# How-to DATASHEETS

Technical lecture

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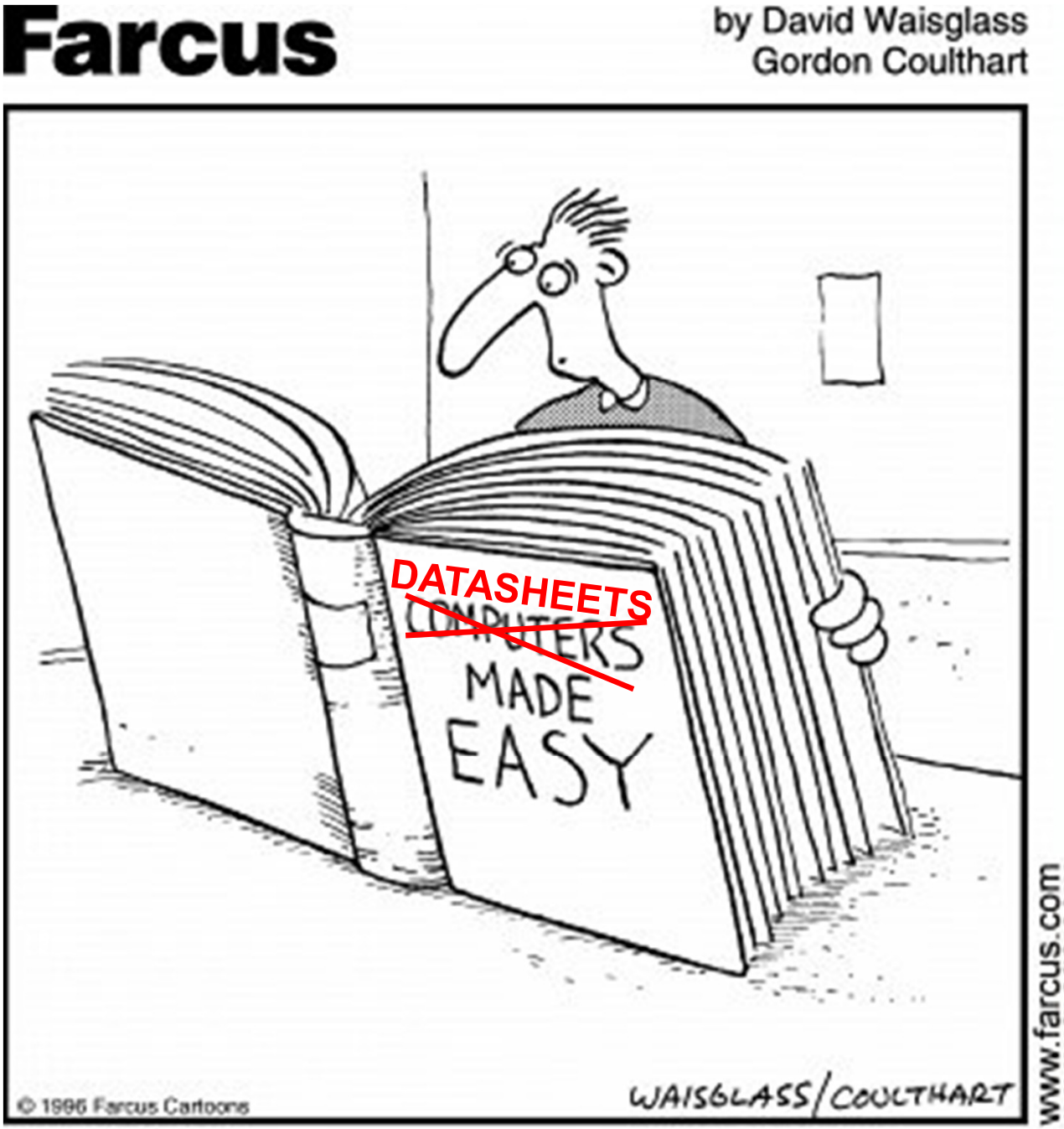
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# What are the datasheets?

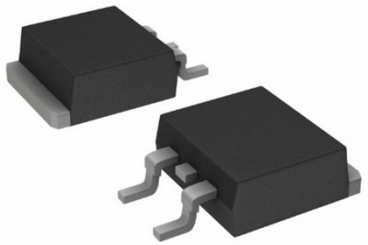
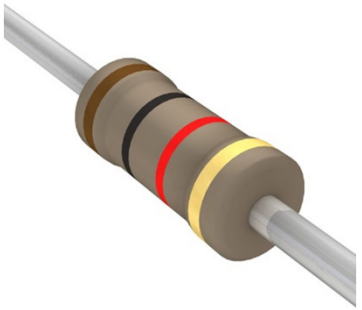
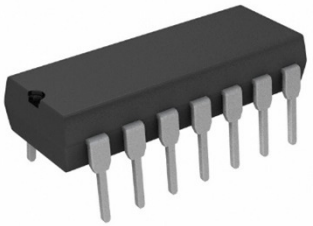
- **Essential engineering tool**
- "A document summarising:
  - the performance;
  - other technical characteristics of:
    - a product;
    - machine;
    - component (e.g. an electronic component);
    - material;
    - a subsystem (e.g. a power supply) or
    - software

in sufficient detail
to be used by
a **design engineer**
to integrate
the component into
a system."

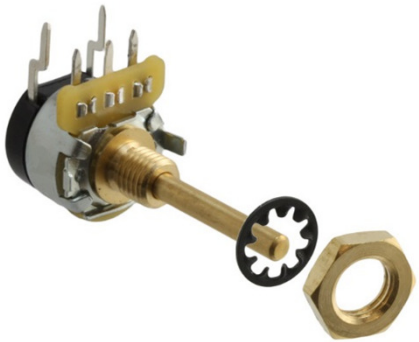
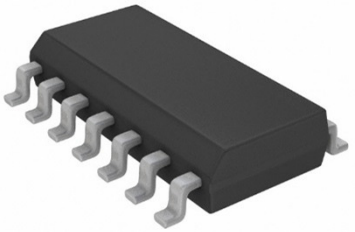
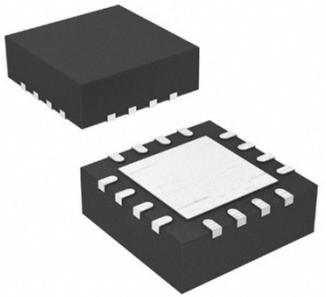
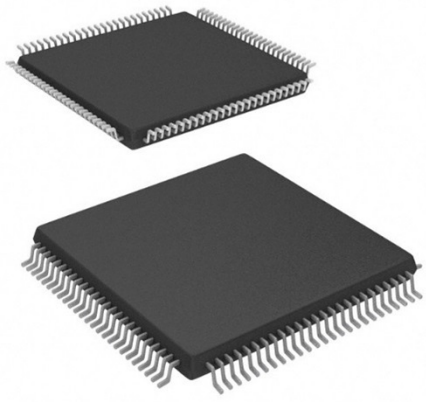
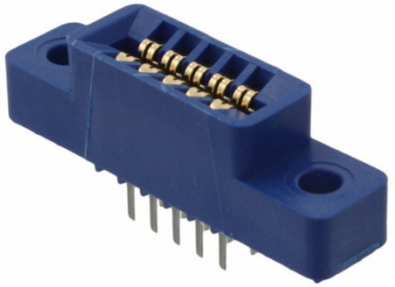


http://en.wikipedia.org/wiki/Datasheet



# Component description

All pictures of components: www.digikey.ca

# Electronics component Datasheets

## Component description

- Manufacturer's name.
- Date and release number.
- Manufacturer Part Number(s).
- Notable device properties.
- Device overview or short functional description.
- List of available package formats (with images).
- Pin connection diagram and pins' functions description.



Adapted from: http://en.wikipedia.org/wiki/Datasheet

# VN2222LLG

## Small Signal MOSFET 150 mAmps, 60 Volts

N–Channel TO–92

**Features**

- This is a Pb–Free Device*

**MAXIMUM RATINGS**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain–Source Voltage | $V_{DSS}$ | 60 | Vdc |
| Drain–Gate Voltage ($R_{GS}$ = 1.0 MΩ) | $V_{DGR}$ | 60 | Vdc |
| Gate–Source Voltage<br>– Continuous<br>– Non–repetitive ($t_p \le 50$ μs) | $V_{GS}$<br>$V_{GSM}$ | ±20<br>±40 | Vdc<br>Vpk |
| Drain Current<br>– Continuous<br>– Pulsed | $I_D$<br>$I_{DM}$ | 150<br>1000 | mAdc |
| Total Power Dissipation @ $T_A$ = 25°C<br>Derate above 25°C | $P_D$ | 400<br>3.2 | mW<br>mW/°C |
| Operating and Storage Temperature Range | $T_J$, $T_{stg}$ | –55 to +150 | °C |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

**THERMAL CHARACTERISTICS**

| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Thermal Resistance, Junction–to–Ambient | $R_{\theta JA}$ | 312.5 | °C/W |
| Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds | $T_L$ | 300 | °C |

*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

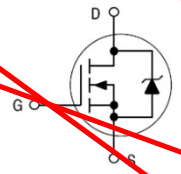
ON Semiconductor®

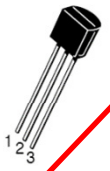
http://onsemi.com

150 mA, 60 V

$R_{DS(on)}$ = 7.5 Ω

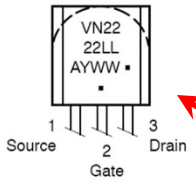
N–Channel




TO–92
CASE 29
STYLE 22

**MARKING DIAGRAM & PIN ASSIGNMENT**




A = Assembly Location
Y = Year
WW = Work Week
▪ = Pb–Free Package
(Note: Microdot may be in either location)

**ORDERING INFORMATION**

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.




- Manufacturer's name
- Date and release number
- Manufacturer Part Number(s)
- Notable device properties
- Device overview or short functional description
- List of available package formats (with images)
- Pin connection diagram and pins' functions description

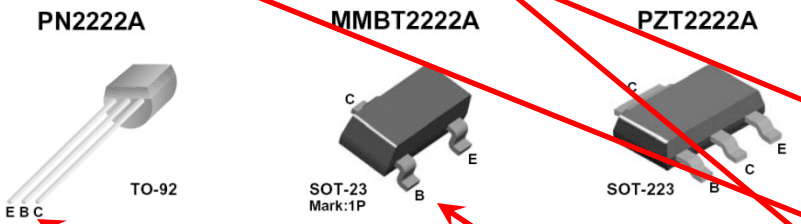
FAIRCHILD
SEMICONDUCTOR®

August 2010

# PN2222A / MMBT2222A / PZT2222A
# NPN General Purpose Amplifier

## Features

- This device is for use as a medium power amplifier and switch requiring collector currents up to 500mA.
- Sourced from process 19.




## Absolute Maximum Ratings * $T_a$ = 25°C unless otherwise noted

| Symbol | Parameter | Value | Units |
|---|---|---|---|
| $V_{CEO}$ | Collector-Emitter Voltage | 40 | V |
| $V_{CBO}$ | Collector-Base Voltage | 75 | V |
| $V_{EBO}$ | Emitter-Base Voltage | 6.0 | V |
| $I_C$ | Collector Current | 1.0 | A |
| $T_{STG}$ | Operating and Storage Junction Temperature Range | - 55 ~ 150 | °C |

* This ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

**NOTES:**

1) These rating are based on a maximum junction temperature of 150 degrees C.
2) These are steady limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

## Thermal Characteristics $T_a$ = 25°C unless otherwise noted

| Symbol | Parameter | Max. | | | Units |
|---|---|---|---|---|---|
| | | PN2222A | *MMBT2222A | **PZT2222A | |
| $P_D$ | Total Device Dissipation<br>Derate above 25°C | 625<br>5.0 | 350<br>2.8 | 1,000<br>8.0 | mW<br>mW/°C |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case | 83.3 | | | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 200 | 357 | 125 | °C/W |

* Device mounted on FR-4 PCB 1.6" × 1.6" × 0.06".
** Device mounted on FR-4 PCB 36mm × 18mm × 1.5mm; mounting pad for the collector lead min. 6cm$^2$.






- Manufacturer's name
- Date and release number
- Manufacturer Part Number(s)
- Notable device properties
- Device overview or short functional description
- List of available package formats (with images)
- Pin connection diagram and pins' functions description

# LM117/LM317A/LM317-N Three-Terminal Adjustable Regulator

Check for Samples: LM117, LM317A, LM317-N

## FEATURES

- Specified 1% Output Voltage Tolerance (LM317A)
- Specified max. 0.01%/V Line Regulation (LM317A)
- Specified max. 0.3% Load Regulation (LM117)
- Specified 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

## 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.

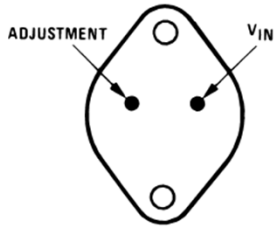
Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded,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

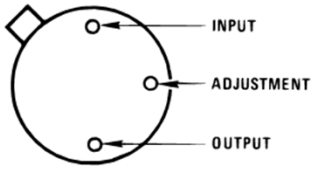
- Manufacturer's name
- Date and release number
- Manufacturer Part Number(s)
- Notable device properties
- Device overview or short functional description

**Connection Diagrams**




CASE IS OUTPUT

**Figure 3. TO-3 (NDS)**
**Metal Can Package**
**Bottom View**
**Package Drawing NDS**




CASE IS OUTPUT

**Figure 4. TO (NDT)**
**Metal Can Package**
**Bottom View**
**Package Drawing NDT**

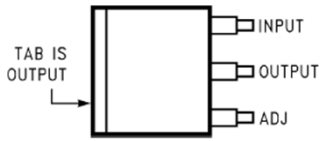



**Figure 5. TO-263 (KTT)**
**Surface-Mount Package**
**Top View**
**Package Drawing KTT**

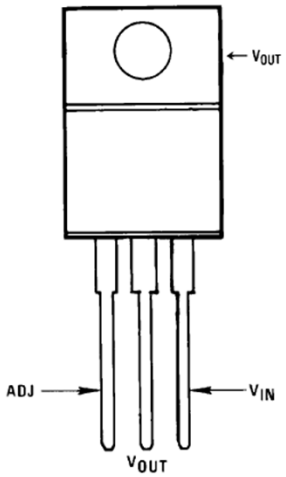



**Figure 6. TO-220 (NDE)**
**Plastic Package**
**Front View**
**Package Drawing NDE**

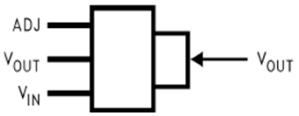



**Figure 7. 4-Lead SOT-223 (DCY)**
**Top View Surface-Mount Package**
**Package Number DCY**

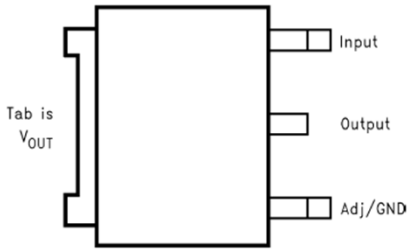



**Figure 8. TO-252 (NDP)**
**Front View Surface Mount Package**
**Package Drawing NDP**

**LM117, LM317A, LM317-N**

List of available package formats (with images)

Pin connection diagram and pins' functions description

Manufacturer's name

# PIC16F610/16HV610
# PIC16F616/16HV616
# Data Sheet

14-Pin, Flash-Based 8-Bit
CMOS Microcontrollers

Manufacturer Part Number(s)




Date and release number

MICROCHIP

# PIC16F610/616/16HV610/616

## 14-Pin Flash-Based, 8-Bit CMOS Microcontrollers

### High-Performance RISC CPU:

- Only 35 Instructions to Learn:
  - All single-cycle instructions except branches
- Operating Speed:
  - DC – 20 MHz oscillator/clock input
  - DC – 200 ns instruction cycle
- Interrupt Capability
- 8-Level Deep Hardware Stack
- Direct, Indirect and Relative Addressing modes

### Special Microcontroller Features:

- Precision Internal Oscillator:
  - Factory calibrated to ±1%, typical
  - User selectable frequency: 4 MHz or 8 MHz
- Power-Saving Sleep mode
- Voltage Range:
  - PIC16F610/616: 2.0V to 5.5V
  - PIC16HV610/616: 2.0V to user defined maximum (see note)
- Industrial and Extended Temperature Range
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Brown-out Reset (BOR)
- Watchdog Timer (WDT) with Independent Oscillator for Reliable Operation
- Multiplexed Master Clear with Pull-up/Input Pin
- Programmable Code Protection
- High Endurance Flash:
  - 100,000 write Flash endurance
  - Flash retention: > 40 years

### Low-Power Features:

- Standby Current:
  - 50 nA @ 2.0V, typical
- Operating Current:
  - 20 µA @ 32 kHz, 2.0V, typical
  - 220 µA @ 4 MHz, 2.0V, typical
- Watchdog Timer Current:
  - 1 µA @ 2.0V, typical

**Note:** Voltage across internal shunt regulator cannot exceed 5V.

### Peripheral Features:

- Shunt Voltage Regulator (PIC16HV610/616 only):
  - 5 volt regulation
  - 4 mA to 50 mA shunt range
- 11 I/O Pins and 1 Input Only
  - High current source/sink for direct LED drive
  - Interrupt-on-Change pins
  - Individually programmable weak pull-ups
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference ($C_{VREF}$) module (% of $V_{DD}$)
  - Fixed Voltage Reference
  - Comparator inputs and outputs externally accessible

| Device | Program Memory | Data Memory | I/O | 10-bit A/D (ch) | Comparators | Timers 8/16-bit | Voltage Range |
|---|---|---|---|---|---|---|---|
| | Flash (words) | SRAM (bytes) | | | | | |
| PIC16F610 | 1024 | 64 | 11 | — | 2 | 1/1 | 2.0-5.5V |
| PIC16HV610 | 1024 | 64 | 11 | — | 2 | 1/1 | 2.0-user defined |
| PIC16F616 | 2048 | 128 | 11 | 8 | 2 | 2/1 | 2.0-5.5V |
| PIC16HV616 | 2048 | 128 | 11 | 8 | 2 | 2/1 | 2.0-user defined |

**PIC16F616/16HV616 only:**

- A/D Converter:
  - 10-bit resolution
  - 8 external input channels
  - 2 internal reference channels
- Timer2: 8-Bit Timer/Counter with 8-Bit Period Register, Prescaler and Postscaler
- Enhanced Capture, Compare, PWM module:
  - 16-bit Capture, max. resolution 12.5 ns
  - 16-bit Compare, max. resolution 200 ns
  - 10-bit PWM with 1, 2 or 4 output channels, programmable "dead time", max. frequency 20 kHz




Manufacturer's name

Date and release number

Manufacturer Part Number(s)

Notable device properties

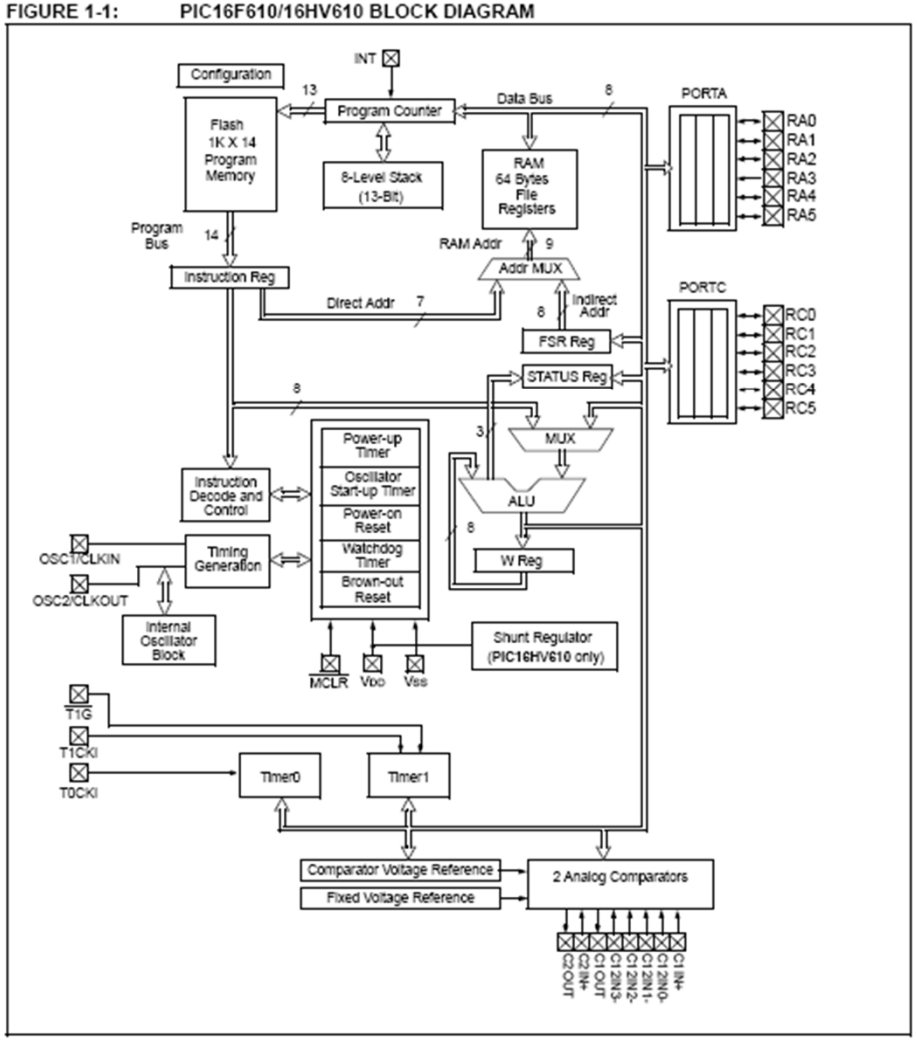
## 1.0 DEVICE OVERVIEW

The PIC16F610/616/16HV610/616 is covered by this data sheet. It is available in 14-pin PDIP, SOIC, TSSOP and 16-pin QFN packages.

Block Diagrams and pinout descriptions of the devices are as follows:

- PIC16F610/16HV610 (Figure 1-1, Table 1-1)
- PIC16F616/16HV616 (Figure 1-2, Table 1-2)

**FIGURE 1-1: PIC16F610/16HV610 BLOCK DIAGRAM**

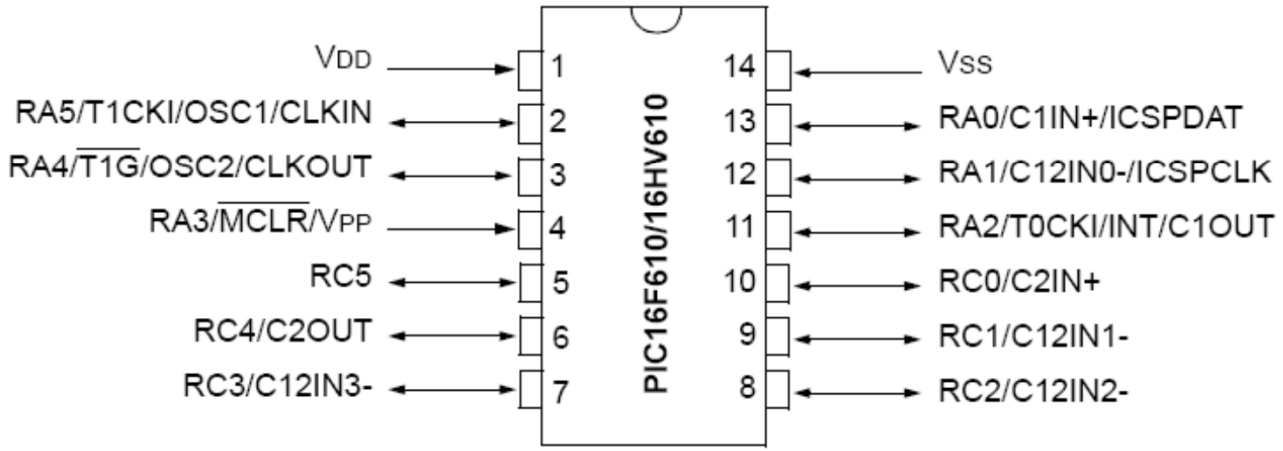




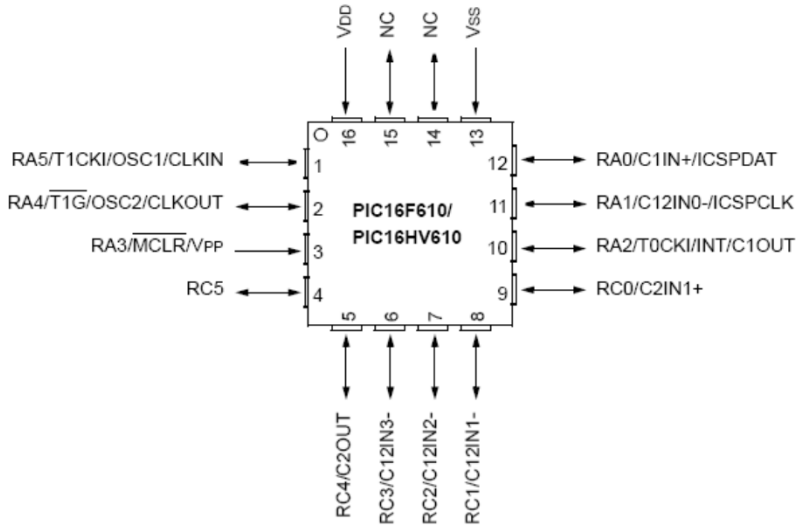

Device overview or
short functional description

# List of available package formats (with images)
# Pin connection diagram

**PIC16F610/16HV610 14-Pin Diagram (PDIP, SOIC, TSSOP)**




**PIC16F610/16HV610 16-Pin Diagram (QFN)**



# Pins' functions description

**TABLE 1-1: PIC16F610/16HV610 PINOUT DESCRIPTION**

| Name | Function | Input Type | Output Type | Description |
|---|---|---|---|---|
| RA0/C1IN+/ICSPDAT | RA0 | TTL | CMOS | PORTA I/O with prog. pull-up and interrupt-on-change |
| | C1IN+ | AN | — | Comparator C1 non-inverting input |
| | ICSPDAT | ST | CMOS | Serial Programming Data I/O |
| RA1/C12IN0-/ICSPCLK | RA1 | TTL | CMOS | PORTA I/O with prog. pull-up and interrupt-on-change |
| | C12IN0- | AN | — | Comparators C1 and C2 inverting input |
| | ICSPCLK | ST | — | Serial Programming Clock |
| RA2/T0CKI/INT/C1OUT | RA2 | ST | CMOS | PORTA I/O with prog. pull-up and interrupt-on-change |
| | T0CKI | ST | — | Timer0 clock input |
| | INT | ST | — | External Interrupt |
| | C1OUT | — | CMOS | Comparator C1 output |
| RA3/$\overline{\text{MCLR}}$/VPP | RA3 | TTL | — | PORTA input with interrupt-on-change |
| | $\overline{\text{MCLR}}$ | ST | — | Master Clear w/internal pull-up |
| | VPP | HV | — | Programming voltage |
| RA4/$\overline{\text{T1G}}$/OSC2/CLKOUT | RA4 | TTL | CMOS | PORTA I/O with prog. pull-up and interrupt-on-change |
| | $\overline{\text{T1G}}$ | ST | — | Timer1 gate (count enable) |
| | OSC2 | — | XTAL | Crystal/Resonator |
| | CLKOUT | — | CMOS | Fosc/4 output |
| RA5/T1CKI/OSC1/CLKIN | RA5 | TTL | CMOS | PORTA I/O with prog. pull-up and interrupt-on-change |
| | T1CKI | ST | — | Timer1 clock input |
| | OSC1 | XTAL | — | Crystal/Resonator |

**MAXIMUM RATINGS**

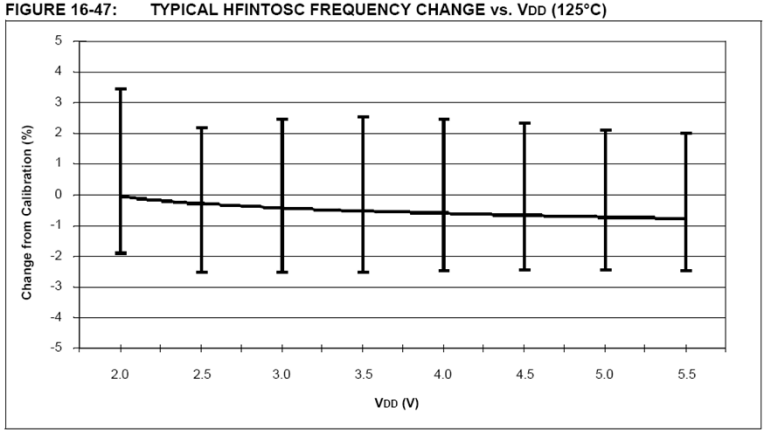
| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain–Source Voltage | $V_{DSS}$ | 60 | Vdc |
| Drain–Gate Voltage ($R_{GS}$ = 1.0 MΩ) | $V_{DGR}$ | 60 | Vdc |

**ELECTRICAL CHARACTERISTICS** ($T_C$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | |
| Drain–Source Breakdown Voltage ($V_{GS}$ = 0, $I_D$ = 100 μAdc) | $V_{(BR)DSS}$ | 60 | – | Vdc |
| Zero Gate Voltage Drain Current ($V_{DS}$ = 48 Vdc, $V_{GS}$ = 0) | $I_{DSS}$ | – | 10 | μAdc |
| ($V_{DS}$ = 48 Vdc, $V_{GS}$ = 0, $T_J$ = 125°C) | | – | 500 | |
| Gate–Body Leakage Current, Forward ($V_{GSF}$ = 30 Vdc, $V_{DS}$ = 0) | $I_{GSSF}$ | – | –100 | nAdc |

# Electrical data

**FIGURE 16-47: TYPICAL HFINTOSC FREQUENCY CHANGE vs. VDD (125°C)**




**TYPICAL PERFORMANCE CHARACTERISTICS**

Output Capacitor = 0 μF unless otherwise noted

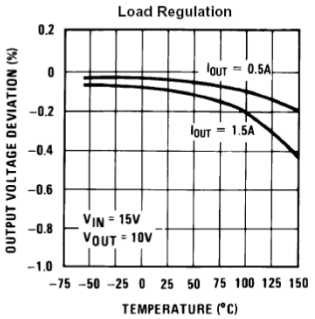



Figure 9.

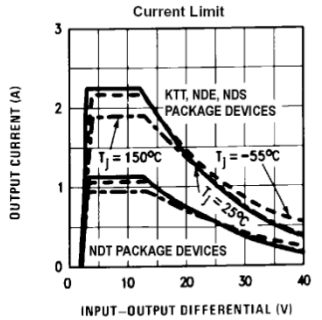



Figure 10.

# Electronics component Datasheets

## Electrical data

- Absolute maximum (minimum) ratings.
- Recommended operating conditions.
- DC specifications (various temperatures, supply voltages, input signals, etc.) NOTE: TEST CONDITIONS!
- AC/timing specifications (various temperatures, supply voltages, frequencies, etc.)
- Input/output wave shape diagram.
- Timing diagram.
- Input/output parameters' graphs.



Adapted from: http://en.wikipedia.org/wiki/Datasheet

# VN2222LGN

**MAXIMUM RATINGS**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain – Source Voltage | $V_{DSS}$ | 60 | Vdc |
| Drain–Gate Voltage ($R_{GS}$ = 1.0 MΩ) | $V_{DGR}$ | 60 | Vdc |
| Gate–Source Voltage<br>– Continuous<br>– Non–repetitive ($t_p \leq 50$ μs) | <br>$V_{GS}$<br>$V_{GSM}$ | <br>±20<br>±40 | <br>Vdc<br>Vpk |
| Drain Current<br>– Continuous<br>– Pulsed (Note: NO timing/duty cycle of the pulse!!!) | <br>$I_D$<br>$I_{DM}$ | <br>150<br>1000 | mAdc |
| Total Power Dissipation @ $T_A$ = 25°C<br>Derate above 25°C | $P_D$ | 400<br>3.2 | mW<br>mW/°C |
| Operating and Storage Temperature Range | $T_J$, $T_{stg}$ | –55 to +150 | °C |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

## ABSOLUTE MAXIMUM RATINGS (1)(2)

| | | |
|---|---|---|
| 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 (3) | | 3 kV |

(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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed.

(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

(3) Human body model, 100 pF discharged through a 1.5 kΩ resistor.

# Absolute maximum (minimum) ratings

**PIC16F610/616/16HV610/616**

## 15.0 ELECTRICAL SPECIFICATIONS

### Absolute Maximum Ratings(†)

Ambient temperature under bias ..... -40° to +125°C

Storage temperature ..... -65°C to +150°C

Voltage on $V_{DD}$ with respect to $V_{SS}$ ..... -0.3V to +6.5V

Voltage on $\overline{MCLR}$ with respect to $V_{SS}$ ..... -0.3V to +13.5V

Voltage on all other pins with respect to $V_{SS}$ ..... -0.3V to ($V_{DD}$ + 0.3V)

Total power dissipation(1) ..... 800 mW

Maximum current out of $V_{SS}$ pin ..... 95 mA

Maximum current into $V_{DD}$ pin ..... 95 mA

Input clamp current, $I_{IK}$ ($V_I$ < 0 or $V_I$ > $V_{DD}$) ..... ± 20 mA

Output clamp current, $I_{OK}$ ($V_O$ < 0 or $V_O$ > $V_{DD}$) ..... ± 20 mA

Maximum output current sunk by any I/O pin ..... 25 mA

Maximum output current sourced by any I/O pin ..... 25 mA

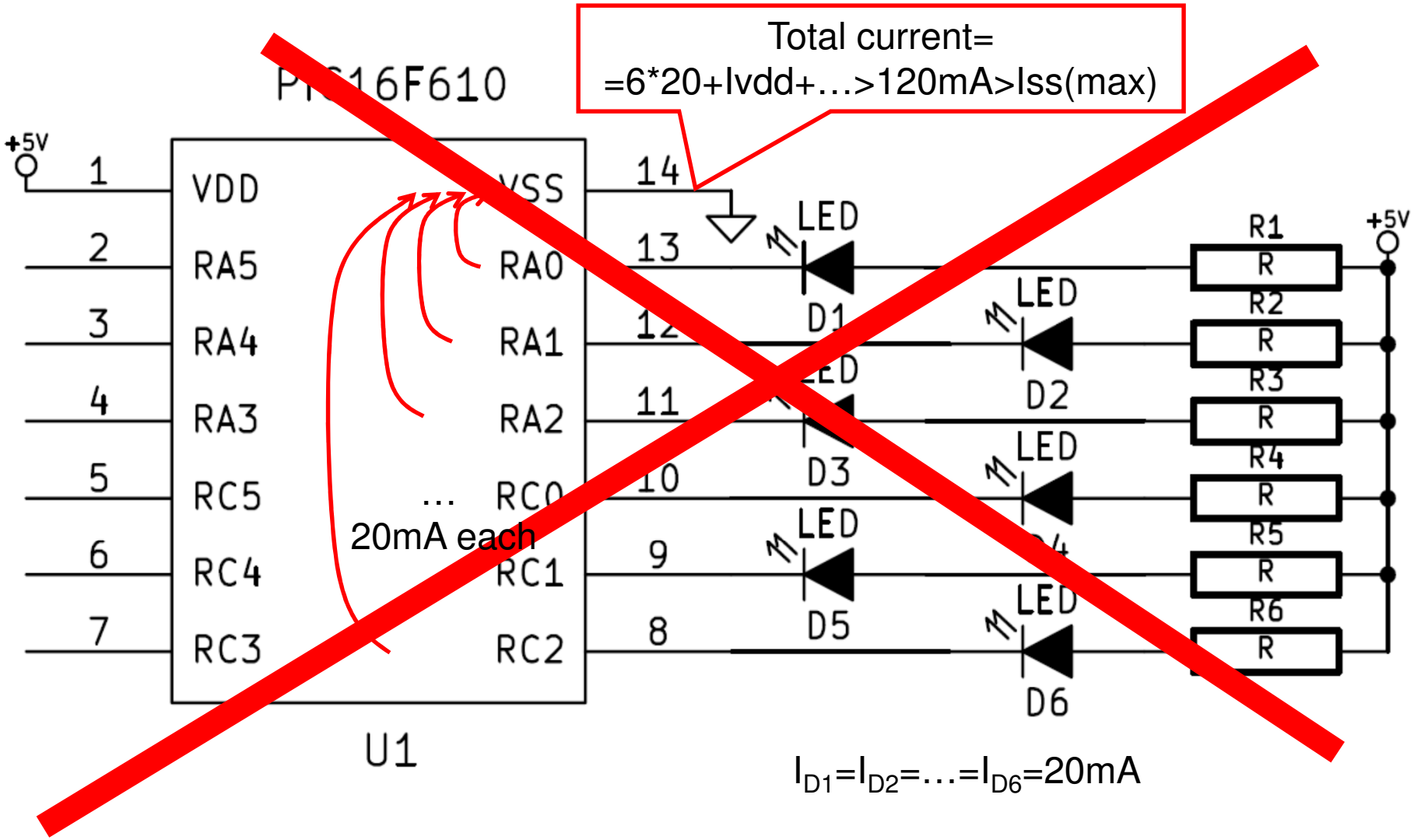
Maximum current sunk by PORTA and PORTC (combined) ..... 90 mA

Maximum current sourced PORTA and PORTC (combined) ..... 90 mA

**Note 1:** Power dissipation is calculated as follows: $P_{DIS} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum(V_{OL} \times I_{OL})$.

† NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure above maximum rating conditions for extended periods may affect device reliability.

# Is this circuit designed properly?



# AC/DC specifications/characteristics

- Symbol.
- Parameter name/description.
- **TEST CONDITION(S)**:
  - Common for all parameters.
  - Parameter-specific.
- Values (min., typ., max).
- Units.

**LM317A and LM317-N ELECTRICAL CHARACTERISTICS**[1]

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-N | | | |
|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | Units |

**Table 29-1.** Common DC characteristics $T_A$ = -40°C to 85°C, $V_{CC}$ = 1.8V to 5.5V (unless otherwise noted)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|

# VN2222LLG

Test condition(s) common for all parameters

**ELECTRICAL CHARACTERISTICS** ($T_C$ = 25°C unless otherwise noted)

TEST CONDITIONS:

| Characteristic | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | |
| Drain–Source Breakdown Voltage ($V_{GS}$ = 0, $I_D$ = 100 μAdc) | $V_{(BR)DSS}$ | 60 | – | Vdc |
| Zero Gate Voltage Drain Current ($V_{DS}$ = 48 Vdc, $V_{GS}$ = 0) | $I_{DSS}$ | – | 10 | μAdc |
| ($V_{DS}$ = 48 Vdc, $V_{GS}$ = 0, $T_J$ = 125°C) | | – | 500 | |
| Gate–Body Leakage Current, Forward ($V_{GSF}$ = 30 Vdc, $V_{DS}$ = 0) | $I_{GSSF}$ | – | –100 | nAdc |
| **ON CHARACTERISTICS** (Note 1) | | | | |
| Gate Threshold Voltage ($V_{DS}$ = $V_{GS}$, $I_D$ = 1.0 mAdc) | $V_{GS(th)}$ | 0.6 | 2.5 | Vdc |
| Static Drain–Source On–Resistance ($V_{GS}$ = 10 Vdc, $I_D$ = 0.5 Adc) | $r_{DS(on)}$ | – | 7.5 | Ω |
| ($V_{GS}$ = 10 Vdc, $I_D$ = 0.5 Vdc, $T_C$ = 125°C) | | – | 13.5 | |
| Drain–Source On–Voltage ($V_{GS}$ = 5.0 Vdc, $I_D$ = 200 mAdc) | $V_{DS(on)}$ | – | 1.5 | Vdc |
| ($V_{GS}$ = 10 Vdc, $I_D$ = 500 mAdc) | | – | 3.75 | |
| On–State Drain Current ($V_{GS}$ = 10 Vdc, $V_{DS} \geq 2.0\ V_{DS(on)}$) | $I_{D(on)}$ | 750 | – | mA |
| Forward Transconductance ($V_{DS}$ = 10 Vdc, $I_D$ = 500 mAdc) | $g_{fs}$ | 100 | – | μmhos |
| **DYNAMIC CHARACTERISTICS** | | | | |
| Input Capacitance ($V_{DS}$ = 25 Vdc, $V_{GS}$ = 0, f = 1.0 MHz) | $C_{iss}$ | – | 60 | pF |
| Output Capacitance | $C_{oss}$ | – | 25 | |
| Reverse Transfer Capacitance | $C_{rss}$ | – | 5.0 | |
| **SWITCHING CHARACTERISTICS** (Note 1) | | | | |
| Turn–On Delay Time ($V_{DD}$ = 15 Vdc, $I_D$ = 600 mA, $R_{gen}$ = 25 Ω, $R_L$ = 23 Ω) | $t_{on}$ | – | 10 | ns |
| Turn–Off Delay Time | $t_{off}$ | – | 10 | |

1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

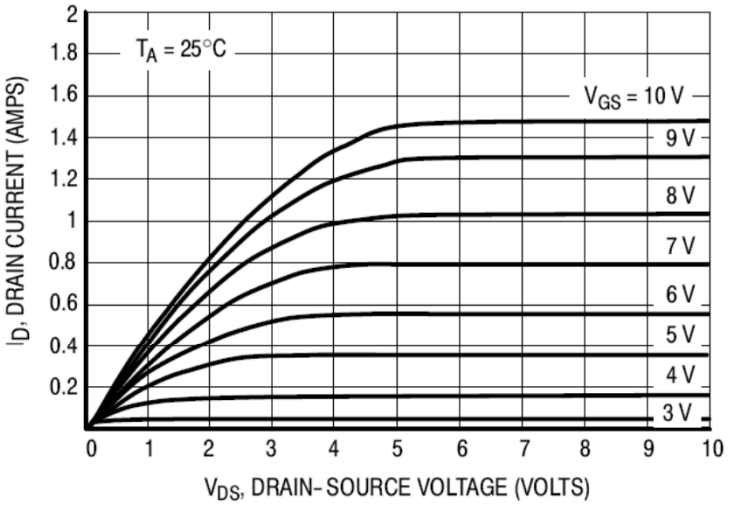



**Figure 1. Ohmic Region**

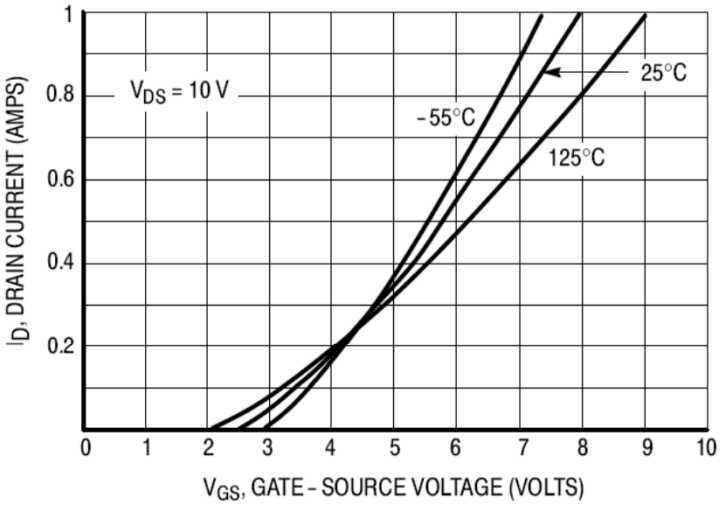



**Figure 2. Transfer Characteristics**

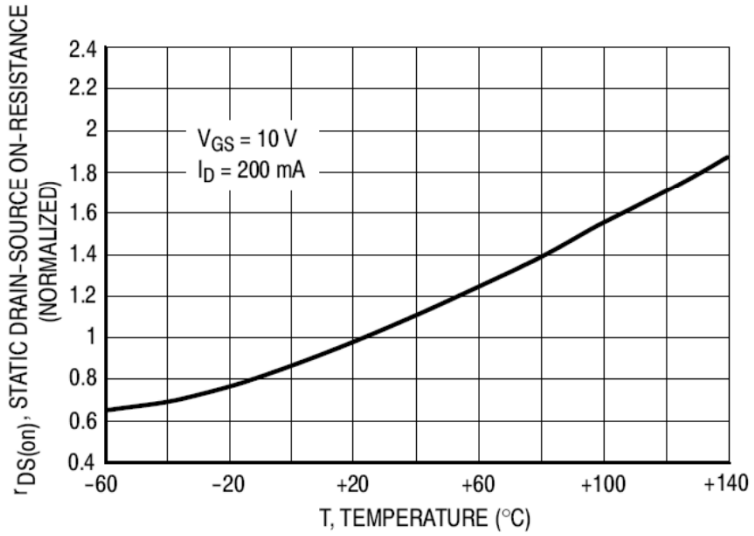



**Figure 3. Temperature versus Static Drain−Source On−Resistance**

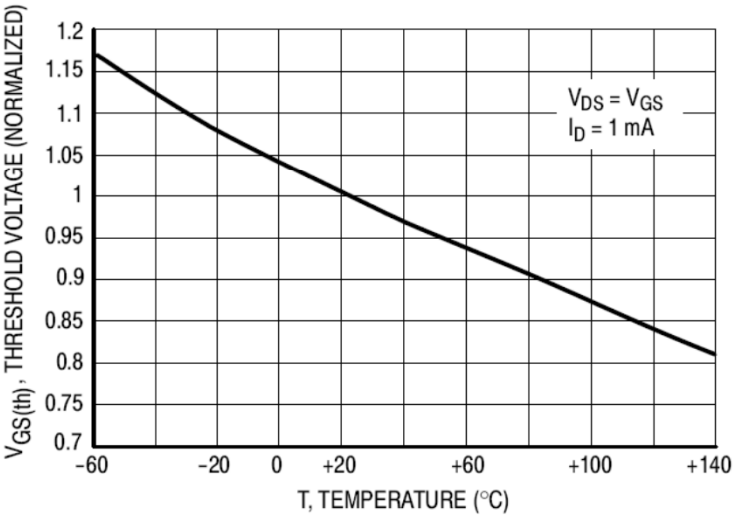



**Figure 4. Temperature versus Gate Threshold Voltage**

Test condition(s) common for all parameters

## LM317A and LM317-N ELECTRICAL CHARACTERISTICS[1]

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-N | | | Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | Min | Typ | Max | |
| Reference Voltage | | | 1.238 | 1.250 | 1.262 | - | 1.25 | - | V |
| | $3V \le (V_{IN} - V_{OUT}) \le 40V$, $10\ mA \le I_{OUT} \le I_{MAX}$ [1] | | **1.225** | **1.250** | **1.270** | **1.20** | **1.25** | **1.30** | V |
| Line Regulation | $3V \le (V_{IN} - V_{OUT}) \le 40V$ [2] | | | 0.005<br>**0.01** | 0.01<br>**0.02** | | 0.01<br>**0.02** | 0.04<br>**0.07** | %/V |
| Load Regulation | $10\ mA \le I_{OUT} \le I_{MAX}$ [1] [2] | | | 0.1<br>**0.3** | 0.5<br>**1** | | 0.1<br>**0.3** | 0.5<br>**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 | $10\ mA \le I_{OUT} \le I_{MAX}$ [1]<br>$3V \le (V_{IN} - V_{OUT}) \le 40V$ | | | **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 | $(V_{IN} - V_{OUT}) \le 15V$ | NDS, KTT Packages | - | - | - | **1.5** | **2.2** | **3.4** | A |
| | | DCY, NDE Packages | **1.5** | **2.2** | **3.4** | **1.5** | **2.2** | **3.4** | |
| | | NDT Package | **0.5** | **0.8** | **1.8** | **0.5** | **0.8** | **1.8** | |
| | $(V_{IN} - V_{OUT}) = 40V$ | NDS, KTT Packages | - | - | | 0.15 | 0.40 | | A |
| | | DCY, NDE Packages | 0.15 | 0.40 | | 0.15 | 0.40 | | |
| | | NDT Package | 0.075 | 0.20 | | 0.075 | 0.20 | | |

## TYPICAL PERFORMANCE CHARACTERISTICS

Output Capacitor = 0 µF unless otherwise noted

Load Regulation

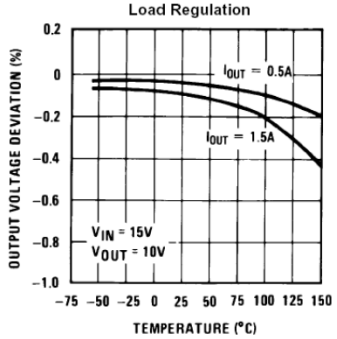



Figure 9.

Current Limit

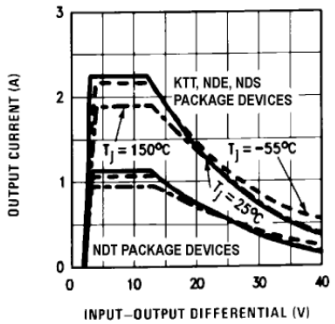



Figure 10.

Adjustment Current

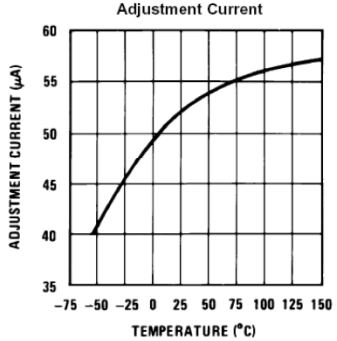



Figure 11.

Dropout Voltage

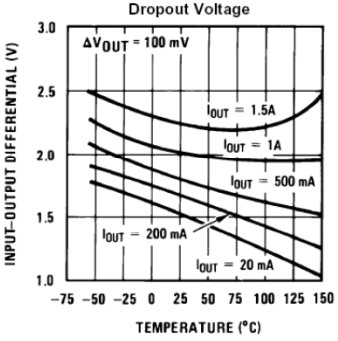



Figure 12.

$V_{OUT}$ vs $V_{IN}$, $V_{OUT}$ = $V_{REF}$

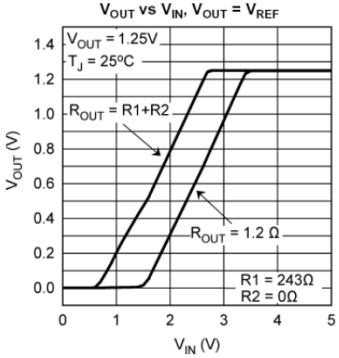



Figure 13.

$V_{OUT}$ vs $V_{IN}$, $V_{OUT}$ = 5V

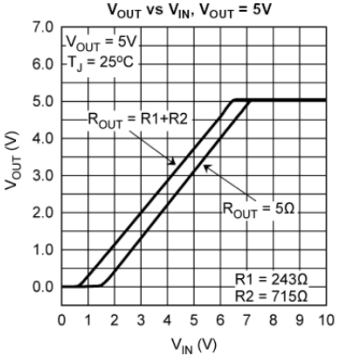



Figure 14.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Output Capacitor = 0 µF unless otherwise noted

Temperature Stability

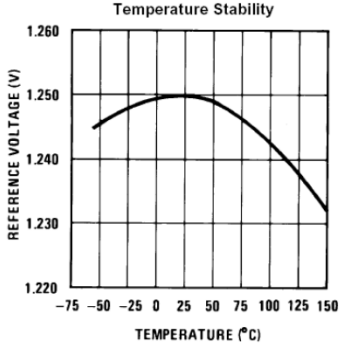



Figure 15.

Minimum Operating Current

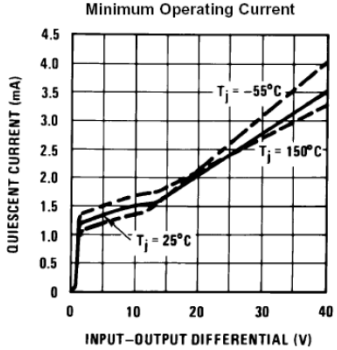



Figure 16.

Ripple Rejection

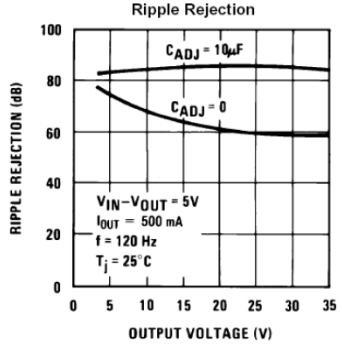



Figure 17.

Ripple Rejection

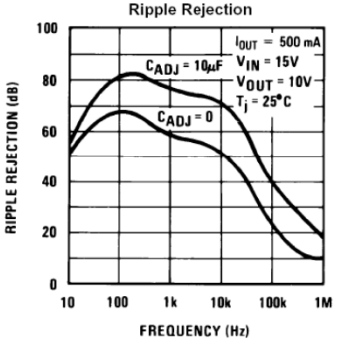



Figure 18.

Ripple Rejection

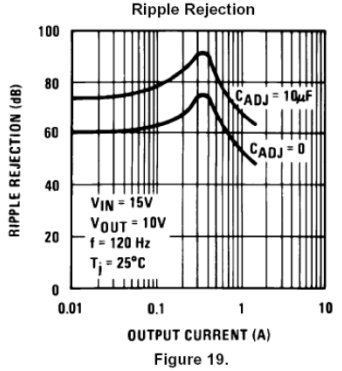



Figure 19.

Output Impedance

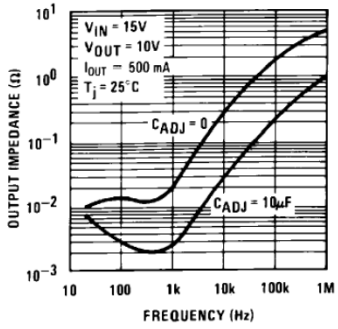



Figure 20.

## 15.8 DC Characteristics: PIC16F610/616/16HV610/616- I (Industrial)
## PIC16F610/616/16HV610/616 - E (Extended)

| DC CHARACTERISTICS | | | Standard Operating Conditions (unless otherwise stated)<br>Operating temperature -40°C ≤ TA ≤ +85°C for industrial<br>-40°C ≤ TA ≤ +125°C for extended | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Sym** | **Characteristic** | **Min** | **Typ†** | **Max** | **Units** | **Conditions** |
| | VIL | **Input Low Voltage** | | | | | |
| | | I/O port: | | | | | |
| D030 | | with TTL buffer | Vss | — | 0.8 | V | 4.5V ≤ VDD ≤ 5.5V |
| D030A | | | Vss | — | 0.15 VDD | V | 2.0V ≤ VDD ≤ 4.5V |
| D031 | | with Schmitt Trigger buffer | Vss | — | 0.2 VDD | V | 2.0V ≤ VDD ≤ 5.5V |
| D032 | | $\overline{MCLR}$, OSC1 (RC mode) | VSS | — | 0.2 VDD | V | |
| D033 | | OSC1 (XT and LP modes) | VSS | — | 0.3 | V | |
| D033A | | OSC1 (HS mode) | VSS | — | 0.3 VDD | V | |
| | VIH | **Input High Voltage** | | | | | |
| | | I/O ports: | | — | | | |
| D040 | | with TTL buffer | 2.0 | — | VDD | V | 4.5V ≤ VDD ≤ 5.5V |
| D040A | | | 0.25 VDD + 0.8 | — | VDD | V | 2.0V ≤ VDD ≤ 4.5V |
| D041 | | with Schmitt Trigger buffer | 0.8 VDD | — | VDD | V | 2.0V ≤ VDD ≤ 5.5V |
| D042 | | $\overline{MCLR}$ | 0.8 VDD | — | VDD | V | |
| D043 | | OSC1 (XT and LP modes) | 1.6 | — | VDD | V | |
| D043A | | OSC1 (HS mode) | 0.7 VDD | — | VDD | V | |
| D043B | | OSC1 (RC mode) | 0.9 VDD | — | VDD | V | **(Note 1)** |

# Table 15.8 DC Characteristics (cont-d)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | VOL | **Output Low Voltage** | — | — | 0.6 | V | IOL = 7.0 mA, VDD = 4.5V, -40°C to +125°C |
| D080 | | I/O ports | — | — | 0.6 | V | IOL = 8.5 mA, VDD = 4.5V, -40°C to +85°C |
| | VOH | **Output High Voltage** | VDD – 0.7 | — | — | V | IOH = -2.5 mA, VDD = 4.5V, -40°C to +125°C |
| D090 | | I/O ports(2) | VDD – 0.7 | — | — | V | IOH = -3.0 mA, VDD = 4.5V, -40°C to +85°C |

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

**Note 1:** In RC oscillator configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended to use an external clock in RC mode.

**2:** Negative current is defined as current sourced by the pin.

**3:** The leakage current on the $\overline{\text{MCLR}}$ pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

**4:** This specification applies to RA3/$\overline{\text{MCLR}}$ configured as RA3 input with internal pull-up disabled.

**5:** This specification applies to all weak pull-up pins, including the weak pull-up on RA3/$\overline{\text{MCLR}}$. When RA3/$\overline{\text{MCLR}}$ is configured as $\overline{\text{MCLR}}$ reset pin, the weak pull-up is always enabled.

**FIGURE 16-36: VOL vs. IOL OVER TEMPERATURE (VDD = 3.0V)**

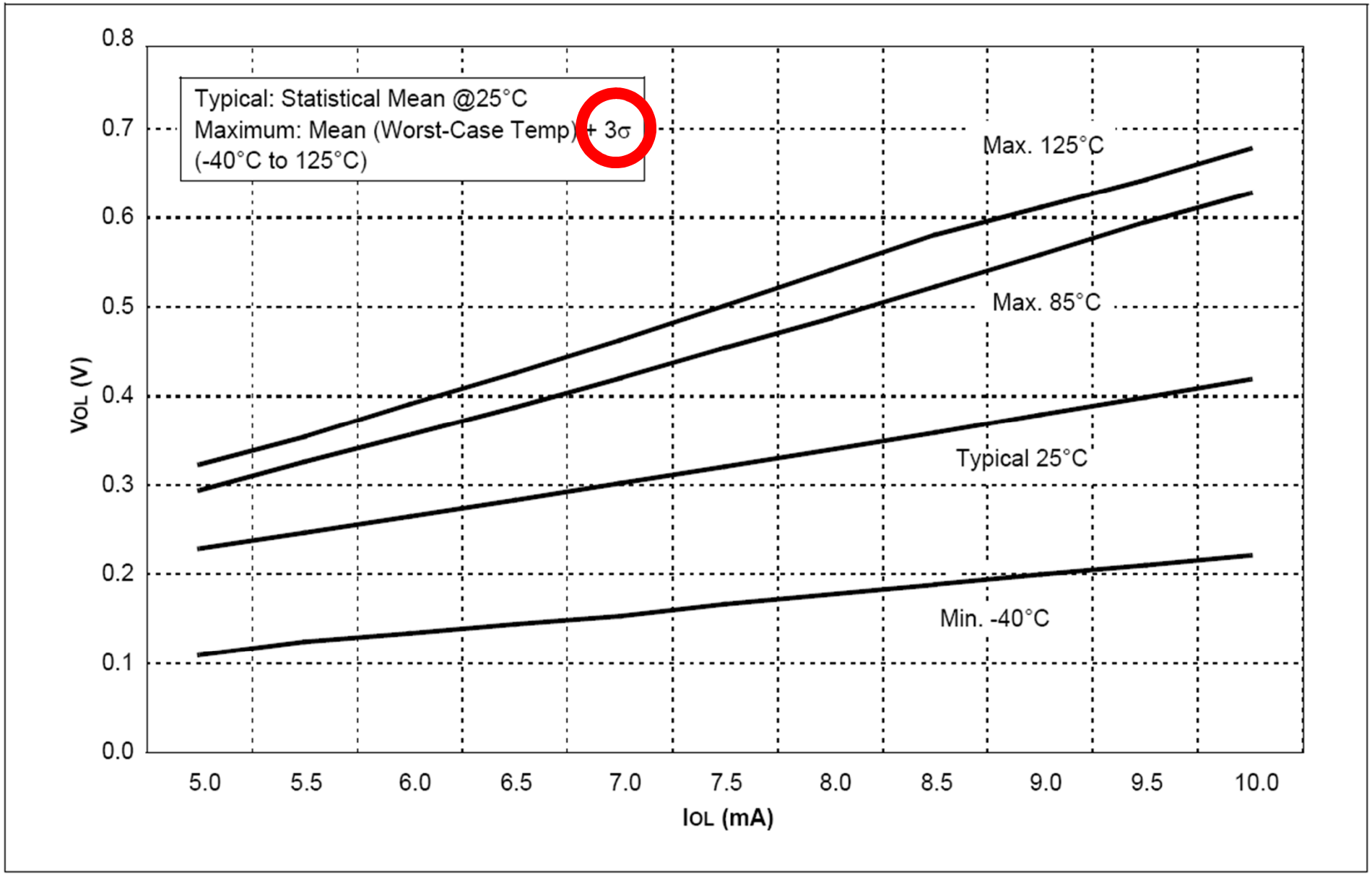


**FIGURE 15-7: CLKOUT AND I/O TIMING**

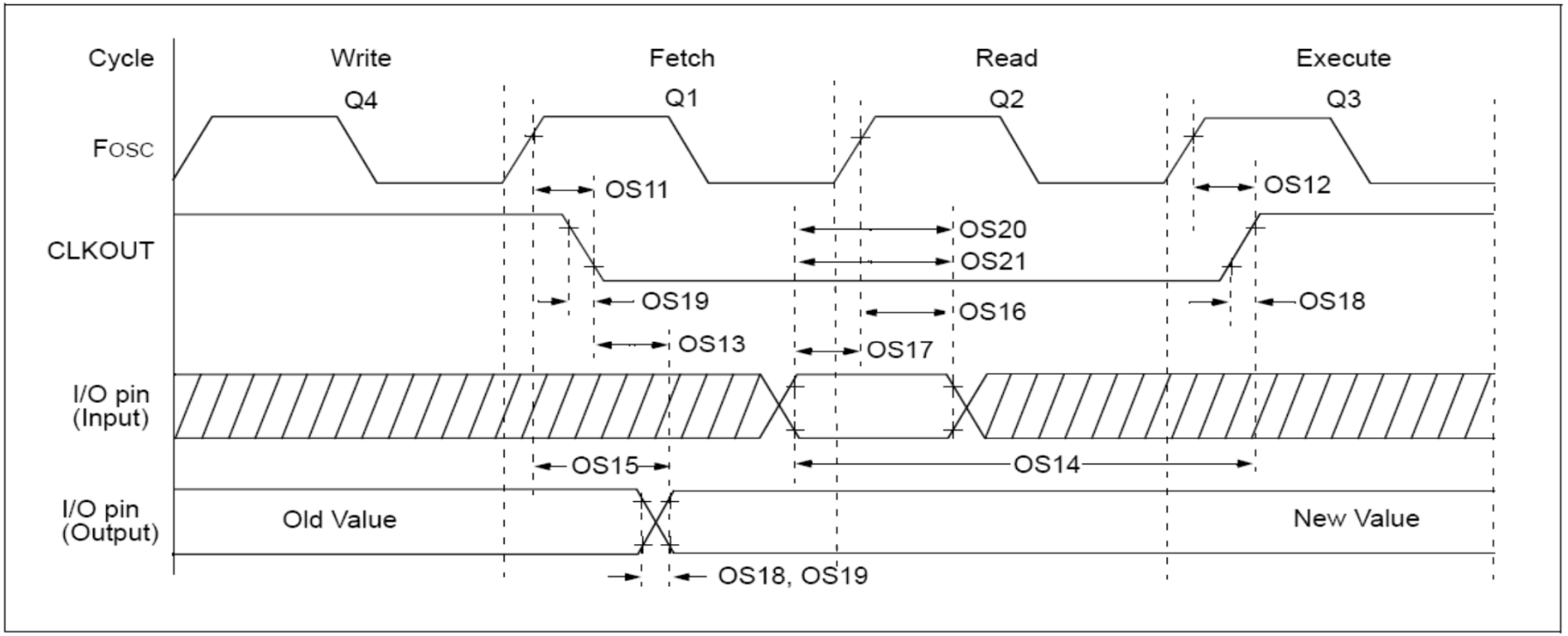
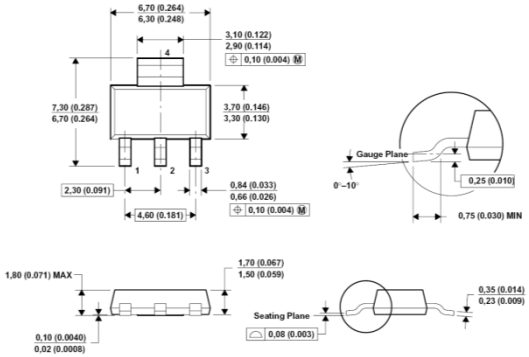



**TABLE 15-3: CLKOUT AND I/O TIMING PARAMETERS**

| **Standard Operating Conditions (unless otherwise stated)**<br>Operating Temperature -40°C ≤ TA ≤ +125°C | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Sym** | **Characteristic** | **Min** | **Typ†** | **Max** | **Units** | **Conditions** |
| OS11 | TosH2ckL | Fosc↑ to CLKOUT↓ (1) | — | — | 70 | ns | VDD = 5.0V |
| OS12 | TosH2ckH | Fosc↑ to CLKOUT↑ (1) | — | — | 72 | ns | VDD = 5.0V |
| OS13 | TckL2ioV | CLKOUT↓ to Port out valid(1) | — | — | 20 | ns | |
| OS14 | TioV2ckH | Port input valid before CLKOUT↑(1) | Tosc + 200 ns | — | — | ns | |

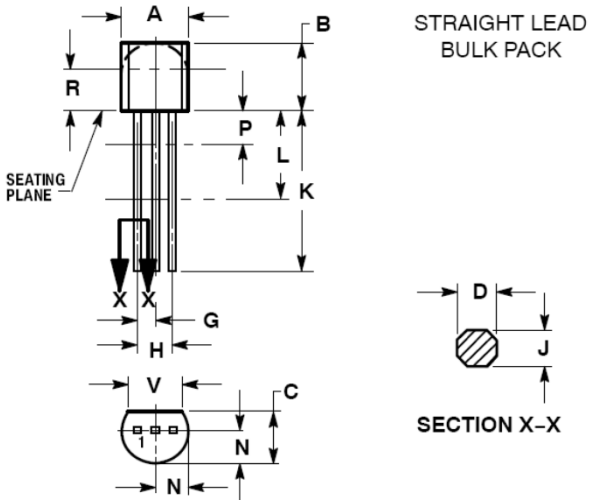



**ORDERING INFORMATION**

| Device | Package | Shipping† |
|---|---|---|
| VN2222LLG | TO–92<br>(Pb–Free) | 1000 Unit / Box |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# Application, dimensions and ordering



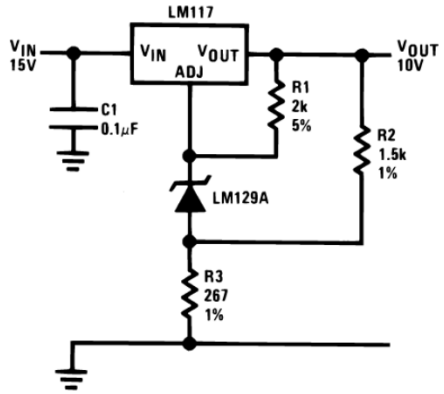
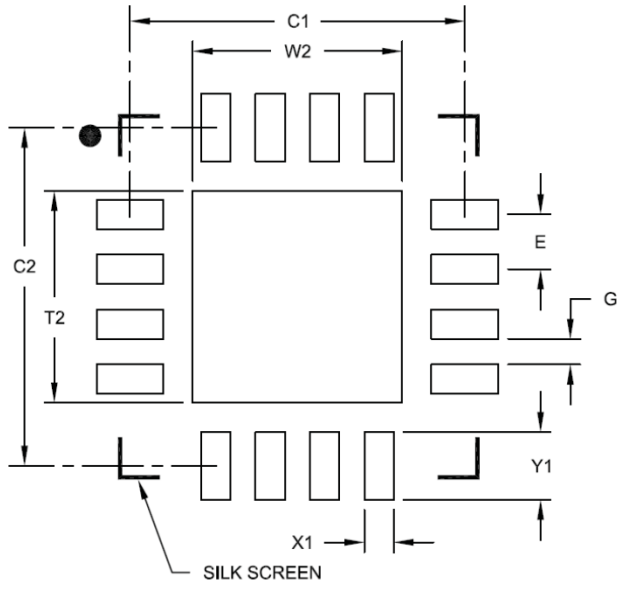




Figure 38. High Stability 10V Regulator




RECOMMENDED LAND PATTERN

# Electronics component Datasheets

## Application, dimensions and ordering

- Test circuit.
- Application notes and examples (including formulas for calculating external components).
- Physical details showing minimum/typical/maximum dimensions, contact locations and sizes.
- Printed circuit board layout recommendations.
- Ordering codes for differing packages and performance criteria.
- Liability disclaimer regarding device use in certain environments such as nuclear power plants and life support systems.
- Errata: NOT a part of datasheet! It is published by the manufacturer.

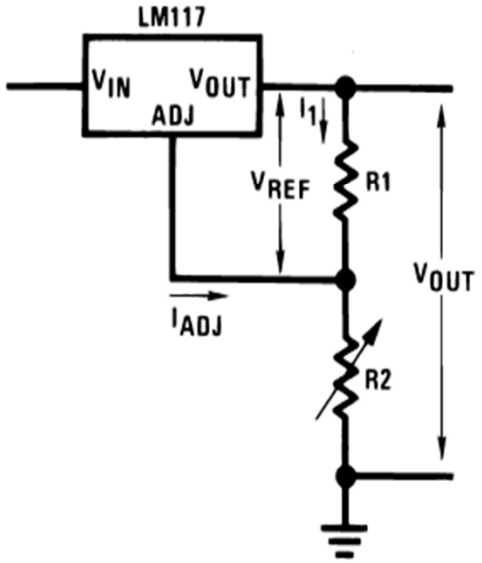


Adapted from: http://en.wikipedia.org/wiki/Datasheet

## 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

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



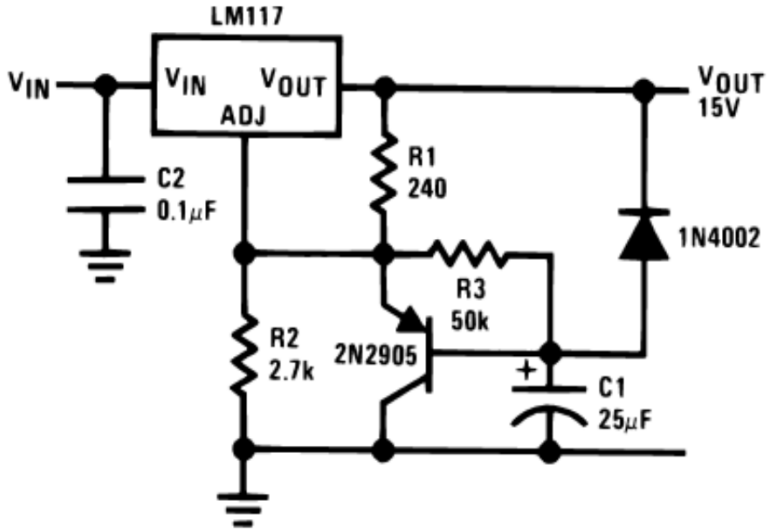
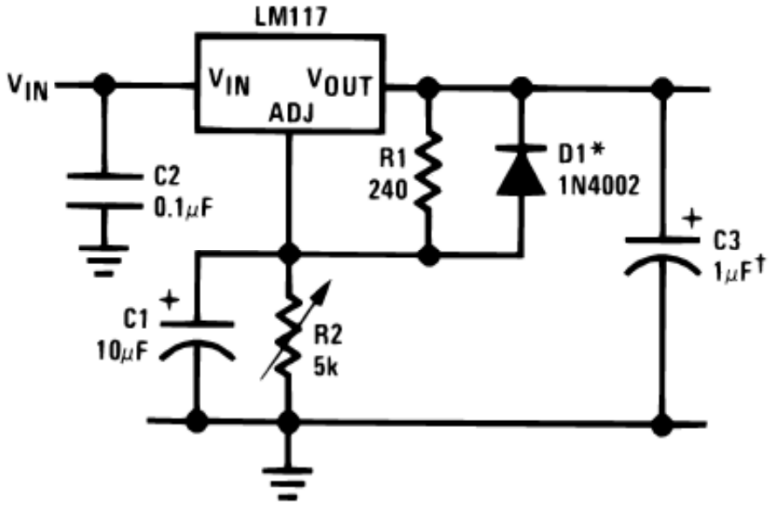



Figure 36. Slow Turn-On 15V Regulator




†Solid tantalum

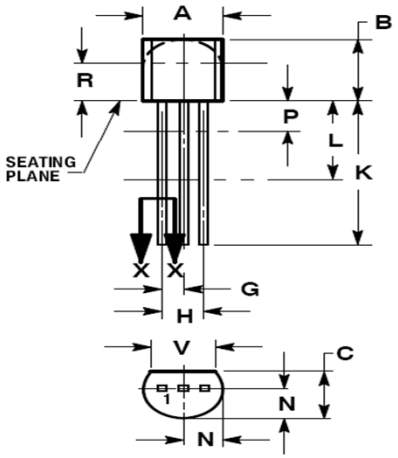
*Discharges C1 if output is shorted to ground

Figure 37. Adjustable Regulator with Improved Ripple Rejection

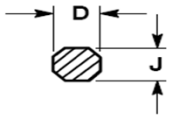
# VN2222LLG

## PACKAGE DIMENSIONS

**TO−92**
CASE 29−11
ISSUE AM



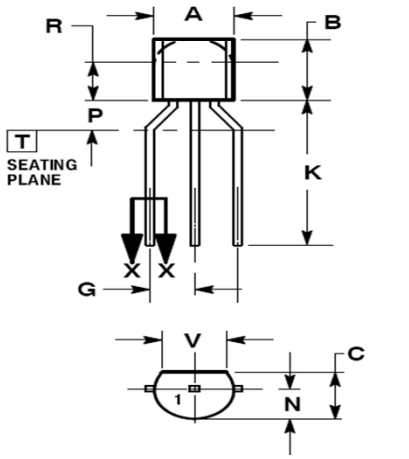

STRAIGHT LEAD
BULK PACK



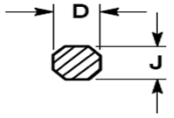

SECTION X−X

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.175 | 0.205 | 4.45 | 5.20 |
| B | 0.170 | 0.210 | 4.32 | 5.33 |
| C | 0.125 | 0.165 | 3.18 | 4.19 |
| D | 0.016 | 0.021 | 0.407 | 0.533 |
| G | 0.045 | 0.055 | 1.15 | 1.39 |
| H | 0.095 | 0.105 | 2.42 | 2.66 |
| J | 0.015 | 0.020 | 0.39 | 0.50 |
| K | 0.500 | --- | 12.70 | --- |
| L | 0.250 | --- | 6.35 | --- |
| N | 0.080 | 0.105 | 2.04 | 2.66 |
| P | --- | 0.100 | --- | 2.54 |
| R | 0.115 | --- | 2.93 | --- |
| V | 0.135 | --- | 3.43 | --- |




BENT LEAD
TAPE & REEL
AMMO PACK



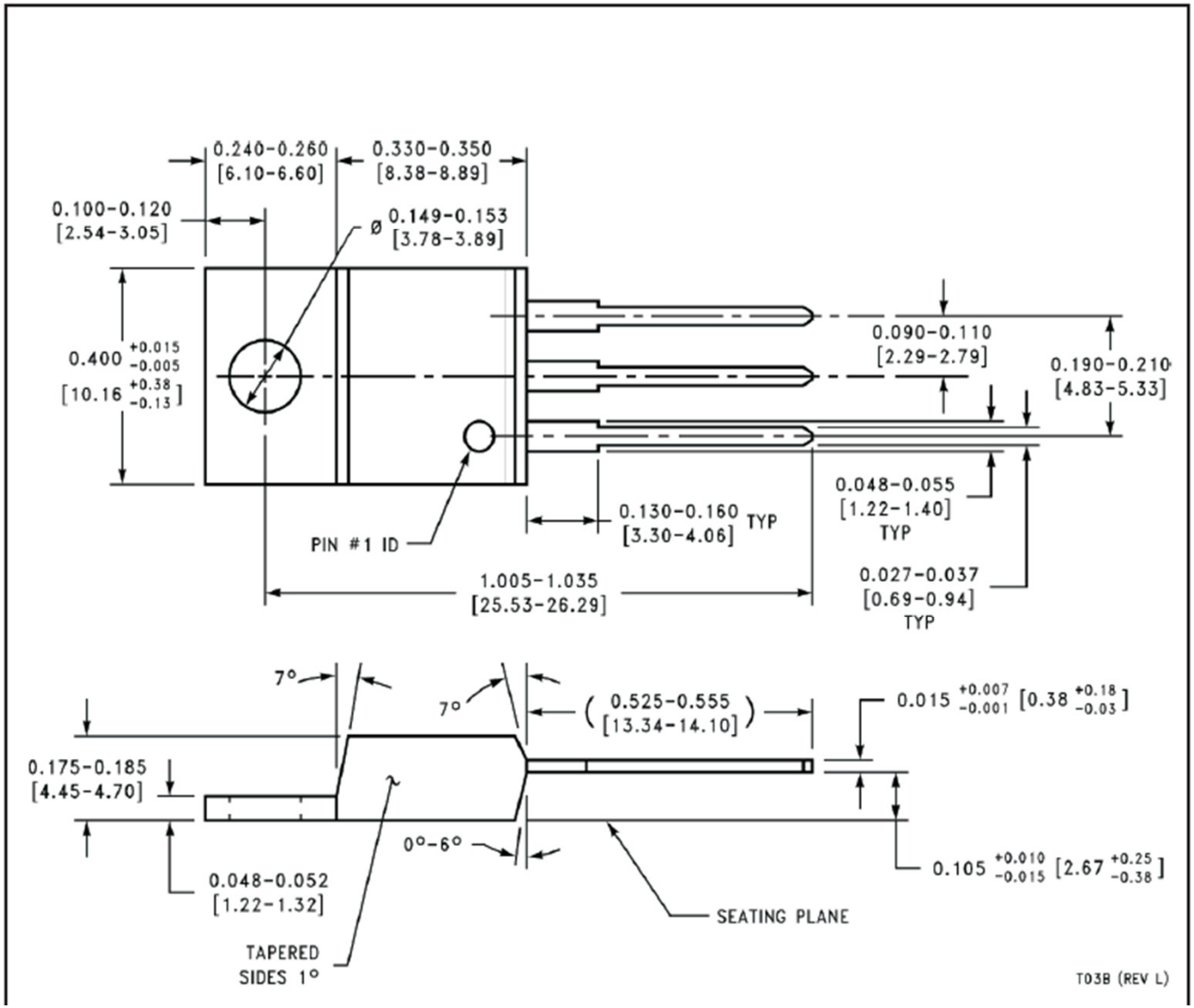

SECTION X−X

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| | MILLIMETERS | |
|---|---|---|
| DIM | MIN | MAX |
| A | 4.45 | 5.20 |
| B | 4.32 | 5.33 |
| C | 3.18 | 4.19 |
| D | 0.40 | 0.54 |
| G | 2.40 | 2.80 |
| J | 0.39 | 0.50 |
| K | 12.70 | --- |
| N | 2.04 | 2.66 |
| P | 1.50 | 4.00 |
| R | 2.93 | --- |
| V | 3.43 | --- |

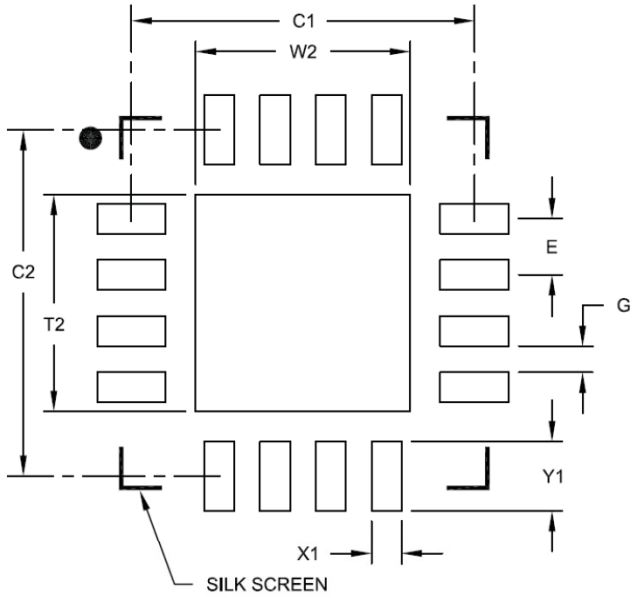
STYLE 22:
PIN 1. SOURCE
2. GATE
3. DRAIN

NDE0003B


0.240-0.260
[6.10-6.60]
0.330-0.350
[8.38-8.89]
0.100-0.120
[2.54-3.05]
Ø 0.149-0.153
[3.78-3.89]
0.400 +0.015 -0.005
[10.16 +0.38 -0.13]
0.090-0.110
[2.29-2.79]
0.190-0.210
[4.83-5.33]
0.048-0.055
[1.22-1.40]
TYP
0.130-0.160 TYP
[3.30-4.06]
PIN #1 ID
1.005-1.035
[25.53-26.29]
0.027-0.037
[0.69-0.94]
TYP
7°
7°
( 0.525-0.555
[13.34-14.10] )
0.015 +0.007 -0.001 [0.38 +0.18 -0.03]
0.175-0.185
[4.45-4.70]
0°-6°
0.105 +0.010 -0.015 [2.67 +0.25 -0.38]
0.048-0.052
[1.22-1.32]
SEATING PLANE
TAPERED
SIDES 1°
T03B (REV L)

16-Lead Plastic Quad Flat, No Lead Package (ML) - 4x4x0.9mm Body [QFN]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




RECOMMENDED LAND PATTERN

| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Contact Pitch | E | | 0.65 BSC | |
| Optional Center Pad Width | W2 | | | 2.50 |
| Optional Center Pad Length | T2 | | | 2.50 |
| Contact Pad Spacing | C1 | | 4.00 | |
| Contact Pad Spacing | C2 | | 4.00 | |
| Contact Pad Width (X28) | X1 | | | 0.35 |
| Contact Pad Length (X28) | Y1 | | | 0.80 |
| Distance Between Pads | G | 0.30 | | |

Notes:

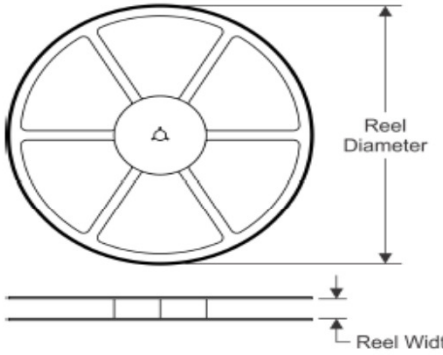
1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

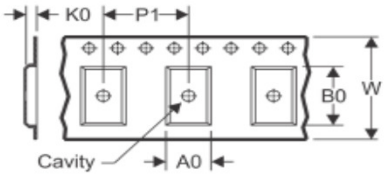
Microchip Technology Drawing No. C04-2127A

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

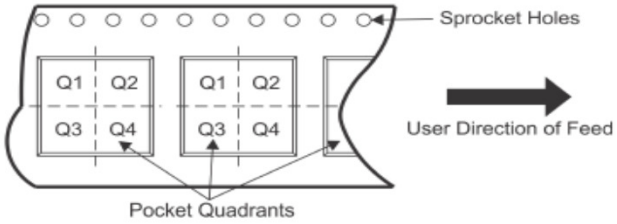



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM317AEMP | SOT-223 | DCY | 4 | 1000 | 330.0 | 16.4 | 7.0 | 7.5 | 2.2 | 12.0 | 16.0 | Q3 |
| LM317AEMP/NOPB | SOT-223 | DCY | 4 | 1000 | 330.0 | 16.4 | 7.0 | 7.5 | 2.2 | 12.0 | 16.0 | Q3 |
| LM317AEMPX | SOT-223 | DCY | 4 | 2000 | 330.0 | 16.4 | 7.0 | 7.5 | 2.2 | 12.0 | 16.0 | Q3 |
| LM317AEMPX/NOPB | SOT-223 | DCY | 4 | 2000 | 330.0 | 16.4 | 7.0 | 7.5 | 2.2 | 12.0 | 16.0 | Q3 |
| LM317AMDTX | TO-252 | NDP | 3 | 2500 | 330.0 | 16.4 | 6.9 | 10.5 | 2.7 | 8.0 | 16.0 | Q2 |
| LM317AMDTX/NOPB | TO-252 | NDP | 3 | 2500 | 330.0 | 16.4 | 6.9 | 10.5 | 2.7 | 8.0 | 16.0 | Q2 |
| LM317EMP | SOT-223 | DCY | 4 | 1000 | 330.0 | 16.4 | 7.0 | 7.5 | 2.2 | 12.0 | 16.0 | Q3 |
| LM317EMP/NOPB | SOT-223 | DCY | 4 | 1000 | 330.0 | 16.4 | 7.0 | 7.5 | 2.2 | 12.0 | 16.0 | Q3 |
| LM317EMPX/NOPB | SOT-223 | DCY | 4 | 2000 | 330.0 | 16.4 | 7.0 | 7.5 | 2.2 | 12.0 | 16.0 | Q3 |
| LM317MDTX/NOPB | TO-252 | NDP | 3 | 2500 | 330.0 | 16.4 | 6.9 | 10.5 | 2.7 | 8.0 | 16.0 | Q2 |
| LM317SX/NOPB | DDPAK/ TO-263 | KTT | 3 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |

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2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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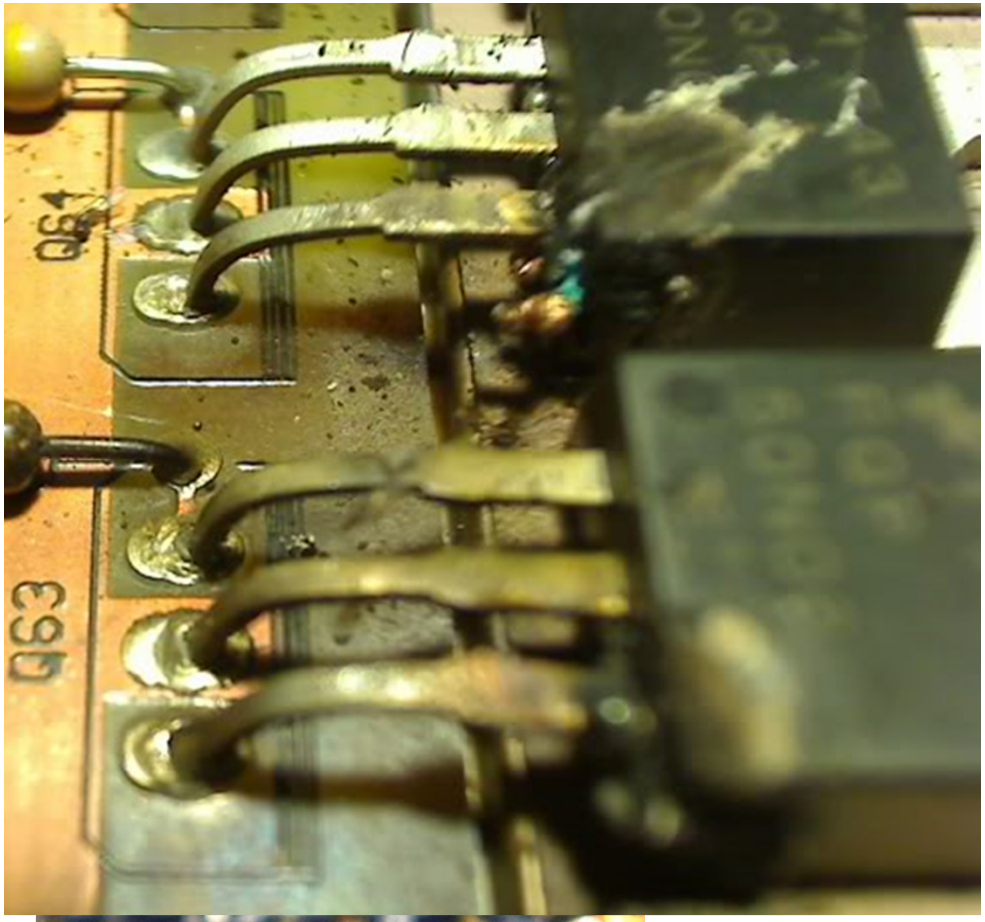
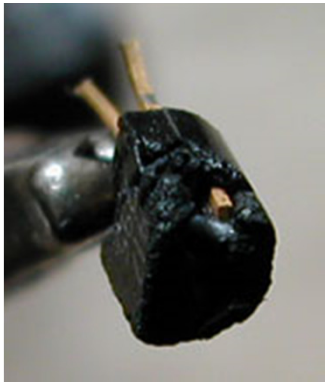
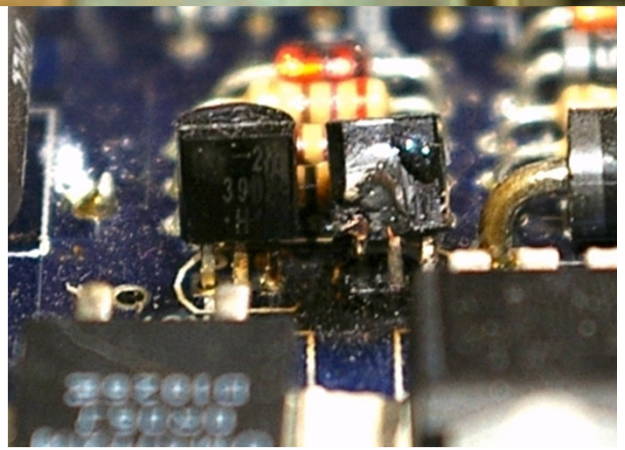


# Thermal considerations




http://i20.photobucket.com/albums/b250/newtoCA/FriedTransistor.jpg
http://www.vitriol.com/images/tech/burnt-transistor.jpeg
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# Thermal considerations

- **Question:** Will the component operate properly in the operating ambient temperature range?
- **Answer:** It depends on:
  - Operating temperature range for the component.
  - Power dissipation on the component (component heat up).
  - Heat dissipation measures.

# Design example (1/2): Requirements and data

The data required to make a decision:

- LM317A operating at (circuit requirements):
  - $V_{in}$=7.4V
  - $V_{out}$=3.4V
  - $I_{out}$=1A
  - Operating temperature range: -30…+50 $^{o}$C
- From the datasheet (see the next slide):
  - Operating temperature range:
    - » -40…+125 $^{o}$C
  - Thermal resistance junction-to-ambient (TO-220):
    - » $\Theta_{JA}$=50 $^{o}$C/W
  - Thermal resistance junction-to-case:
    - » $\Theta_{JC}$=4 $^{o}$C/W
- Temperature restriction by design (optional)



http://media.digikey.com/Photos/Assmann%20Photos/V5583C.JPG

# Datasheet excerpts

**OPERATING TEMPERATURE RANGE**

| | |
|---|---|
| LM117 | $-55°C \le T_J \le +150°C$ |
| LM317A | $-40°C \le T_J \le +125°C$ |
| LM317-N | $0°C \le T_J \le +125°C$ |
| **Preconditioning** | |
| Thermal Limit Burn-In | All Devices 100% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Thermal Resistance, $\theta_{JA}$ Junction-to-Ambient (No Heat Sink) | NDS (TO-3) Package | | | | | 39 | | °C/W |
| | NDE (TO-220) Package | | 50 | | | 50 | | |
| | KTT (TO-263) Package (3) | | - | | | 50 | | |
| | DCY (SOT-223) Package (3) | | 140 | | | 140 | | |
| | NDT (TO) Package | | 186 | | | 186 | | |
| | NDP (TO-252) Package (3) | | 103 | | | 103 | | |

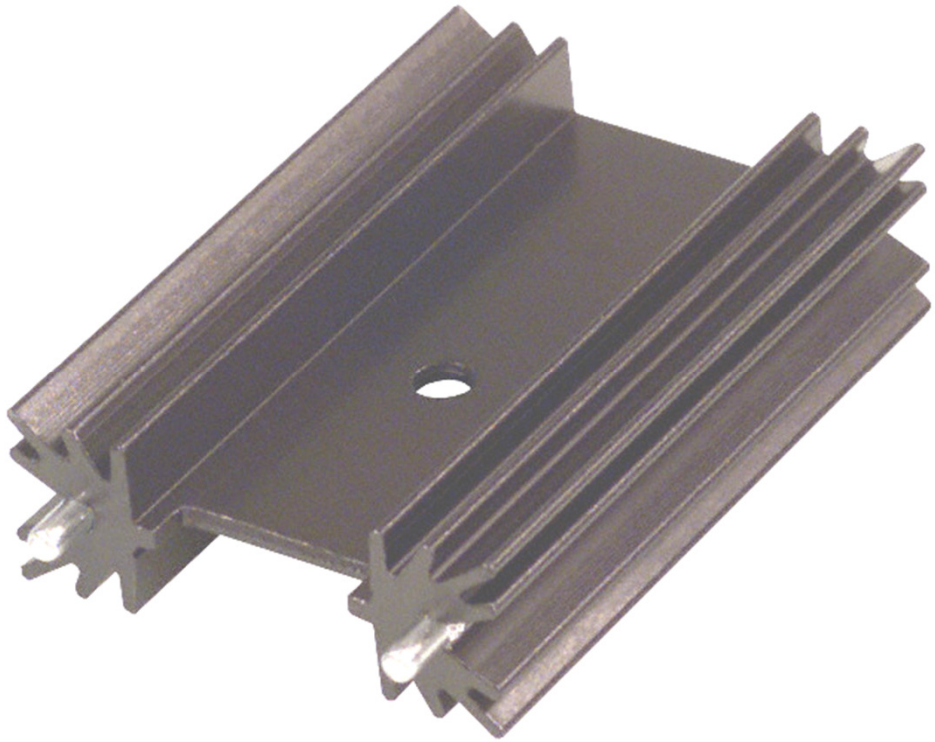
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Thermal Resistance, $\theta_{JC}$ Junction-to-Case | NDS (TO-3) Package | | | | | 2 | | °C/W |
| | NDE (TO-220) Package | | 4 | | | 4 | | |
| | KTT (TO-263) Package | | | | | 4 | | |
| | DCY (SOT-223) Package | | 23.5 | | | 23.5 | | |
| | NDT (TO) Package | | 21 | | | 21 | | |
| | NDP (TO-252) Package | | 12 | | | 12 | | |

i.e. thermal resistance from the junction to the heatsink (add ~0.3-4 C/W for the gap and insulator, depending on the type of insulator. That is called “case-to-sink” thermal resistance).

# Design example (2/2): Calculations and choice

- Power dissipated on the chip:
  - P=IV=1A*(7.4V-3.4V)=4W
- No heatsink mode:
  - $t^o=\Theta_{JA}*P=50\ ^oC/W\ *4W=200^oC > t^o_{max}$
- Heatsink sizing:
  - $(\Theta_{JC}+\Theta_{HS})*P + t^o_{amb\ max} < t^o_{oper\ max}$ (or $t^o_{restr\ max}$)
  - $\Theta_{HS}<(100^oC-50^oC)/4W-4=8.5\ ^oC/W$
  - Note that the formula does not account for “case-to-heatsink” thermal resistance for sake of simplicity.

# The chosen heatsink



http://www.digikey.ca/product-detail/en/513201B02500G/HS347-ND/1216354

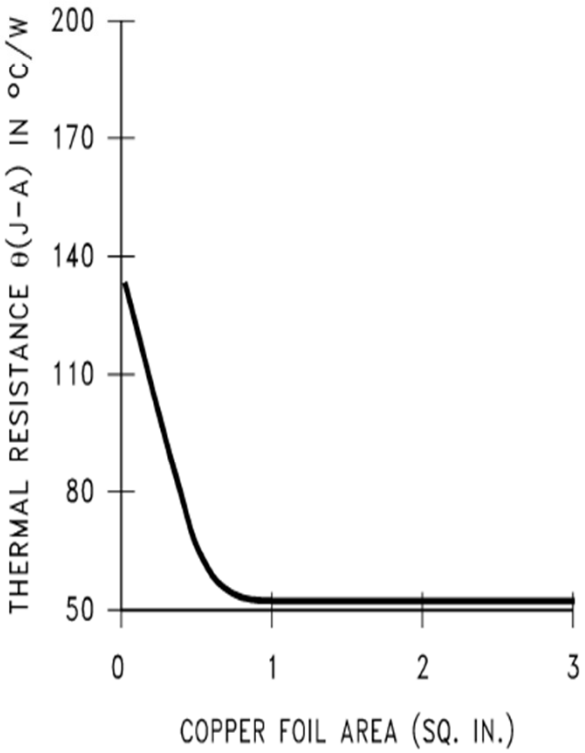



**Figure 26. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package**

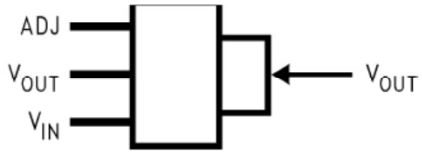



**Figure 7. 4-Lead SOT-223 (DCY)**
**Top View Surface-Mount Package**
**Package Number DCY**

Questions?