National Semiconductor Corporation

# LM105/LM205/LM305/LM305A, LM376 Voltage Regulators

## General Description

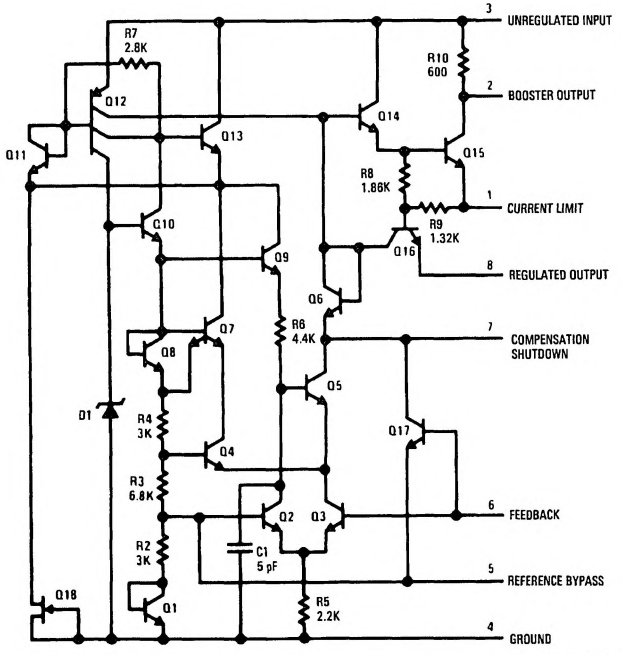
The LM105 series are positive voltage regulators similar to the LM100, except that an extra gain stage has been added for improved regulation. A redesign of the biasing circuitry removes any minimum load current requirement and at the same time reduces standby current drain, permitting higher voltage operation. They are direct, plug-in replacements for the LM100 in both linear and switching regulator circuits with output voltages greater than 4.5V. Important characteristics of the circuits are:

- Output voltage adjustable from 4.5V to 40V
- Output currents in excess of 10A possible by adding external transistors
- Load regulation better than 0.1%, full load with current limiting
- DC line regulation guaranteed at 0.03%/V
- Ripple rejection on 0.01%V
- 45 mA output current without external pass transistor (LM305A)

Like the LM100, they also feature fast response to both load and line transients, freedom from oscillations with varying resistive and reactive loads and the ability to start reliably on any load within rating. The circuits are built on a single silicon chip and are supplied in either an 8-lead, TO-5 header or a 1/4" x 1/4" metal flat package.

The LM105 is specified for operation for $-55°C \leq T_A \leq +125°C$, the LM205 is specified for $-25°C \leq T_A \leq +85°C$, and the LM305/LM305A, LM376 is specified for $0°C \leq T_A \leq +70°C$.

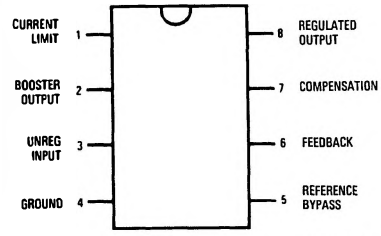
## Schematic and Connection Diagrams




TL/H/7755–1

Pin connections shown are for metal can.

**Dual-In-Line Package**

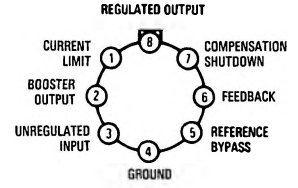



TL/H/7755–2

**Top View**

**Order Number LM376N**
**See NS Package Number N08E**

**Metal Can Package**




TL/H/7755–3

**Top View**

**Order Number LM105H, LM205H, LM305H or LM305AH**
**See NS Package Number H08C**

## Absolute Maximum Ratings

**If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/Distributors for availability and specifications.**
**(Note 5)**

| | LM105 | LM205 | LM305 | LM305A | LM376 |
|---|---|---|---|---|---|
| Input Voltage | 50V | 50V | 40V | 50V | 40V |
| Input-Output Differential | 40V | 40V | 40V | 40V | 40V |
| Power Dissipation (Note 1) | 800 mW | 800 mW | 800 mW | 800 mW | 400 mW |
| Operating Temperature Range | −55°C to +125°C | −25°C to +85°C | −0°C to +70°C | 0°C to +70°C | 0°C to +70°C |
| Storage Temperature Range | −65°C to +150°C | −65°C to +150°C | −65°C to +150°C | −65°C to +150°C | −65°C to +150°C |
| Lead Temperature (Soldering, 10 seconds) | 300°C | 300°C | 300°C | 300°C | 260°C |

## Electrical Characteristics (Note 2)

| Parameter | Conditions | LM105 | | | LM205 | | | LM305 | | | LM305A | | | LM376 | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| Input Voltage Range | | 8.5 | | 50 | 8.5 | | 50 | 8.5 | | 40 | 8.5 | | 50 | 9.0 | | 40 | V |
| Output Voltage Range | | 4.5 | | 40 | 4.5 | | 40 | 4.5 | | 30 | 4.5 | | 40 | 5.0 | | 37 | V |
| Input-Output Voltage Differential | | 3.0 | | 30 | 3.0 | | 30 | 3.0 | | 30 | 3.0 | | 30 | 3.0 | | 30 | V |
| Load Regulation (Note 3) | $R_{SC} = 10\Omega$, $T_A = 25°C$ | | 0.02 | 0.05 | | 0.02 | 0.05 | | 0.02 | 0.05 | | | | | | | % |
| | $R_{SC} = 10\Omega$, $T_A = T_{A(MAX)}$ | | 0.03 | 0.1 | | 0.03 | 0.1 | | 0.03 | 0.1 | | | | | | | % |
| | $R_{SC} = 10\Omega$, $T_A = T_{A(MIN)}$ | | 0.03 | 0.1 | | 0.03 | 0.1 | | 0.03 | 0.1 | | | | | | | % |
| | | $0 \le I_O \le 12$ mA | | | $0 \le I_O \le 12$ mA | | | $0 \le I_O \le 12$ mA | | | | | | | | | |
| | $R_{SC} = 0\Omega$, $T_A = 25°C$ | | | | | | | | | | | 0.02 | 0.2 | | | 0.2 | % |
| | $R_{SC} = 0\Omega$, $T_A = 70°C$ | | | | | | | | | | | 0.03 | 0.4 | | | 0.5 | % |
| | $R_{SC} = 0\Omega$, $T_A = 0°C$ | | | | | | | | | | | 0.03 | 0.4 | | | 0.5 | % |
| | | | | | | | | | | | $0 \le I_O \le 45$ mA | | | $0 \le I_O \le 25$ mA | | | |
| Line Regulation | $T_A = 25°C$ | | | | | | | | | | | | | | | 0.03 | %/V |
| | $0°C \le T_A \le +70°C$ | | | | | | | | | | | | | | | 0.1 | %/V |
| | $V_{IN} - V_{OUT} \le 5V$, $T_A = 25°C$ | | 0.025 | 0.06 | | 0.025 | 0.06 | | 0.025 | 0.06 | | 0.025 | 0.06 | | | | %/V |
| | $V_{IN} - V_{OUT} \ge 5V$, $T_A = 25°C$ | | 0.015 | 0.03 | | 0.015 | 0.03 | | 0.015 | 0.03 | | 0.015 | 0.03 | | | | %/V |
| Temperature Stability | $T_{A(MIN)} \le T_A \le T_{A(MAX)}$ | | 0.3 | 1.0 | | 0.3 | 1.0 | | 0.3 | 1.0 | | 0.3 | 1.0 | | | | % |

## Electrical Characteristics (Note 2) (Continued)

| Parameter | Conditions | LM105 | | | LM205 | | | LM305 | | | LM305A | | | LM376 | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| Feedback Sense Voltage | | 1.63 | 1.7 | 1.81 | 1.63 | 1.7 | 1.81 | 1.63 | 1.7 | 1.81 | 1.55 | 1.7 | 1.85 | 1.60 | 1.72 | 1.80 | V |
| Output Noise Voltage | 10 Hz ≤ f ≤ 10 kHz | | | | | | | | | | | | | | | | |
| | $C_{REF}$ = 0 | | 0.005 | | | 0.005 | | | 0.005 | | | 0.005 | | | | | % |
| | $C_{REF}$ = 0.1 μF | | 0.002 | | | 0.002 | | | 0.002 | | | 0.002 | | | | | % |
| Standby Current Drain | $V_{IN}$ = 30V, $T_A$ = 25°C | | | | | | | | | | | | | | | 2.5 | mA |
| | $V_{IN}$ = 40V | | | | | | | | 0.8 | 2.0 | | | | | | | mA |
| | $V_{IN}$ = 50V | | 0.8 | 2.0 | | 0.8 | 2.0 | | | | | 0.8 | 2.0 | | | | mA |
| Current Limit Sense Voltage | $T_A$ = 25°C, $R_{SC}$ = 10Ω, $V_{OUT}$ = 0V, (Note 4) | 225 | 300 | 375 | 225 | 300 | 375 | 225 | 300 | 375 | 225 | 300 | 375 | | 300 | | mV |
| Long Term Stability | | | 0.1 | | | 0.1 | | | 0.1 | | | 0.1 | | | | | % |
| Ripple Rejection | $C_{REF}$ = 10 μF, f = 120 Hz | | 0.003 | | | 0.003 | | | 0.003 | | | 0.003 | | | | | %/V |
| $\theta_{JA}$ | Epoxy Dual-In-Line Package | | | | | | | | | | | | | | 140 | | °C/W |
| $\theta_{JA}$ | TO-5 Board Mount in Still Air | | 230 | | | 230 | | | 230 | | | 230 | | | | | °C/W |
| $\theta_{JA}$ | TO-5 Board Mount in 400 LF/Min Air Flow | | 92 | | | 92 | | | 92 | | | 92 | | | | | °C/W |
| $\theta_{JC}$ | TO-5 | | 25 | | | 25 | | | 25 | | | 25 | | | | | °C/W |

**Note 1:** The maximum junction temperature of the LM105 and LM305A is 150°C, the LM205 and LM376 is 100°C, and the LM305 is 85°C. For operation at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 231°C/W junction to ambient, or 25°C/W junction to case. For the epoxy dual-in-line package, derating is based on a thermal resistance of 138°C/W junction to ambient. Peak dissipations to 1W are allowable providing the dissipation rating is not exceeded with the power average over a five second interval for the LM105 and LM205, and averaged over a two second interval for the LM305.

**Note 2:** Unless otherwise specified, these specifications apply for temperatures within the operating temperature range, for input and output voltages within the range given, and for a divider impedance seen by the feedback terminal of 2 kΩ. Load and line regulation specifications are for a constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

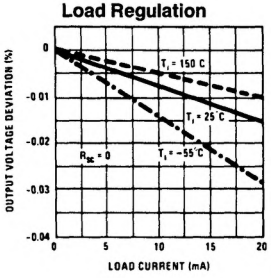
**Note 3:** The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

**Note 4:** With no external pass transistor.

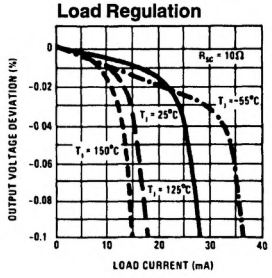
**Note 5:** Refer to RETS105X Drawing for military specifications for the LM105.

# Typical Performance Characteristics LM105/LM205/LM305/LM305A

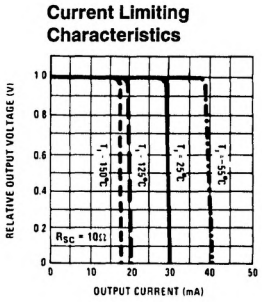
### Load Regulation



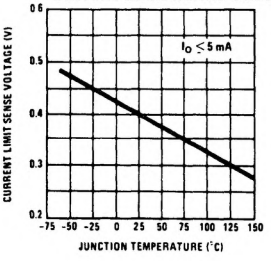

### Load Regulation



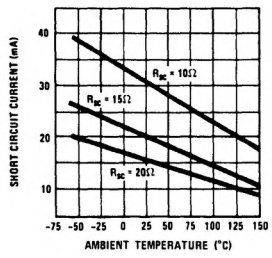

### Current Limiting Characteristics



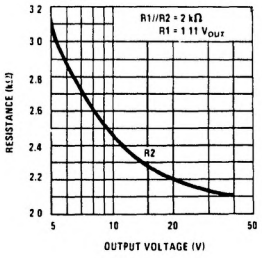

### Current Limit Sense Voltage



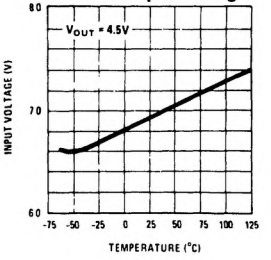

### Short Circuit Current



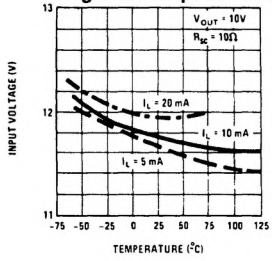

### Optimum Divider Resistance Values



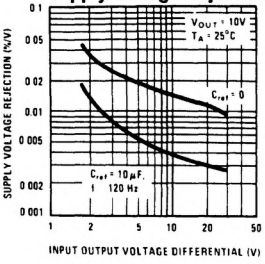

### Minimum Input Voltage



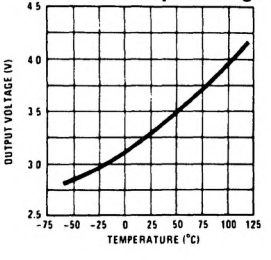

### Regulator Dropout Voltage



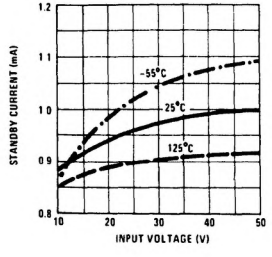

### Supply Voltage Rejection



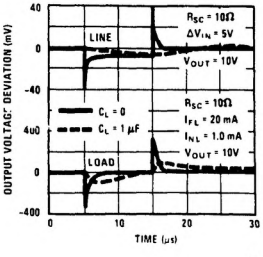

### Minimum Output Voltage




### Standby Current Drain



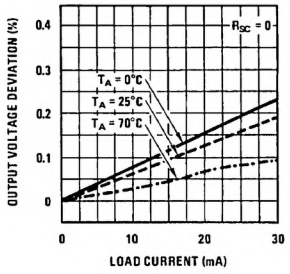

### Transient Response



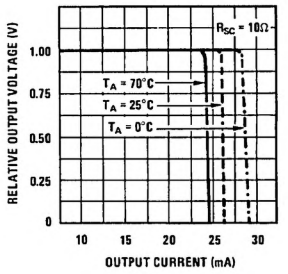

TL/H/7755–6

# Typical Performance Characteristics LM376

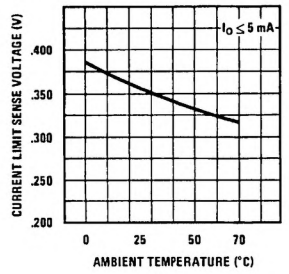
### Load Regulation



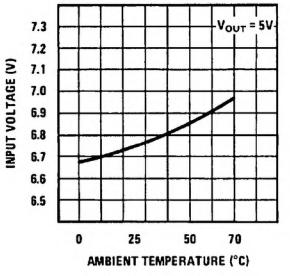

### Current Limiting Characteristics



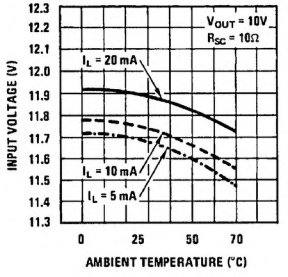

### Current Limiting Sense Voltage



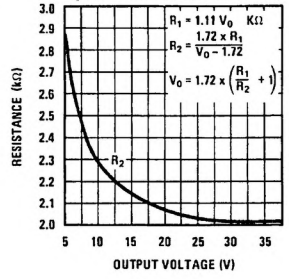

### Minimum Input Voltage



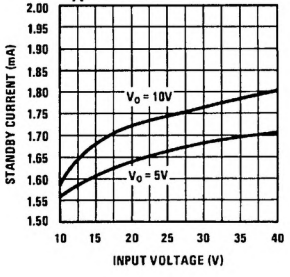

### Regulator Dropout Voltage



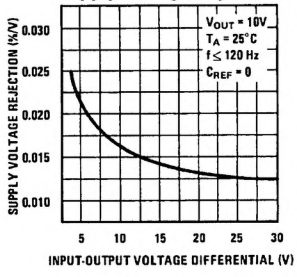

### Optimum Divider Resistance



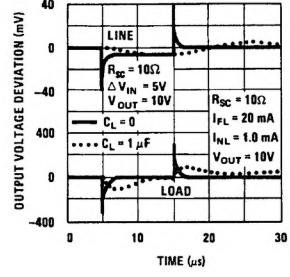

### Standby Current Drain
$T_A$ = 25°C




### Supply Voltage Rejection



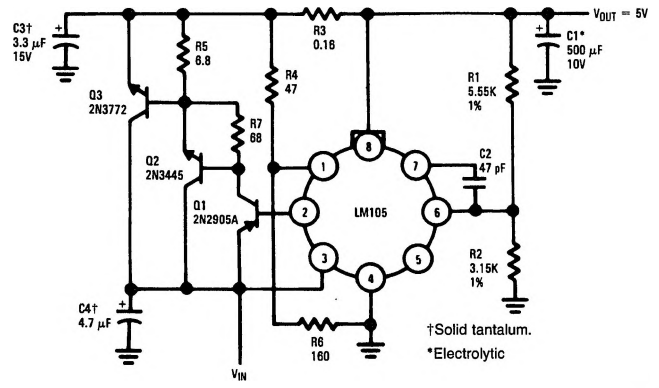

### Transient Response




TL/H/7755–7

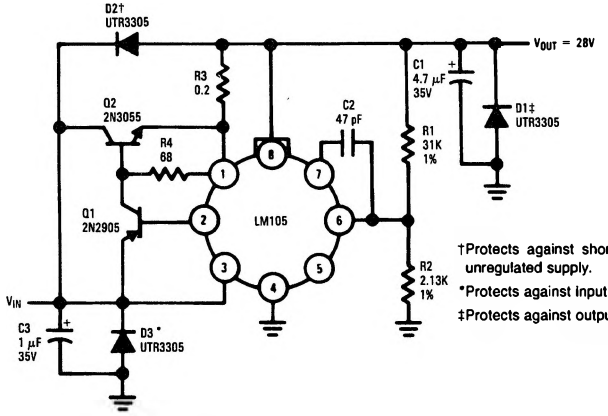
# Typical Applications

### 10A Regulator with Foldback Current Limiting



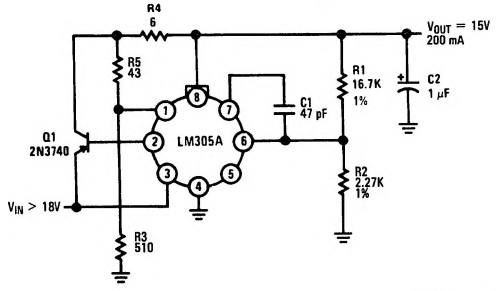

TL/H/7755–4

### 1.0A Regulator with Protective Diodes



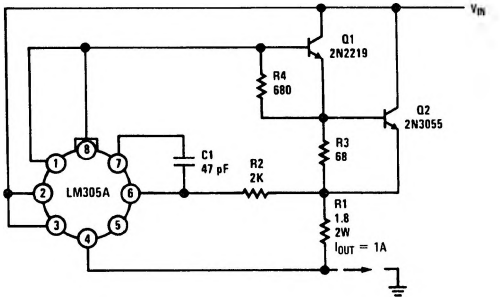

TL/H/7755–5

### Linear Regulator with Foldback Current Limiting




TL/H/7755–8

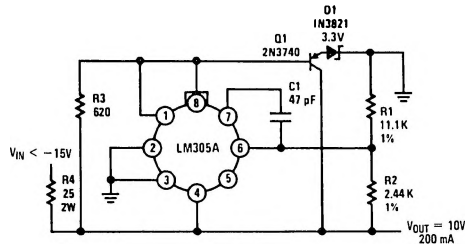
### Current Regulator




TL/H/7755–9

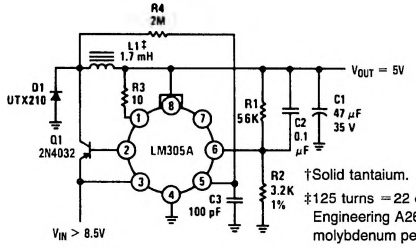
## Typical Applications (Continued)

### Shunt Regulator




TL/H/7755–10

### Switching Regulator

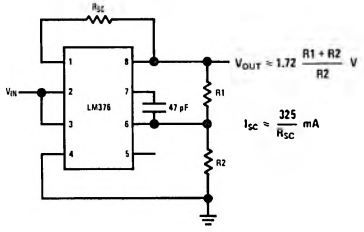



†Solid tantalum.

‡125 turns = 22 on Arnold Engineering A262123-2 molybdenum permally core.

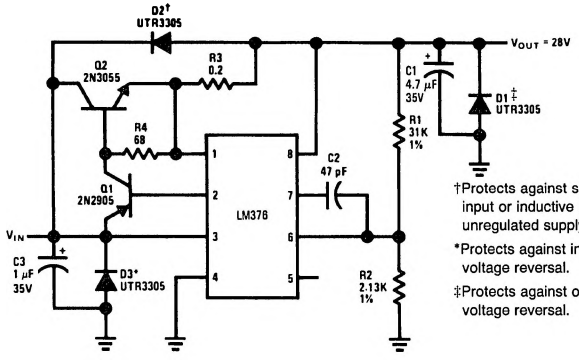
TL/H/7755–11

### Basic Positive Regulator with Current Limiting




TL/H/7755–12

### 1.0A Regulator with Protective Diodes



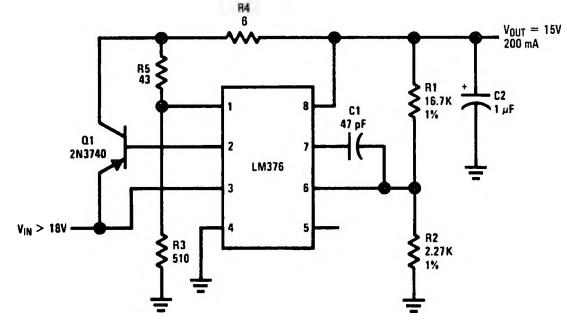

†Protects against shorted input or inductive loads on unregulated supply.

*Protects against input voltage reversal.

‡Protects against output voltage reversal.

TL/H/7755–13

### Linear Regulator with Foldback Current Limiting




TL/H/7755–14