

## LM195/LM395 Ultra Reliable Power Transistors

Check for Samples: [LM195](#), [LM395](#)

### FEATURES

- **Internal Thermal Limiting**
- **Greater than 1.0A Output Current**
- **3.0  $\mu$ A Typical Base Current**
- **500 ns Switching Time**
- **2.0V Saturation**
- **Base Can be Driven up to 40V without Damage**
- **Directly Interfaces with CMOS or TTL**
- **100% Electrical Burn-in**

### DESCRIPTION

The LM195/LM395 are fast, monolithic power integrated circuits with complete overload protection. These devices, which act as high gain power transistors, have included on the chip, current limiting, power limiting, and thermal overload protection making them virtually impossible to destroy from any type of overload. In the standard TO-3 transistor power package, the LM195 will deliver load currents in excess of 1.0A and can switch 40V in 500 ns.

The inclusion of thermal limiting, a feature not easily available in discrete designs, provides virtually absolute protection against overload. Excessive power dissipation or inadequate heat sinking causes the thermal limiting circuitry to turn off the device preventing excessive heating.

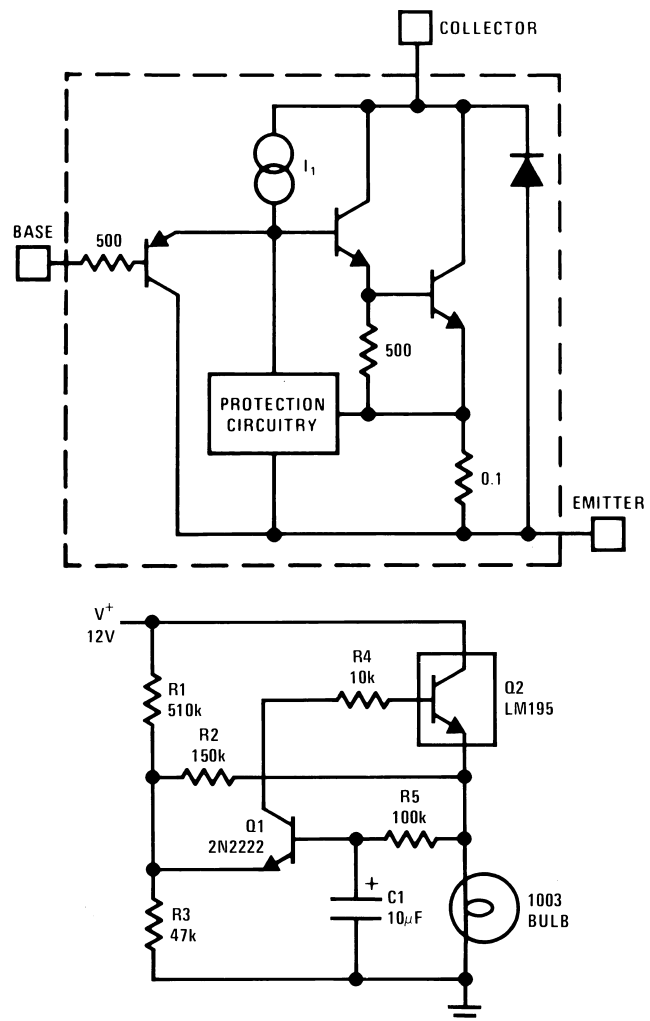
The LM195 offers a significant increase in reliability as well as simplifying power circuitry. In some applications, where protection is unusually difficult, such as switching regulators, lamp or solenoid drivers where normal power dissipation is low, the LM195 is especially advantageous.

The LM195 is easy to use and only a few precautions need be observed. Excessive collector to emitter voltage can destroy the LM195 as with any power transistor. When the device is used as an emitter follower with low source impedance, it is necessary to insert a 5.0k resistor in series with the base lead to prevent possible emitter follower oscillations. Although the device is usually stable as an emitter follower, the resistor eliminates the possibility of trouble without degrading performance. Finally, since it has good high frequency response, supply bypassing is recommended.

For low-power applications (under 100 mA), refer to the LP395 Ultra Reliable Power Transistor.

The LM195/LM395 are available in the standard TO-3, Kovar TO-5, and TO-220 packages. The LM195 is rated for operation from  $-55^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$  and the LM395 from  $0^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### Simplified Circuit



**Figure 1. 1.0 Amp Lamp Flasher**



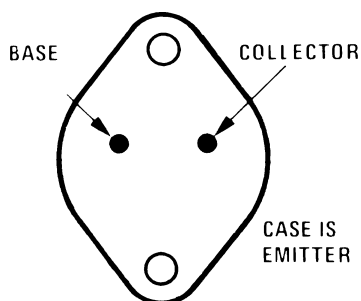
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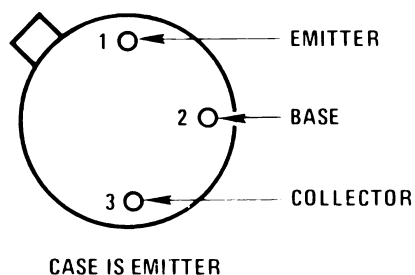
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## Connection Diagram



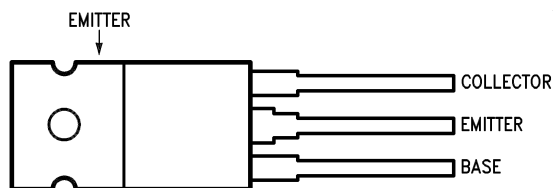
Refer to RETS195H and RETS195K drawings of military LM195H and LM195K versions for specifications.

**Figure 2. TO-3 Metal Can Package  
Bottom View  
See Package Number NDS0002A**



Refer to RETS195H and RETS195K drawings of military LM195H and LM195K versions for specifications.

**Figure 3. TO-5 Metal Can Package  
Bottom View**



Case is Emitter

**Figure 4. TO-220 Plastic Package  
Top View  
See Package Number NDE0003B**



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)(2)</sup>

|                                   |                    |
|-----------------------------------|--------------------|
| Collector to Emitter Voltage      |                    |
| LM195                             | 42V                |
| LM395                             | 36V                |
| Collector to Base Voltage         |                    |
| LM195                             | 42V                |
| LM395                             | 36V                |
| Base to Emitter Voltage (Forward) |                    |
| LM195                             | 42V                |
| LM395                             | 36V                |
| Base to Emitter Voltage (Reverse) | 20V                |
| Collector Current                 | Internally Limited |
| Power Dissipation                 | Internally Limited |
| Operating Temperature Range       |                    |
| LM195                             | –55°C to +150°C    |
| LM395                             | 0°C to +125°C      |
| Storage Temperature Range         | –65°C to +150°C    |
| Lead Temperature                  |                    |
| (Soldering, 10 sec.)              | 260°C              |

- (1) "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

## PRECONDITIONING

|                                      |
|--------------------------------------|
| <b>100% Burn-In In Thermal Limit</b> |
|--------------------------------------|

## ELECTRICAL CHARACTERISTICS

| Parameter  | Conditions  | LM195 |     |     | LM395 |     |     | Units   |
|--|---|-------|-----|-----|-------|-----|-----|---------|
|  |   | Min   | Typ | Max | Min   | Typ | Max |         |
| Collector-Emitter Operating Voltage <sup>(2)</sup> | $I_Q \leq I_C \leq I_{MAX}$                                 |       |     | 42  |       |     | 36  | V       |
| Base to Emitter Breakdown Voltage                  | $0 \leq V_{CE} \leq V_{CEMAX}$                              | 42    |     |     | 36    | 60  |     | V       |
| Collector Current                                  |   |       |     |     |       |     |     |         |
| TO-3, TO-220                                       | $V_{CE} \leq 15V$   | 1.2   | 2.2 |     | 1.0   | 2.2 |     | A       |
| TO-5   | $V_{CE} \leq 7.0V$  | 1.2   | 1.8 |     | 1.0   | 1.8 |     | A       |
| Saturation Voltage                                 | $I_C \leq 1.0A, T_A = 25^\circ C$                           |       | 1.8 | 2.0 |       | 1.8 | 2.2 | V       |
| Base Current                                       | $0 \leq I_C \leq I_{MAX}$<br>$0 \leq V_{CE} \leq V_{CEMAX}$ |       | 3.0 | 5.0 |       | 3.0 | 10  | $\mu A$ |
| Quiescent Current ( $I_Q$ )                        | $V_{be} = 0$<br>$0 \leq V_{CE} \leq V_{CEMAX}$              |       | 2.0 | 5.0 |       | 2.0 | 10  | mA      |
| Base to Emitter Voltage                            | $I_C = 1.0A, T_A = +25^\circ C$                             |       | 0.9 |     |       | 0.9 |     | V       |
| Switching Time                                     | $V_{CE} = 36V, R_L = 36\Omega,$<br>$T_A = 25^\circ C$       |       | 500 |     |       | 500 |     | ns      |

(1) Unless otherwise specified, these specifications apply for  $-55^\circ C \leq T_j \leq +150^\circ C$  for the LM195 and  $0^\circ C \leq +125^\circ C$  for the LM395.

(2) Selected devices with higher breakdown available.

**ELECTRICAL CHARACTERISTICS (continued)**

(1)

| Parameter  | Conditions           | LM195 |     |     | LM395 |     |     | Units |
|--|----------------------|-------|-----|-----|-------|-----|-----|-------|
|  |                      | Min   | Typ | Max | Min   | Typ | Max |       |
| Thermal Resistance Junction to Case <sup>(3)</sup> | TO-3 Package (NDS)   |       | 2.3 | 3.0 |       | 2.3 | 3.0 | °C/W  |
|  | TO-5 Package         |       | 12  | 15  |       | 12  | 15  | °C/W  |
|  | TO-220 Package (NDE) |       |     |     |       | 4   | 6   | °C/W  |

(3) Without a heat sink, the thermal resistance of the TO-5 package is about +150°C/W, while that of the TO-3 package is +35°C/W.

## TYPICAL PERFORMANCE CHARACTERISTICS

(for NDS and NDE Packages)

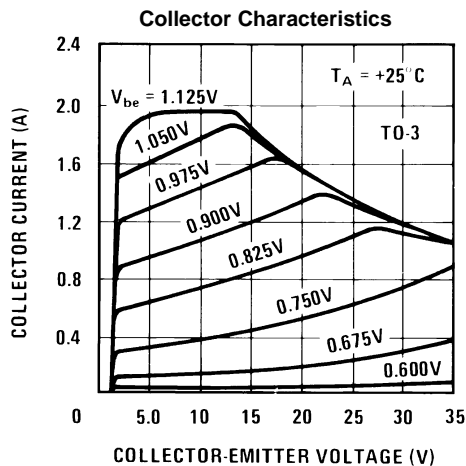


Figure 5.

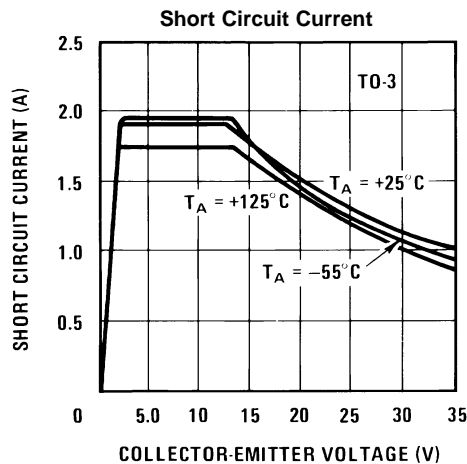


Figure 6.

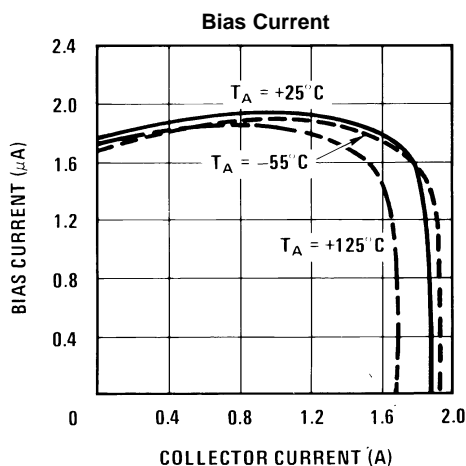


Figure 7.

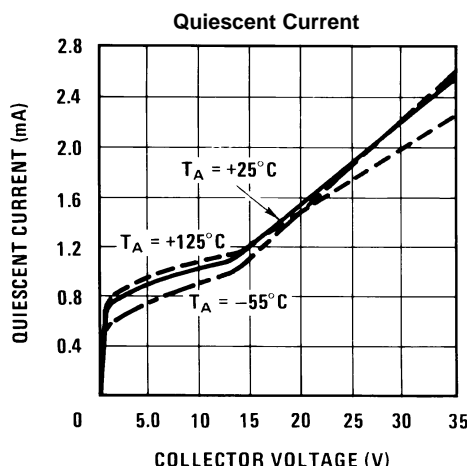


Figure 8.

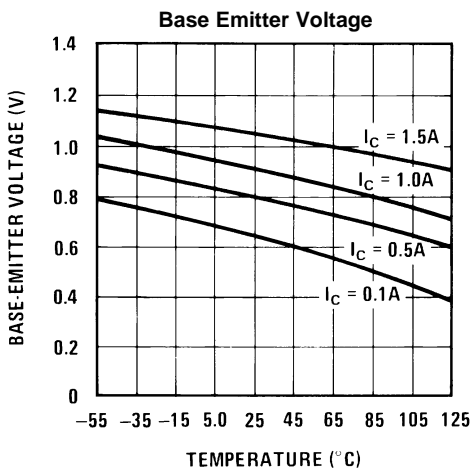


Figure 9.

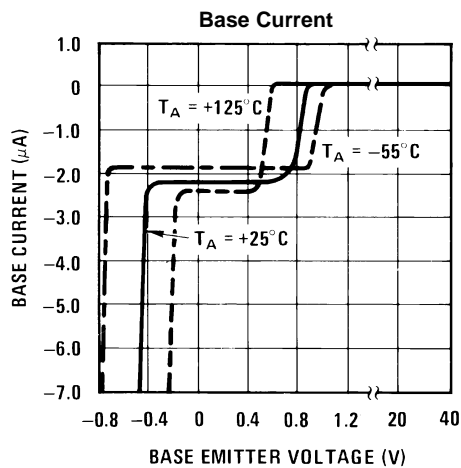


Figure 10.

**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

(for NDS and NDE Packages)

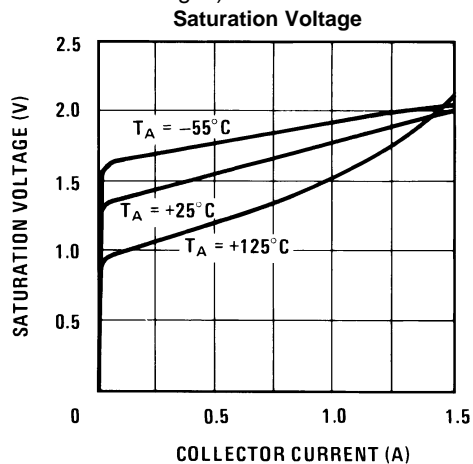


Figure 11.

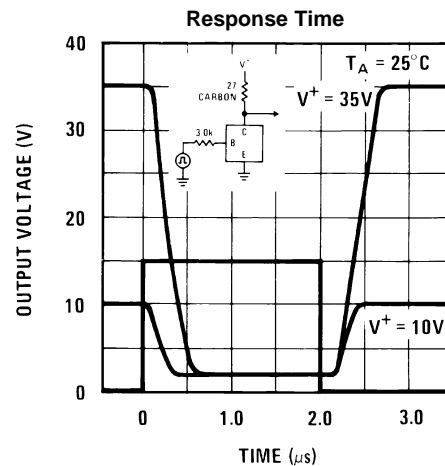


Figure 12.

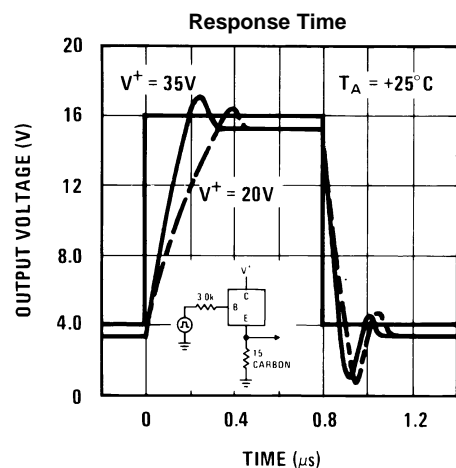


Figure 13.

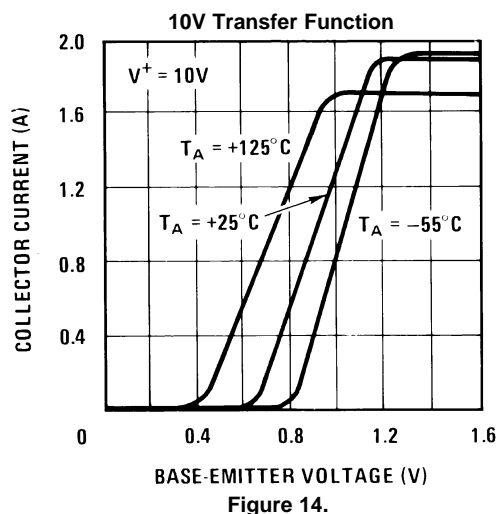


Figure 14.

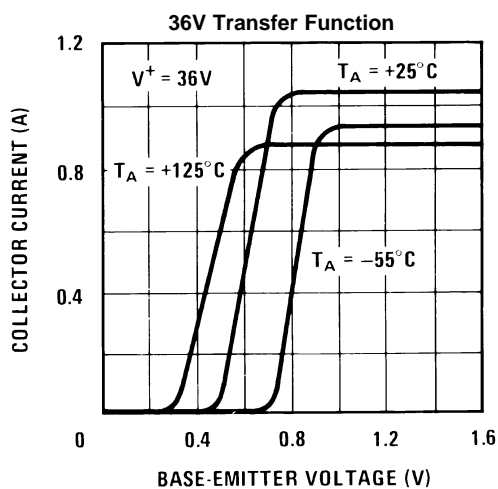


Figure 15.

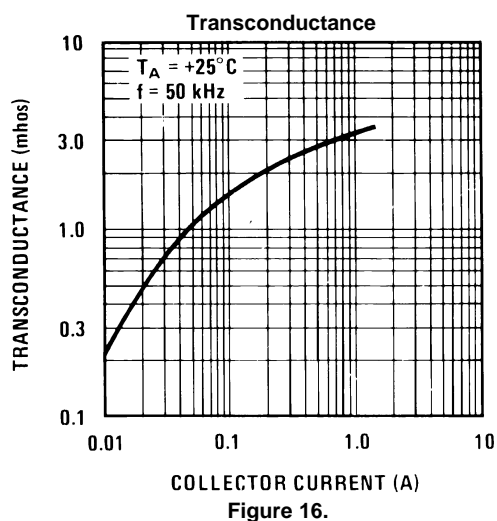
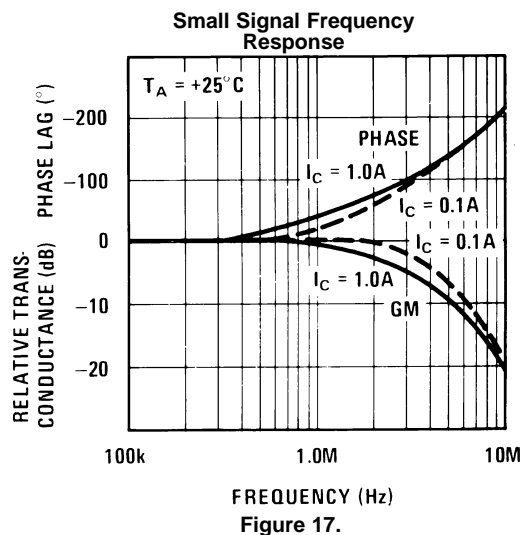
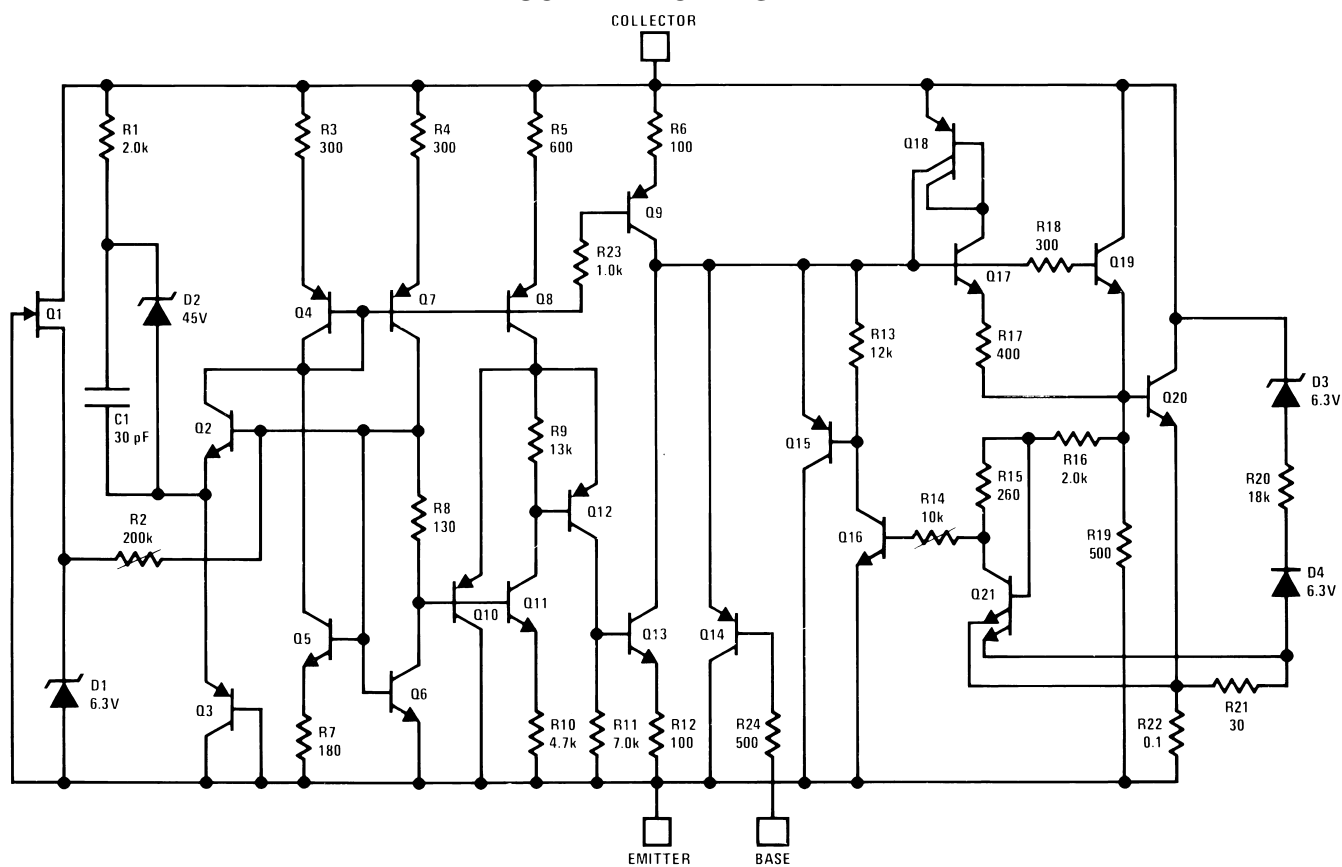


Figure 16.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

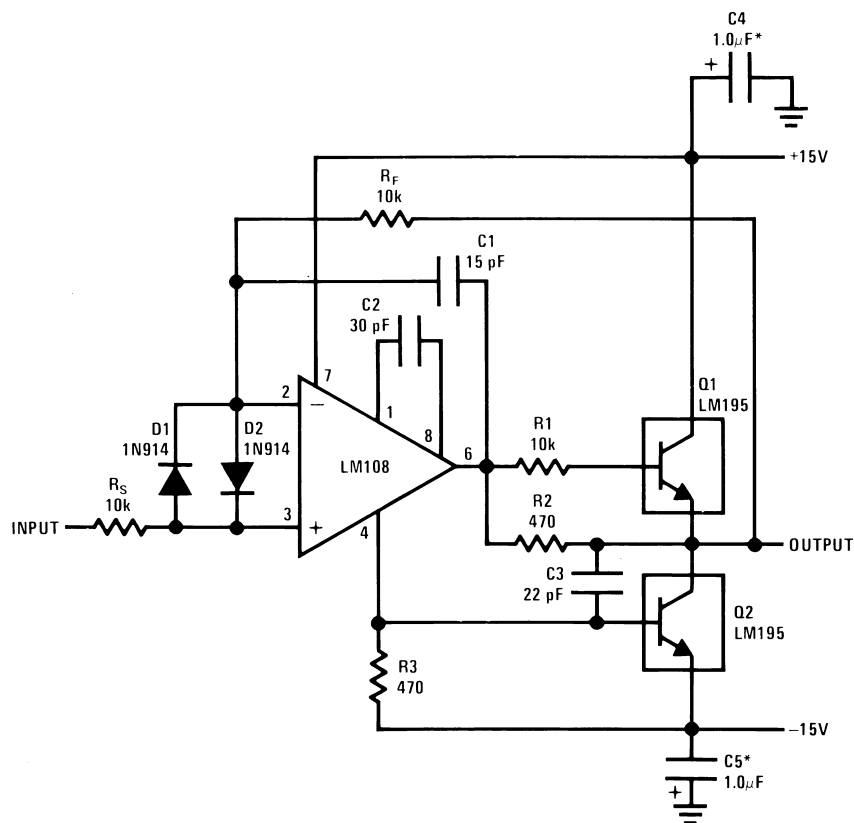
(for NDS and NDE Packages)



**SCHEMATIC DIAGRAM**

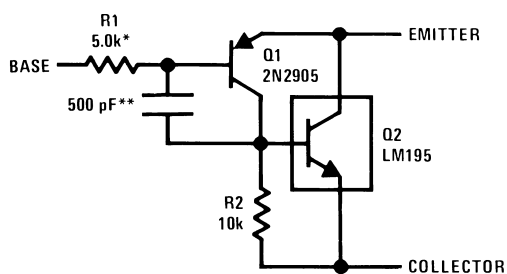


## TYPICAL APPLICATIONS



\*Solid Tantalum

Figure 18. 1.0 Amp Voltage Follower



\*Protects against excessive base drive

\*\*Needed for stability

Figure 19. Power PNP

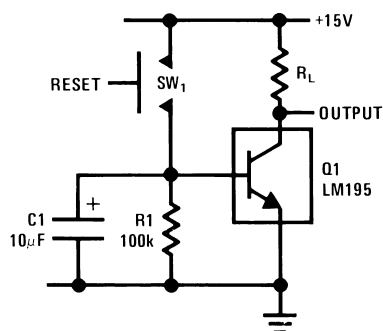


Figure 20. Time Delay

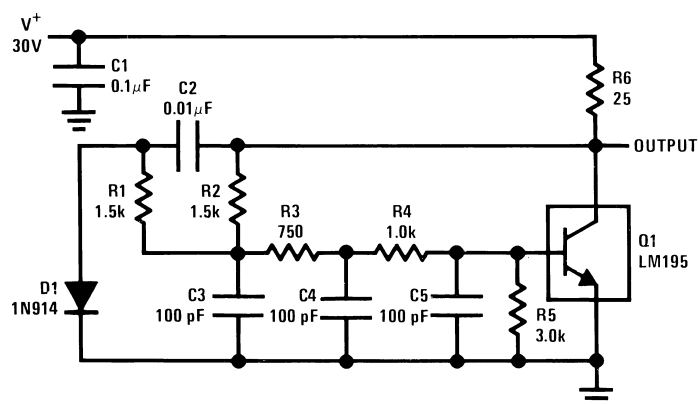
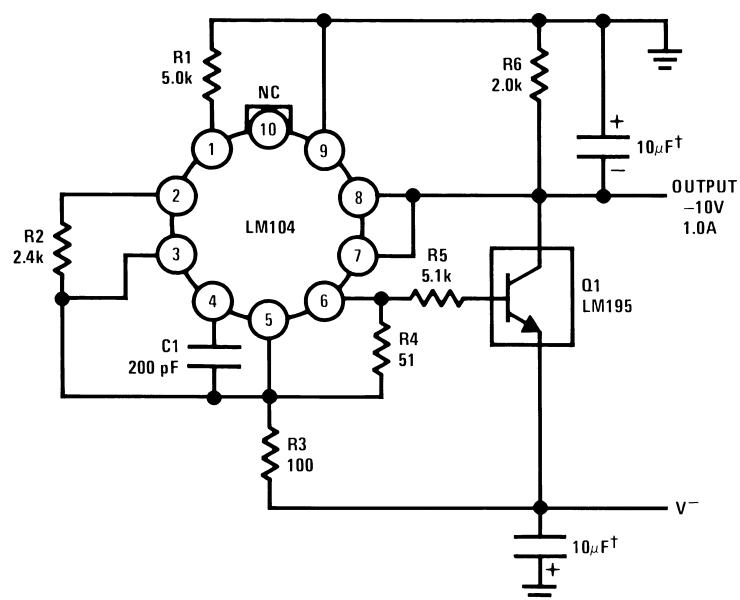
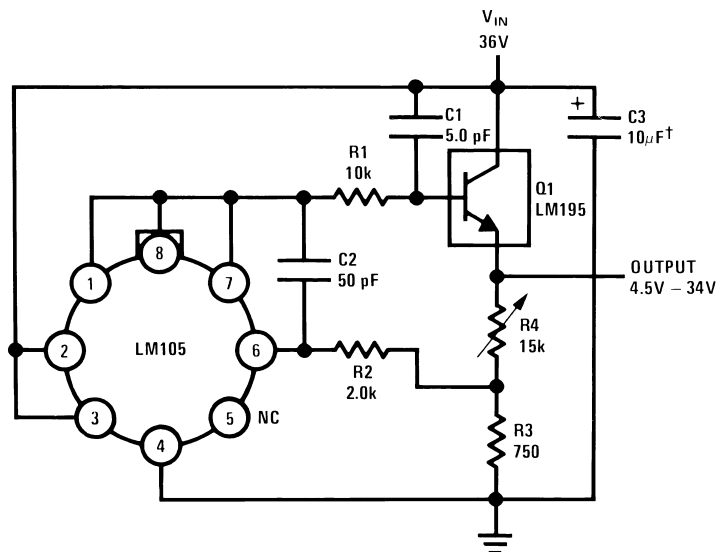


Figure 21. 1.0 MHz Oscillator



†Solid Tantalum

Figure 22. 1.0 Amp Negative Regulator



†Solid Tantalum

Figure 23. 1.0 Amp Positive Voltage Regulator

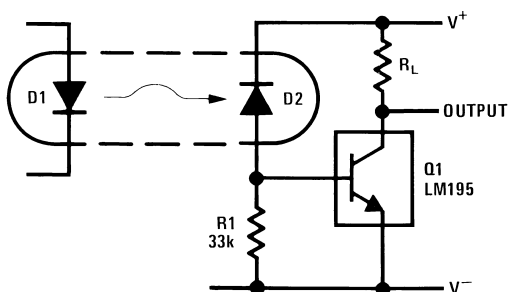


Figure 24. Fast Optically Isolated Switch

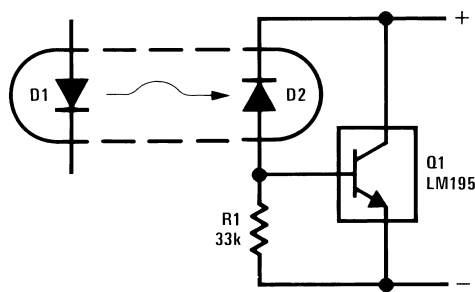


Figure 25. Optically Isolated Power Transistor

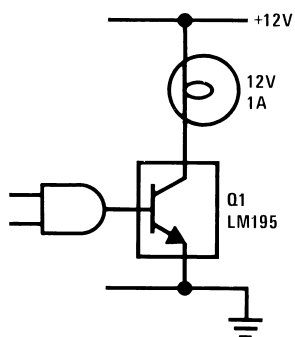


Figure 26. CMOS or TTL Lamp Interface

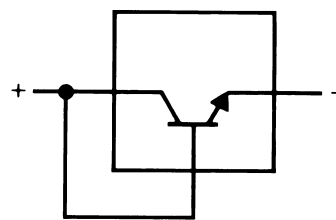
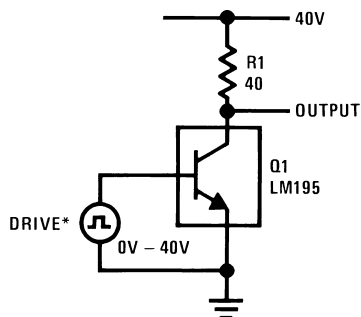
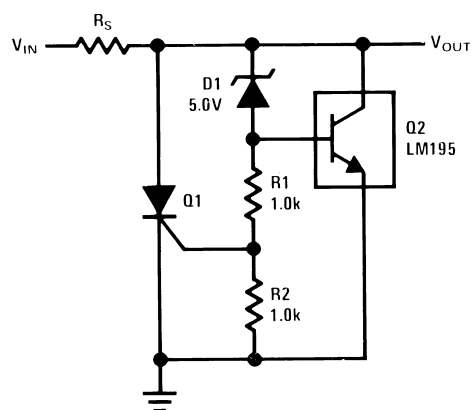


Figure 27. Two Terminal Current Limiter

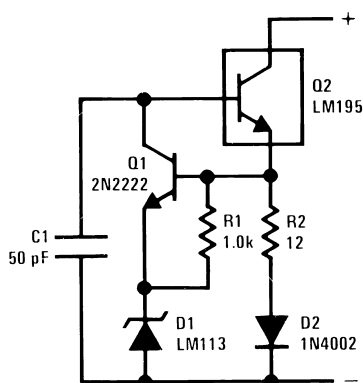


\*Drive Voltage 0V to  $\geq 10\text{V} \leq 42\text{V}$

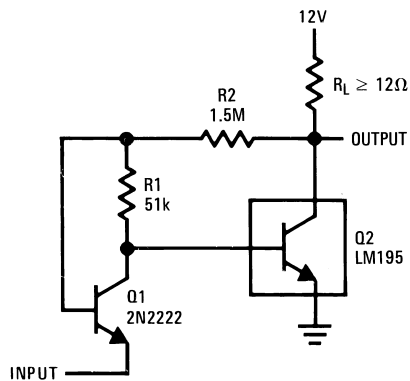
**Figure 28. 40V Switch**



**Figure 29. 6.0V Shunt Regulator with Crowbar**

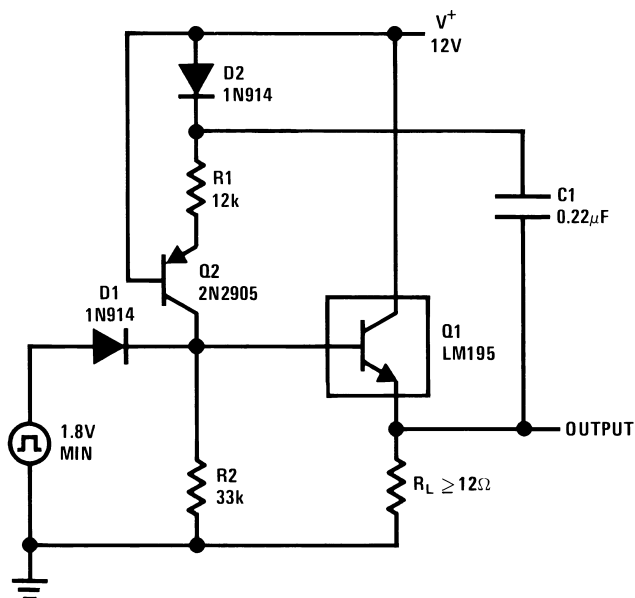


**Figure 30. Two Terminal 100 mA Current Regulator**



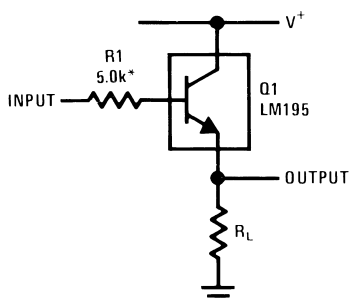
Turn ON = 350 mV  
Turn OFF = 200 mV

Figure 31. Low Level Power Switch



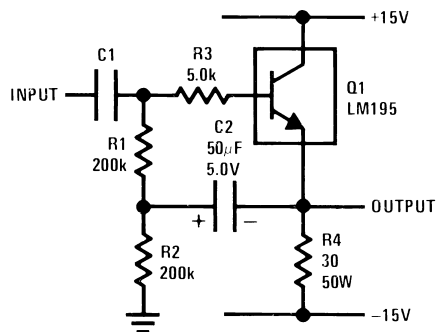
$T = R1C$   
 $R2 = 3R1$   
 $R2 \leq 82k$

Figure 32. Power One-Shot

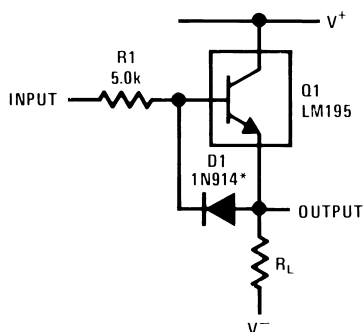


\*Need for Stability

Figure 33. Emitter Follower

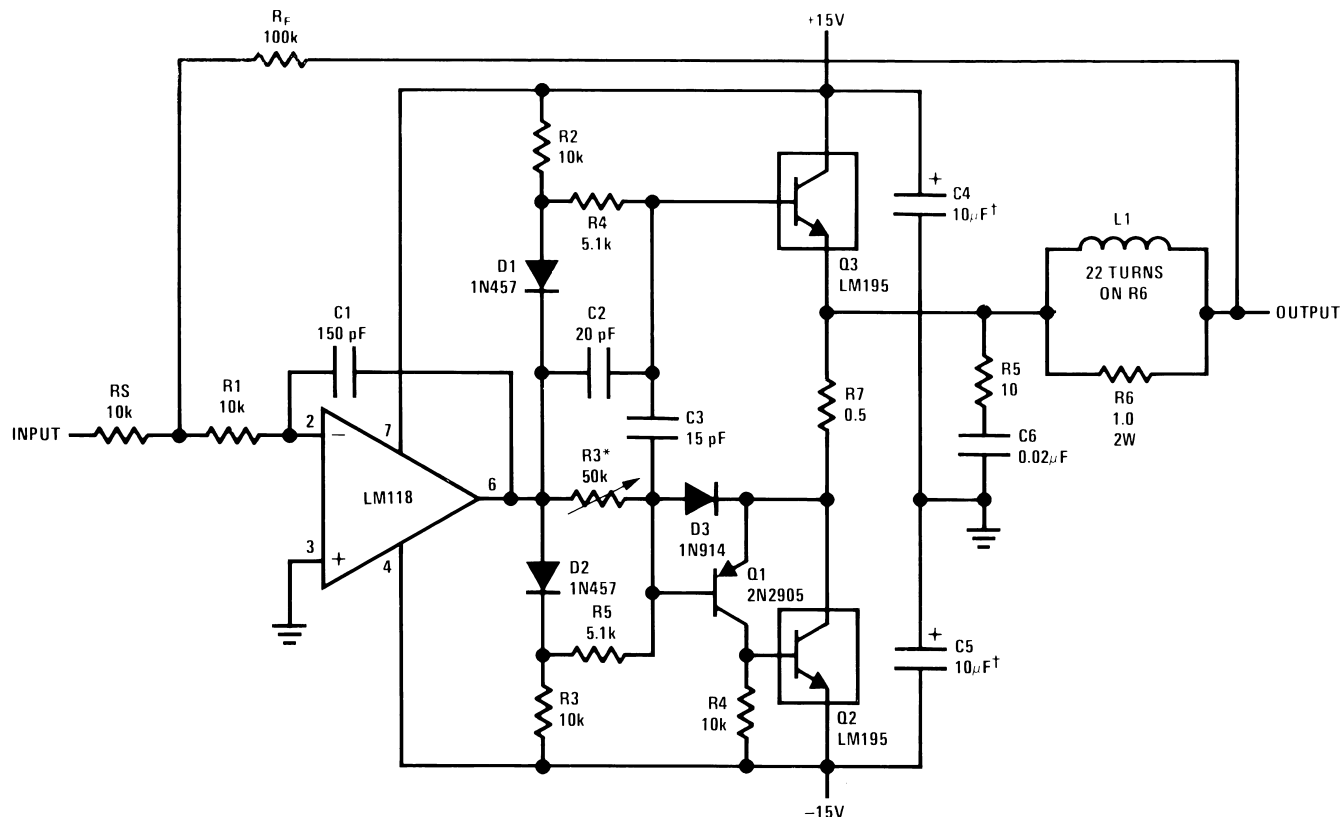


**Figure 34. High Input Impedance AC Emitter Follower**



\*Prevents storage with fast fall time square wave drive

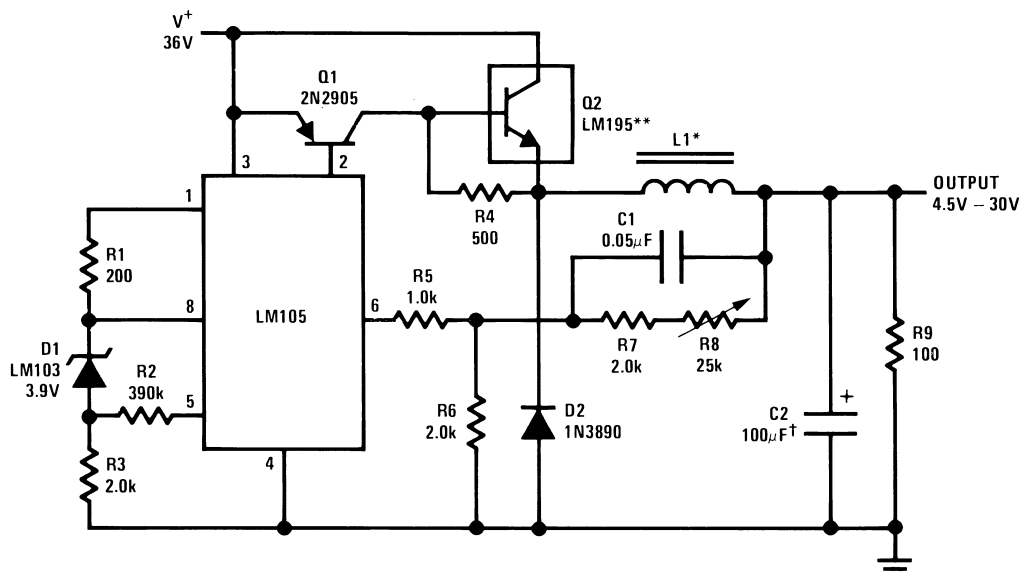
**Figure 35. Fast Follower**



\*Adjust for 50 mA quiescent current

†Solid Tantalum

### Figure 36. Power Op Amp



\*Sixty turns wound on Arnold Type A-083081-2 core.

\*\*Four devices in parallel

†Solid tantalum

**Figure 37. 6.0 Amp Variable Output Switching Regulator**

## REVISION HISTORY

| Changes from Revision B (April 2013) to Revision C         | Page               |
|--|--------------------|
| • Changed layout of National Data Sheet to TI format ..... | <a href="#">15</a> |



## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM395T           | NRND          | TO-220       | NDE                | 3    | 45             | TBD                        | Call TI                 | Call TI              | 0 to 125     | LM395T                  |                         |
| LM395T/NOPB      | ACTIVE        | TO-220       | NDE                | 3    | 45             | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-NA-UNLIM     | 0 to 125     | LM395T                  | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

|                              |  |
|------------------------------|--|
| Audio                        | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                               |
| Amplifiers                   | <a href="http://amplifier.ti.com">amplifier.ti.com</a>                               |
| Data Converters              | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>                       |
| DLP® Products                | <a href="http://www.dlp.com">www.dlp.com</a>   |
| DSP                          | <a href="http://dsp.ti.com">dsp.ti.com</a>   |
| Clocks and Timers            | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>                             |
| Interface                    | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                        | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt                   | <a href="http://power.ti.com">power.ti.com</a>                                       |
| Microcontrollers             | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a>                   |
| RFID                         | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
| OMAP Applications Processors | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                 |
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### Applications

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