
<td>Collector Current-Continuous</td>
<td>$I_C$</td>
<td>15</td>
<td>A</td>
</tr>
<tr>
<td>Base Current</td>
<td>$I_B$</td>
<td>7.0</td>
<td>A</td>
</tr>
<tr>
<td>Total Power Dissipation @ $T_C = 25^\circ C$</td>
<td>$P_D$</td>
<td>115</td>
<td>W</td>
</tr>
<tr>
<td>Derate above $25^\circ C$</td>
<td></td>
<td>0.057</td>
<td>W/K</td>
</tr>
<tr>
<td>Operating and Storage Junction</td>
<td>$T_J, T_{STG}$</td>
<td>250</td>
<td>°C</td>
</tr>
<tr>
<td>Temperature Range</td>
<td></td>
<td>-65 to +200</td>
<td>°C</td>
</tr>
</tbody>
</table>

THERMAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Resistance Junction to Case</td>
<td>$R_{ejc}$</td>
<td>1.52</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

FIGURE 1 POWER DERATING

<table>
<thead>
<tr>
<th>DIM</th>
<th>MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
</tr>
<tr>
<td>A</td>
<td>36.75</td>
</tr>
<tr>
<td>B</td>
<td>19.25</td>
</tr>
<tr>
<td>C</td>
<td>7.96</td>
</tr>
<tr>
<td>D</td>
<td>11.18</td>
</tr>
<tr>
<td>E</td>
<td>25.30</td>
</tr>
<tr>
<td>F</td>
<td>0.92</td>
</tr>
<tr>
<td>G</td>
<td>1.36</td>
</tr>
<tr>
<td>H</td>
<td>29.60</td>
</tr>
<tr>
<td>I</td>
<td>16.64</td>
</tr>
<tr>
<td>J</td>
<td>3.90</td>
</tr>
<tr>
<td>K</td>
<td>10.67</td>
</tr>
</tbody>
</table>
ELECTRICAL CHARACTERISTICS (T_c = 25°C unless otherwise noted)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector - Emitter Sustaining Voltage (1)</td>
<td>V_CEB[Min] 60</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(I_C = 200 mA, I_B = 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector- Emitter Sustaining Voltage (1)</td>
<td>V_CER[Min] 70</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(I_C = 200 mA, R_E = 100 Ohms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector Cutoff Current</td>
<td>I_CEO 0.7</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_CE = 30 V, I_B = 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector Cutoff Current</td>
<td>I_CE 1.0</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_CE = 100 V, I_B[Min] = 1.5 V)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector Cutoff Current</td>
<td>I_CE 5.0</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_CE = 100 V, I_B[Min] = 1.5 V, T_C = 150°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emitter Cutoff Current</td>
<td>I_EBO 5.0</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_BE = 7.0 V, I_C = 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| ON CHARACTERISTICS (1)                              |        |     |     |      |
| DC Current Gain                                     | hFE 20 |      |
| (I_C = 4.0 A, V_CE = 4.0 V)                         |        |     |     |      |
| (I_C = 10 A, V_CE = 4.0 V)                          |        |     |     |      |
| Collector - Emitter Saturation Voltage               | V_CE[Min] 1.1 | V  |
| (I_C = 4.0 A, I_B = 0.4 A)                           |        |     |     |      |
| (I_C = 10 A, I_B = 3.3 A)                            |        |     |     |      |
| Base - Emitter On Voltage                            | V_BE[Min] 1.5 | V  |
| (I_B = 4.0 A, V_CE = 4.0 V)                          |        |     |     |      |

| DYNAMIC CHARACTERISTICS                             |        |     |     |      |
| Current Gain - Bandwidth Product (2)                | f_T 2.5 | MHz |
| (I_C = 500 mA, V_CE = 10 V, f = 1.0 MHz)            |        |     |     |      |
| Small-Signal Current Gain                           | h_m 15 | 120 |
| (I_C = 10 A, V_CE = 4.0 V, f = 1 kHz)               |        |     |     |      |

(1) Pulse Test, Pulse width = 300 μs, Duty Cycle ≤ 2.0%
(2) f_T = |h_m| \times f_{sw}

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_CE limits of the transistor that must be observed for reliable operation. If the transistor must not be subjected to greater dissipation then curves indicate.

The data of SOA curve is based on T_Jmax=80°C, T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided T_Jmax=800°C. At high case temperatures, thermal limitation will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

DATASHEET DAC0802
DAC0800/ DAC0802
8-Bit Digital-to-Analog Converters

General Description
The DAC0800 series are monolithic 8-bit high-speed
current-output digital-to-analog converters (DAC) featuring
typical settling times of 120 ns. When used as a multiplying
DAC, monotonic performance over a 40 to 1 reference cur-
rent range is possible. The DAC0800 series also features
high compliance complementary current outputs to allow dif-
ferential output voltages of 20 Vp-p with simple resistor loads
as shown in Figure 1. The reference-to-full-scale current
matching of better than ±1 LSB eliminates the need for
full-scale trims in most applications while the nonlinearities
of better than ±0.1% over temperature minimizes system er-
er accumulations.

The noise immune inputs of the DAC0800 series will accept
TTL levels with the logic threshold pin, \( V_{IL} \), grounded.
Changing the \( V_{IL} \) potential will allow direct interface to other
logic families. The performance and characteristics of the
device are essentially unchanged over the full ±4.5 V to
±16 V power supply range; power dissipation is only 33 mW
with ±5 V supplies and is independent of the logic input
states.

Features
- Fast settling output current: 100 ns
- Full scale error: ±1 LSB
- Nonlinearity over temperature: ±0.1%
- Full scale current drift: ±10 ppb/°C
- High output compliance: ±18 V to +18V
- Complementary current outputs
- Interface directly with TTL, CMOS, PMOS and others
- 2 quadrant wide range multiplying capability
- Wide power supply range: ±4.5V to ±18V
- Low power consumption: 33 mW at ±5V
- Low cost

Typical Applications

![Diagram](image)

**FIGURE 1. ±20 Vp-p Output Digital-to-Analog Converter (Note 5)**

Ordering Information

<table>
<thead>
<tr>
<th>Non-Linearity</th>
<th>Temperature Range</th>
<th>J Package (J16A) (Note 1)</th>
<th>N Package (N16E) (Note 1)</th>
<th>SO Package (M16A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.1% FS</td>
<td>0°C ≤ ( T_A ) ≤ +70°C</td>
<td>DAC0802LJC</td>
<td>DAC0802LCN</td>
<td>DAC0802LCNM</td>
</tr>
<tr>
<td>±0.19% FS</td>
<td>-55°C ≤ ( T_A ) ≤ +125°C</td>
<td>DAC0802LJL</td>
<td>DAC0802LQ</td>
<td>DAC0802LQC</td>
</tr>
<tr>
<td>±0.19% FS</td>
<td>0°C ≤ ( T_A ) ≤ +70°C</td>
<td>DAC0802LJC</td>
<td>DAC0802LCN</td>
<td>DAC0802LCNM</td>
</tr>
</tbody>
</table>

Note 1: Devices may be ordered by using either order number.
## Absolute Maximum Ratings (Note 2)

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

- Supply Voltage ($V^+ - V^-$) ±18V or 36V
- Power Dissipation (Note 3) 500 mW
- Reference Input Differential Voltage ($V_{14}$ to $V_{15}$) $V^+$ to $V^-$
- Reference Input Common-Mode Range ($V_{14}$, $V_{15}$) $V^+$ to $V^-
- Reference Input Current 5 mA
- Logic Inputs $V^-$ to $V^+$ plus 36V
- Analog Current Outputs ($V_{DD}$ = −15V) 4.25 mA
- ESD Susceptibility (Note 4) TBD V

## Operating Conditions (Note 2)

<table>
<thead>
<tr>
<th>Temperature ($T_A$)</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAC0800LC</td>
<td>−55</td>
<td>125</td>
<td>°C</td>
</tr>
<tr>
<td>DAC0800LC</td>
<td>0</td>
<td>70</td>
<td>°C</td>
</tr>
<tr>
<td>DAC0800LC</td>
<td>0</td>
<td>70</td>
<td>°C</td>
</tr>
</tbody>
</table>

## Electrical Characteristics

The following specifications apply for $V_{DD}$ = ±15V, $I_{REF}$ = 2 mA and $T_{MIN} \leq T_A \leq T_{MAX}$ unless otherwise specified. Output characteristics refer to both $I_{OUT}$ and $I_{OUT}$.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>DAC0802LC</th>
<th>DAC0800LC</th>
<th>DAC0800LC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
</tr>
<tr>
<td>Resolution</td>
<td></td>
<td></td>
<td>$R_{LSB}$</td>
<td>$R_{LSB}$</td>
<td>$R_{LSB}$</td>
</tr>
<tr>
<td>Monotonicity</td>
<td></td>
<td></td>
<td>$\Delta$</td>
<td>$\Delta$</td>
<td>$\Delta$</td>
</tr>
<tr>
<td>Nonlinearity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_s$</td>
<td>Setting Time</td>
<td>$T_A$=5°C, All Bits Switched</td>
<td>100</td>
<td>135</td>
<td>ns</td>
</tr>
<tr>
<td>$t_{PLH}$</td>
<td>Propagation Delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{PHL}$</td>
<td>Each Bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Bits Switched</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_{ON}$</td>
<td>Full Scale Tempco</td>
<td></td>
<td>±10</td>
<td>±50</td>
<td>±10</td>
</tr>
<tr>
<td>$V_{ICC}$</td>
<td></td>
<td></td>
<td>−10</td>
<td>19</td>
<td>−10</td>
</tr>
<tr>
<td>$I_{DDA}$</td>
<td>Full Scale Current</td>
<td>$V_{DDA}$=10.000V, $R_{ON}=15.000$ kΩ</td>
<td>1.984</td>
<td>1.962</td>
<td>2.000</td>
</tr>
<tr>
<td>$I_{DDC}$</td>
<td>Full Scale Symmetry</td>
<td>$I_{DDC}=500$ µA</td>
<td>±0.5</td>
<td>±0.4</td>
<td>±1</td>
</tr>
<tr>
<td>$I_{SS}$</td>
<td>Zero Scale Current</td>
<td></td>
<td>0.1</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>$I_{ORB}$</td>
<td>Output Current Range</td>
<td>$V^-$=−5V, $V^-$=−6V to −15V</td>
<td>0</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>$V_{IL}$</td>
<td>Logic Input Levels</td>
<td></td>
<td>2.0</td>
<td>0.8</td>
<td>2.0</td>
</tr>
<tr>
<td>$V_{IH}$</td>
<td>Logic Input Levels</td>
<td></td>
<td>0.3</td>
<td>2.0</td>
<td>0.3</td>
</tr>
<tr>
<td>$I_{IL}$</td>
<td>Logic Input Current</td>
<td></td>
<td>−2.0</td>
<td>−10</td>
<td>−2.0</td>
</tr>
<tr>
<td>$I_{IH}$</td>
<td>Logic '1'</td>
<td></td>
<td>0.002</td>
<td>10</td>
<td>0.002</td>
</tr>
<tr>
<td>$V_{OS}$</td>
<td>Logic Input Swing</td>
<td></td>
<td>−10</td>
<td>19</td>
<td>−10</td>
</tr>
<tr>
<td>$V_{TH+}$</td>
<td>Logic Threshold Range</td>
<td></td>
<td>−10</td>
<td>13.5</td>
<td>−10</td>
</tr>
<tr>
<td>$I_{BS}$</td>
<td>Reference Bias Current</td>
<td></td>
<td>−1.0</td>
<td>−3.0</td>
<td>−1.0</td>
</tr>
<tr>
<td>$I_{BIS}$</td>
<td>Reference Input Slew Rate</td>
<td>(Figure 11)</td>
<td>4.0</td>
<td>0.0</td>
<td>4.0</td>
</tr>
<tr>
<td>$PSS_{LH}$</td>
<td>Power Supply Sensitivity</td>
<td></td>
<td>0.0001</td>
<td>0.01</td>
<td>0.0001</td>
</tr>
<tr>
<td>$PSS_{HI}$</td>
<td></td>
<td></td>
<td>−4.5V/25V±18V</td>
<td>0.0001</td>
<td>0.01</td>
</tr>
</tbody>
</table>

A-10
## Electrical Characteristics (Continued)

The following specifications apply for \( V_{CC} = \pm 15V, I_{REF} = 2 mA \) and \( T_{MIN} \leq T_A \leq T_{MAX} \) unless otherwise specified. Output characteristics refer to both low and high outputs.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>DAC0802LC</th>
<th>DAC0800L/I</th>
<th>DAC0800LC</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>I+</td>
<td>Power Supply Current ( V_{CC} = \pm 15V, I_{REF} = 1 mA )</td>
<td>2.3</td>
<td>3.8</td>
<td>2.3</td>
<td>3.8</td>
<td>mA</td>
</tr>
<tr>
<td>I-</td>
<td></td>
<td>-4.3</td>
<td>-5.8</td>
<td>-4.3</td>
<td>-5.8</td>
<td>mA</td>
</tr>
<tr>
<td>I+</td>
<td>( V_{CC} = 15V, I_{REF} = 2 mA )</td>
<td>2.4</td>
<td>3.8</td>
<td>2.4</td>
<td>3.8</td>
<td>mA</td>
</tr>
<tr>
<td>I-</td>
<td></td>
<td>-8.4</td>
<td>-7.8</td>
<td>-8.4</td>
<td>-7.8</td>
<td>mA</td>
</tr>
<tr>
<td>I+</td>
<td>( V_{CC} = \pm 15V, I_{REF} = 2 mA )</td>
<td>2.5</td>
<td>3.8</td>
<td>2.5</td>
<td>3.8</td>
<td>mA</td>
</tr>
<tr>
<td>I-</td>
<td></td>
<td>-8.5</td>
<td>-7.8</td>
<td>-8.5</td>
<td>-7.8</td>
<td>mA</td>
</tr>
<tr>
<td>P_D</td>
<td>Power Dissipation</td>
<td>33</td>
<td>48</td>
<td>33</td>
<td>48</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>( V_{CC} = \pm 15V, I_{REF} = 2 mA )</td>
<td>108</td>
<td>130</td>
<td>108</td>
<td>130</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>5V, 10V, I_{REF} = 1 mA</td>
<td>135</td>
<td>174</td>
<td>135</td>
<td>174</td>
<td>mW</td>
</tr>
</tbody>
</table>

**Note 2:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating conditions.

**Note 3:** The maximum junction temperature of the DAC0800 and DAC0802 is 125°C. For operating at elevated temperatures, devices in the Dual-In-Line J package must be derated based on a thermal resistance of 100°C/W junction-to-ambient. 115°C/W for the modulated Dual-In-Line N package and 120°C/W for the Small Outline M package.

**Note 4:** Human body model, 100 pF discharged through a 1.5 kΩ resistor.

**Note 5:** Pin-out numbers for the DAC0800 represent the Dual-In-Line package. The Small Outline package pin-out differs from the Dual-In-Line package.

## Connection Diagrams

### Dual-In-Line Package

![Dual-In-Line Package Diagram](image1)

### Small Outline Package

![Small Outline Package Diagram](image2)

See Ordering Information
Block Diagram (Note 5)

Typical Performance Characteristics

Full Scale Current vs Reference Current

LSB Propagation Delay vs I_{REF}

Reference Input Frequency Response

Reference Amp Common-Mode Range

Logic Input Current vs Input Voltage

V_{TH} - V_{LC} vs Temperature

Note: Positive common-mode range is always
$(V_{CC}) - 1.2V$.
Typical Performance Characteristics (Continued)

Output Current vs Output Voltage (Output Voltage Compliance)

Output Voltage Compliance vs Temperature

Bit Transfer Characteristics

Note: R1-R8 have identical transfer characteristics. Bits are fully switched with less than 1 nS delay at less than ±130 mV from actual threshold. These switching points are guaranteed to be between 0.5 and 0.7V over the operating temperature range (VDD - 2V).

Power Supply Current vs -V

Power Supply Current vs -V

Power Supply Current vs Temperature

Equivalent Circuit

FIGURE 2.
Typical Applications

\[ I_{pp} = \frac{+V_{REF}}{R_{pp}} \times 250 \]
\[ I_{pp} = \frac{-V_{REF}}{R_{pp}} \times 250 \]

For fixed reference, TTL operation, typical values are:
\[ V_{dd} = 10.000V \]
\[ R_{pp} = 5000\Omega \]
\[ C_{c} = 0.01\, \mu F \]
\[ V_{cc} = 0V \text{ (Ground)} \]

**FIGURE 3. Basic Positive Reference Operation (Note 5)**

**FIGURE 4. Recommended Full Scale Adjustment Circuit (Note 5)**

Note: \( R_{pp} \) sets \( I_{pp} \); \( R_{15} \) is for bias current cancellation

**FIGURE 5. Basic Negative Reference Operation (Note 5)**

**FIGURE 6. Basic Unipolar Negative Operation (Note 5)**

<table>
<thead>
<tr>
<th>B1 B2 B3 B4 B5 B6 B7 B8</th>
<th>( I_{pp} ) mA</th>
<th>( I_{cc} ) mA</th>
<th>( E_{C} )</th>
<th>( E_{D} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Scale</td>
<td>1 1 1 1 1 1 1 1</td>
<td>1.992</td>
<td>0.003</td>
<td>-3.590</td>
</tr>
<tr>
<td>Full Scale–LSB</td>
<td>1 1 1 1 1 1 0 1 0</td>
<td>1.994</td>
<td>0.008</td>
<td>-3.020</td>
</tr>
<tr>
<td>Half Scale+LSB</td>
<td>1 0 0 0 0 0 0 1 1</td>
<td>1.008</td>
<td>0.984</td>
<td>-5.040</td>
</tr>
<tr>
<td>Half Scale</td>
<td>1 0 0 0 0 0 0 0 0</td>
<td>1.000</td>
<td>0.982</td>
<td>-5.000</td>
</tr>
<tr>
<td>Half Scale–LSB</td>
<td>0 1 1 1 1 1 1 1 1</td>
<td>0.992</td>
<td>1.000</td>
<td>-4.960</td>
</tr>
<tr>
<td>Zero Scale+LSB</td>
<td>0 0 0 0 0 0 0 1 1</td>
<td>0.008</td>
<td>1.984</td>
<td>-0.040</td>
</tr>
<tr>
<td>Zero Scale</td>
<td>0 0 0 0 0 0 0 0 0</td>
<td>0.000</td>
<td>1.992</td>
<td>0.000</td>
</tr>
</tbody>
</table>

A-14
### Typical Applications (Continued)

![Diagram](image)

<table>
<thead>
<tr>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>B8</th>
<th>$E_O$</th>
<th>$E_O$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-9.820</td>
<td>+10.000</td>
</tr>
<tr>
<td>Pos. Full Scale</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-9.820</td>
<td>+10.000</td>
</tr>
<tr>
<td>Pos. Full Scale-LSB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>-9.840</td>
<td>+9.920</td>
</tr>
<tr>
<td>Zero Scale-LSB</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-0.000</td>
<td>+0.100</td>
</tr>
<tr>
<td>Zero Scale</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.000</td>
<td>+0.000</td>
</tr>
<tr>
<td>Neg. Full Scale-LSB</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+9.820</td>
<td>-9.840</td>
</tr>
<tr>
<td>Neg. Full Scale</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+10.000</td>
<td>-9.920</td>
</tr>
</tbody>
</table>

**FIGURE 7. Basic Bipolar Output Operation (Note 5)**

![Diagram](image)

If $R_L = R_O$, within ±2.05%, output is symmetrical about ground.

<table>
<thead>
<tr>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>B8</th>
<th>$E_O$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+9.960</td>
</tr>
<tr>
<td>Pos. Full Scale</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>+9.960</td>
</tr>
<tr>
<td>Pos. Full Scale-LSB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>+9.960</td>
</tr>
<tr>
<td>(+)Zero Scale</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+0.040</td>
</tr>
<tr>
<td>(-)Zero Scale</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-0.040</td>
</tr>
<tr>
<td>Neg. Full Scale-LSB</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-9.880</td>
</tr>
<tr>
<td>Neg. Full Scale</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-9.960</td>
</tr>
</tbody>
</table>

**FIGURE 8. Symmetrical Offset Binary Operation (Note 5)**

![Diagram](image)

For complementary output (operation as negative logic DAC), connect inverting input of op amp to $I_{0}$ (pin 2), connect $I_{0}$ (pin 4) to ground.

**FIGURE 9. Positive Low Impedance Output Operation (Note 5)**
DATASHEET LM 833

LM833
Dual Audio Operational Amplifier

General Description
The LM833 is a dual general purpose operational amplifier designed with particular emphasis on performance in audio systems.

This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level stages in PCM and Hi-Fi systems.

The LM833 is pin-to-pin compatible with industry standard dual operational amplifiers.

Features
- Wide dynamic range: >140dB
- Low input noise voltage: 4.5nV/√Hz
- High slew rate: 7 V/µs (typ); 5V/µs (min)
- High gain bandwidth: 1.5MHz (typ); 10MHz (min)
- Wide power bandwidth: 1200Hz
- Low distortion: 0.002%
- Low offset voltage: 0.3mV
- Large phase margin: 60°
- Available in 6-pin MSOP package

Schematic Diagram

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Connection Diagram

Order Number LM333M, LM333MX, LM333N, LM333MM or LM333MMX
See NS Package Number
M08A, N08E or MUA08A
**Absolute Maximum Ratings** (Note 1)

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CC}$</td>
<td>Input Offset Voltage</td>
<td>$R_{B} = 10\Omega$</td>
<td>0.3</td>
<td>5</td>
<td>mV</td>
</tr>
<tr>
<td>$I_{O}$</td>
<td>Input Offset Current</td>
<td></td>
<td>10</td>
<td>200</td>
<td>nA</td>
</tr>
<tr>
<td>$I_{B}$</td>
<td>Input Bias Current</td>
<td></td>
<td>100</td>
<td>1000</td>
<td>nA</td>
</tr>
<tr>
<td>$A_{V}$</td>
<td>Voltage Gain</td>
<td>$R_{L} = 2\ k\Omega, \ V_{O} = \pm 10\ V$</td>
<td>90</td>
<td>110</td>
<td>dB</td>
</tr>
<tr>
<td>$V_{OM}$</td>
<td>Output Voltage Swing</td>
<td>$R_{L} = 10\ k\Omega$</td>
<td>$\pm 12$</td>
<td>$\pm 12.5$</td>
<td>V</td>
</tr>
<tr>
<td>$I_{CM}$</td>
<td>Input Common-Mode Range</td>
<td>$R_{L} = 2\ k\Omega$</td>
<td>$\pm 10$</td>
<td>$\pm 13.4$</td>
<td>V</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common-Mode Rejection Ratio</td>
<td>$V_{IN} = \pm 12\ V$</td>
<td>80</td>
<td>100</td>
<td>dB</td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>$V_{S} = 15\ V, -15\ V$</td>
<td>80</td>
<td>100</td>
<td>dB</td>
</tr>
<tr>
<td>$I_{O}$</td>
<td>Supply Current</td>
<td>$V_{O} = 0\ V, \text{ Both Amps}$</td>
<td>5</td>
<td>8</td>
<td>mA</td>
</tr>
</tbody>
</table>

**DC Electrical Characteristics** (Notes 1, 2)

($T_{A} = 25^\circ C, V_{S} = \pm 15V$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>Slew Rate</td>
<td>$R_{L} = 2\ k\Omega$</td>
<td>5</td>
<td>7</td>
<td>V/μs</td>
<td></td>
</tr>
<tr>
<td>GBW</td>
<td>Gain Bandwidth Product</td>
<td>$f = 100\ kHz$</td>
<td>10</td>
<td>15</td>
<td>MHz</td>
<td></td>
</tr>
</tbody>
</table>

**AC Electrical Characteristics**

($T_{A} = 25^\circ C, V_{S} = \pm 15V, R_{L} = 2\ k\Omega$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta V_{CC}/\Delta T$</td>
<td>Average Temperature Coefficient of Input Offset Voltage</td>
<td></td>
<td>2</td>
<td></td>
<td>μV/°C</td>
<td></td>
</tr>
<tr>
<td>THD</td>
<td>Distortion</td>
<td>$R_{L} = 2\ k\Omega, f = 20-20\ kHz$</td>
<td></td>
<td>0.002</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>$e_{n}$</td>
<td>Input Referred Noise Voltage</td>
<td>$R_{n} = 100\Omega, f = 1\ kHz$</td>
<td></td>
<td>4.5</td>
<td>nV/√Hz</td>
<td></td>
</tr>
<tr>
<td>$i_{n}$</td>
<td>Input Referred Noise Current</td>
<td>$f = 1\ kHz$</td>
<td></td>
<td>0.7</td>
<td>pA/√Hz</td>
<td></td>
</tr>
<tr>
<td>PSN</td>
<td>Power Bandwidth</td>
<td>$V_{O} = 27\ V_{PP}, R_{L} = 2\ k\Omega, \text{ THD} \leq 1%$</td>
<td></td>
<td>120</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>$f_{U}$</td>
<td>Unity Gain Frequency</td>
<td>Open Loop</td>
<td></td>
<td>9</td>
<td>MHz</td>
<td></td>
</tr>
<tr>
<td>$\phi_{M}$</td>
<td>Phase Margin</td>
<td>Open Loop</td>
<td></td>
<td>60</td>
<td>°</td>
<td></td>
</tr>
<tr>
<td>$\phi_{C}$</td>
<td>Input Referred Cross Talk</td>
<td>$f = 20-20\ kHz$</td>
<td></td>
<td>$-120$</td>
<td>dB</td>
<td></td>
</tr>
</tbody>
</table>
DATASHEET C945

Philips Semiconductors

NPN general purpose transistor

FEATURES
- Low current (max. 100 mA)
- Low voltage (max. 50 V).

APPLICATIONS
- General purpose switching and amplification.

DESCRIPTION
NPN transistor in a TO-92 (SOT54) plastic package.
PNP complement: 2PA733.

PINNING

<table>
<thead>
<tr>
<th>PIN</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>base</td>
</tr>
<tr>
<td>2</td>
<td>collector</td>
</tr>
<tr>
<td>3</td>
<td>emitter</td>
</tr>
</tbody>
</table>

Fig.1 Simplified outline (TO-92; SOT54) and symbol.

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

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCEO</td>
<td>collector-emitter voltage</td>
<td>open base</td>
<td>–</td>
<td>50</td>
<td>V</td>
</tr>
<tr>
<td>VCEO</td>
<td>collector-emitter voltage</td>
<td>open base</td>
<td>–</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>Ic</td>
<td>collector current (DC)</td>
<td>open collector</td>
<td>–</td>
<td>5</td>
<td>V</td>
</tr>
<tr>
<td>Ic</td>
<td>collector current (DC)</td>
<td>open collector</td>
<td>–</td>
<td>100</td>
<td>mA</td>
</tr>
<tr>
<td>ICM</td>
<td>peak collector current</td>
<td>open collector</td>
<td>–</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>ICM</td>
<td>peak collector current</td>
<td>open collector</td>
<td>–</td>
<td>100</td>
<td>mA</td>
</tr>
<tr>
<td>PTOL</td>
<td>total power dissipation</td>
<td>Tamb ≤ 25 °C; note 1</td>
<td>–</td>
<td>500</td>
<td>mW</td>
</tr>
<tr>
<td>TStg</td>
<td>storage temperature</td>
<td>–65 to +150 °C</td>
<td>–</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>TJ</td>
<td>junction temperature</td>
<td>–</td>
<td>–</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>TAMB</td>
<td>operating ambient temperature</td>
<td></td>
<td>–65</td>
<td>+150</td>
<td>°C</td>
</tr>
</tbody>
</table>

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