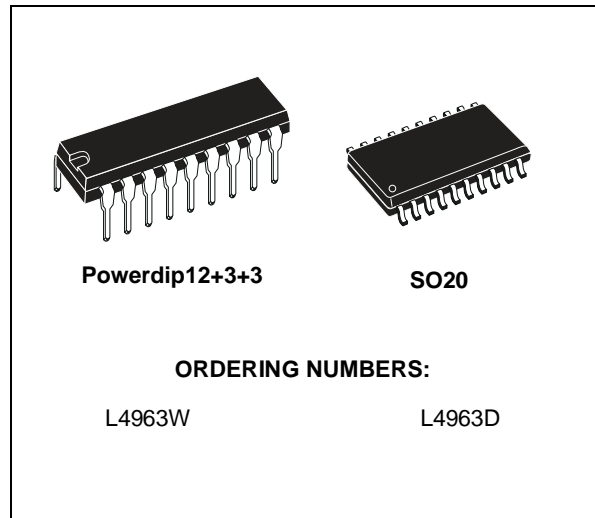


## 1.5A SWITCHING REGULATOR

- 1.5A OUTPUT LOAD CURRENT
- 5.1 TO 36V OUTPUT VOLTAGE RANGE
- DISCONTINUOUS VARIABLE FREQUENCY MODE
- PRECISE (+/-2%) ON CHIP REFERENCE
- VERY HIGH EFFICIENCY
- VERY FEW EXTERNAL COMPONENTS
- NO FREQ. COMPENSATION REQUIRED
- RESET AND POWER FAIL OUTPUT FOR MICROPROCESSOR
- INTERNAL CURRENT LIMITING
- THERMAL SHUTDOWN

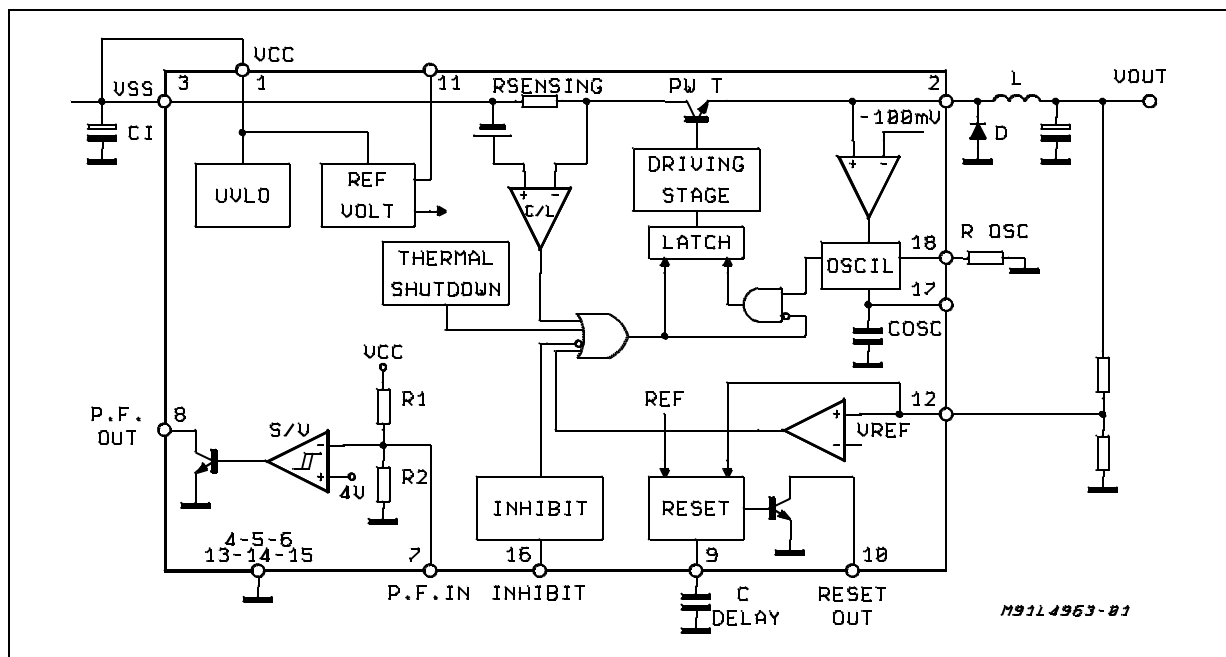
### DESCRIPTION

The L4963 is a monolithic power switching regulator delivering 1.5A at 5.1V. The output voltage is adjustable from 5.1V to 36V, working in discontinuous variable frequency mode. Features of the device include remote inhibit, internal current limiting and thermal protection, reset and power fail outputs for microprocessor.



The L4963 is mounted in a 12+3+3 lead Powerdip (L4963) and SO20 large (L4963D) plastic packages and requires very few external components.

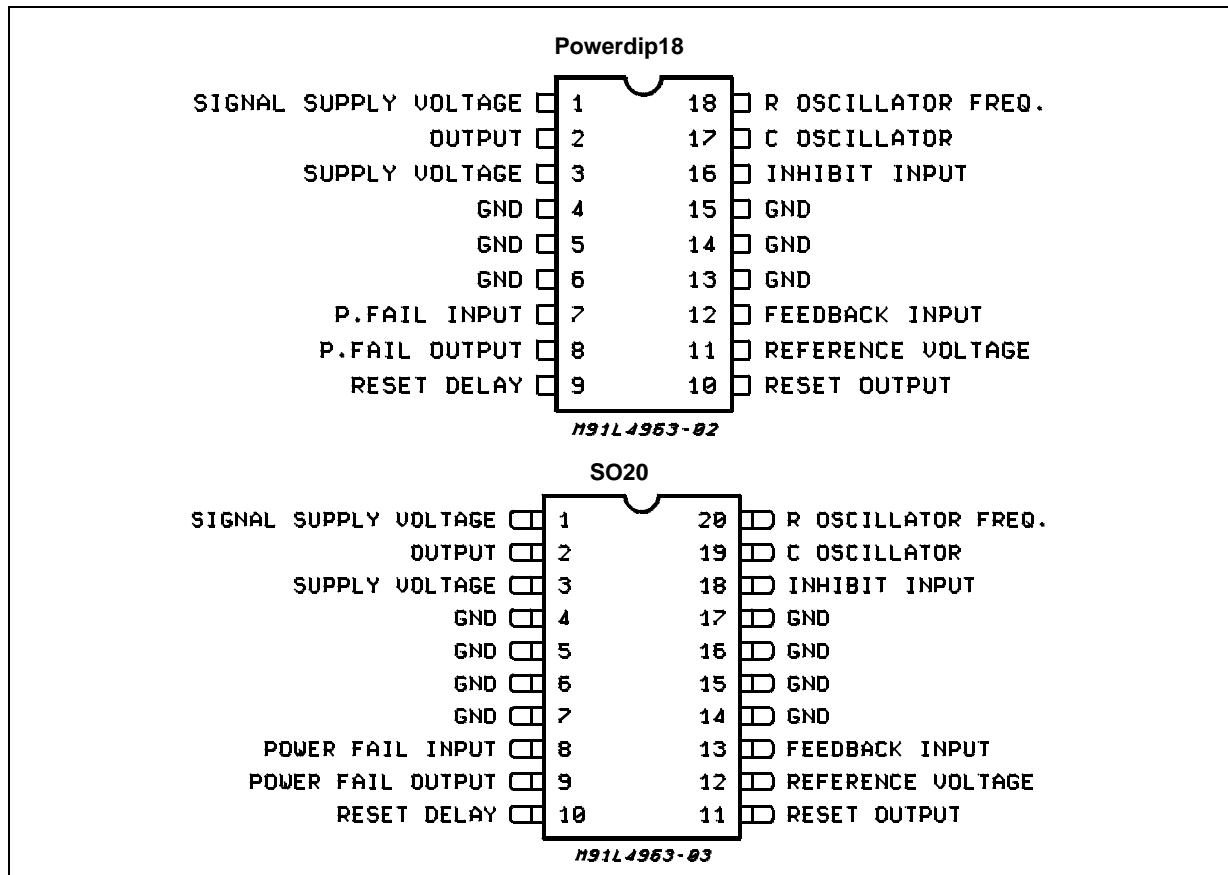
### BLOCK DIAGRAM



**ABSOLUTE MAXIMUM RATINGS**

| Symbol           |                  | Parameter  | Value              | Unit            |
|------------------|------------------|--|--------------------|-----------------|
| SO20             | Powerdip         |  |                    |                 |
| $V_i$            |                  | Input Voltage (pin 1 and pin 3 connected together)   | 47                 | V               |
| $V_3-V_2$        |                  | Input to Output Voltage Difference   | 47                 | V               |
| $V_2$            |                  | Negative Output DC Voltage   | -1                 | V               |
| $V_2$            |                  | Negative Output Peak Voltage at $t=0.2 \mu s, f=50kHz$   | -5                 | V               |
| $V_8$            | $V_7$            | Power Fail Input   | 25                 | V               |
| $V_9, V_{11}$    | $V_8, V_{10}$    | Reset and Power Fail Output  | $V_i$              |                 |
| $V_{10}$         | $V_9$            | Reset Delay Input  | 5.5                | V               |
| $V_{13}, V_{18}$ | $V_{12}, V_{16}$ | Feedback and Inhibit Inputs  | 7                  | V               |
| $V_{19}, V_{20}$ | $V_{17}, V_{18}$ | Oscillator Inputs  | 5.5                | V               |
| $P_{tot}$        |                  | Total Power Dissipation $T_{pins} \leq 90^\circ C$ (Power DIP)<br>( $T_{amb} = 70^\circ C$ no copper area on PCB)<br>( $T_{amb} = 70^\circ C, 4cm^2$ copper area on PCB) | 5<br>1.3<br>2      | W<br>W<br>W     |
| $T_{stg}, T_j$   |                  | Storage & Junction Temperature<br>( $T_{amb} = 70^\circ C, 6cm^2$ copper area on PCB)  | -40 to 150<br>1.45 | $^\circ C$<br>W |
| $P_{tot}$        |                  | Total Power Dissipation $T_{pins} \leq 90^\circ C$ (SO20L)   | 4                  | W               |

**PIN CONNECTION** (top view)



## PIN FUNCTIONS

| SO20L                        | Power DIP             | Name                  | Description  |
|------------------------------|-----------------------|-----------------------|--|
| 1                            | 1                     | SIGNAL SUPPLY VOLTAGE | Must be Connected to pin 3   |
| 2                            | 2                     | OUTPUT                | Regulator output   |
| 3                            | 3                     | SUPPLY VOLTAGE        | Unregulated voltage input. An internal regulator powers the internal logic.  |
| 4, 5, 6, 7<br>14, 15, 16, 17 | 4, 5, 6<br>13, 14, 15 | GROUND                | Common ground terminal   |
| 8                            | 7                     | POWER FAIL INPUT      | Input of the power fail circuit. The threshold can be modified introducing an external voltage divider between the Supply Voltage and GND.                         |
| 9                            | 8                     | POWER FAIL OUTPUT     | Open collector power fail signal output. This output is high when the supply voltage is safe.  |
| 10                           | 9                     | RESET DELAY           | A capacitor connected between this terminal and ground determines the reset signal delay time.   |
| 11                           | 10                    | RESET OUTPUT          | Open collector reset signal output. This output is high when the output voltage value is correct.  |
| 12                           | 11                    | REFERENCE VOLTAGE     | Reference voltage output.  |
| 13                           | 12                    | FEEDBACK INPUT        | Feedback terminal of the regulation loop. The output is connected directly to this terminal for 5.1V operation; it is connected via a divider for higher voltages. |
| 18                           | 16                    | INHIBIT INPUT         | TTL level remote inhibit. A logic low level on this input disables the device.   |
| 19                           | 17                    | C OSCILLATOR          | Oscillator waveform. A capacitor connected between this terminal and ground modifies the maximum oscillator frequency.   |
| 20                           | 18                    | R OSCILLATOR FREQ.    | A resistor connected between this terminal and ground defines the maximum switching frequency.   |

## THERMAL DATA

| Symbol           | Parameter                                  |      | SO20 | Powerdip | Unit |
|------------------|--|------|------|----------|------|
| $R_{th\ j-pins}$ | Thermal Resistance Junction to Pins        | max. | 15   | 12       | °C/W |
| $R_{th\ j-amb}$  | Thermal Resistance Junction to Ambient (*) | max. | 85   | 80       | °C/W |

(\*) See Fig. 28

**CIRCUIT DESCRIPTION (Refer to Block Diagram)**

The L4963 is a monolithic stepdown regulator providing 1.5A at 5.1V working in discontinuous variable frequency mode. In normal operation the device resonates at a frequency depending primarily on the inductance value, the input and output voltage and the load current. The maximum switching however can be limited by an internal oscillator, which can be programmed by only one external resistor.

The fundamental regulation loop consists of two comparators, a precision 5.1V on-chip reference and a drive latch. Briefly the operation is as follows: when the choke ends its discharge the catch free-wheeling recirculation filter diode begins to come out of forward conduction so the output voltage of the device approaches ground. When the output voltage reaches -0.1V the internal comparator sets the latch and the power stage is turned on. Then the inductor current rises linearly until the voltage sensed at the feedback input reaches the 5.1V reference.

The second comparator then resets the latch and the output stage is turned off. The current in the choke falls linearly until it is fully discharged, then the cycle repeats. Closing the loop directly gives an output voltage of 5.1V. Higher output voltages are

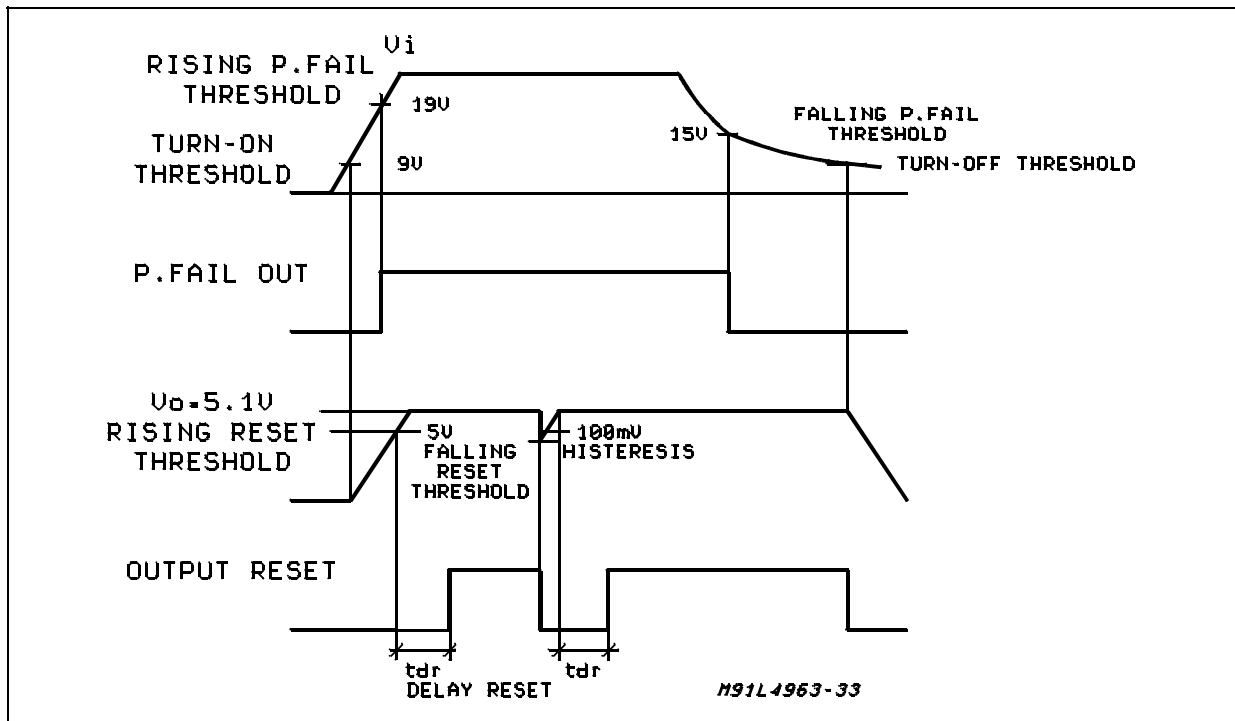
obtained by inserting a voltage divider and this method of control requires no frequency compensation network. At output voltages greater than 5.1V the available output current must be derated due to the increased power dissipation of the device.

Output overload protection is provided by an internal current limiter. The load current is sensed by a on-chip metal resistor connected to a comparator which resets the latch and turns off the power stage in overload condition. The reset circuits (see fig. 1) generates an output high signal when the output voltage value is correct. It has an open collector output and the output signal delay time can be programmed with an external capacitor. A power-fail circuit is also available and is used to monitor the supply voltage. Its output goes high when the supply voltage reaches a pre-programmed threshold set by a voltage divider to its input from the supply to ground. With the input left open the threshold is approximately equal to 5.1V. The output of the power fail is an open collector.

A TTL level inhibit is provided for applications such as remote on/off control. This input is activated by a low logic level and disables circuits operation.

The thermal overload circuit disables the device when the junction temperature is about 150°C and has hysteresis to prevent unstable conditions.

**Figure 1: Reset and Power Fail Function**



**ELECTRICAL CHARACTERISTIC** (Refer to the test circuit  $V_i = 30V$   $T_j = 25^\circ C$  unless otherwise specified )

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit | Fig. |
|--------|-----------|-----------------|------|------|------|------|------|
|--------|-----------|-----------------|------|------|------|------|------|

**DYNAMIC CHARACTERISTICS**

|                 |   |  |           |     |     |                |    |
|-----------------|---|--|-----------|-----|-----|----------------|----|
| $V_o$           | Output Voltage Range                          | $V_i = 46V$ $I_o = 0.5A$   | $V_{ref}$ |     | 36  | V              | 2  |
| $V_i$           | Input Voltage Range                           | $V_o = V_{ref}$ to $36V$ $I_o = 0.5A$                              | 9         |     | 46  | V              | 2  |
| $V_{12}$        | Feedback Voltage                              | $V_i = 9$ to $46V$ $I_o = 0.5A$                                    | 5         | 5.1 | 5.2 | V              | 2  |
| $I_{12}$        | Input Bias Current                            | $V_i = 15V$ $V_{12} = 6V$<br>$V_{17f} = 5V$                        |           | 5   | 20  | $\mu A$        | 3a |
| $V_{OS12}$      | Input Offset Voltage                          |  |           | 5   | 10  | mV             | 3a |
| $\Delta V_o$    | Line Regulation                               | $V_i = 9$ to $46V$ $V_o = V_{ref}$<br>$I_o = 0.5A$                 |           | 15  | 50  | mV             | 2  |
| $\Delta V_o$    | Load Regulation                               | $V_o = V_{ref}$<br>$I_o = 0.5$ to $1.5A$                           |           | 15  | 45  | mV             | 2  |
| $V_d$           | Dropout Voltage Between pin 3 and pin 2       | $I_2 = 3A$<br>$V_i = 20V$  |           | 1.5 | 2   | V              | 2  |
| $I_{2L}$        | Current Limiting                              | $V_i = 9$ to $46V$<br>$V_o = V_{ref}$ to $28V$                     | 3.5       |     | 6.5 | A              | 2  |
| $I_o$           | Maximum Operating Load Current                | $V_i = 9$ to $46V$ $V_o = V_{ref}$                                 | 1.5       |     |     | A              | 2  |
| SVR             | Supply Voltage Ripple Rejection               | $V_i = 2V_{rms}$ $V_o = V_{ref}$<br>fripple = $100Hz$ $I_o = 1.5A$ | 50        | 56  |     | dB             | 2  |
| $V_{11}$        | Reference Voltage                             | $V_i = 9$ to $46V$<br>$0 < I_{11} < 5mA$                           | 5         | 5.1 | 5.2 | V              | 3a |
|                 | Average Temperature Coefficient of Ref. Volt. | $T_j = 0$ to $125^\circ C$   |           | 0.4 |     | mV/ $^\circ C$ | -  |
| $\Delta V_{11}$ | $V_{ref}$ Line Regulation                     | $V_i = 9$ to $46V$   |           | 10  | 20  | mV             | 3a |
| $\Delta V_{11}$ | $V_{ref}$ Line Regulation                     | $I_{ref} = 0$ to $5mA$<br>$V_i = 46V$ $R_{osc} = 51K\Omega$        | 65<br>69  | 7   | 15  | mV             | 3a |
| $\eta$          | Efficiency                                    | $I_o = 1.5A$ $V_o = V_{ref}$                                       | 65        | 75  |     | %              | 2  |
| $T_{sd}$        | Thermal Shutdown Junction Temperature         |  | 145       | 150 |     | $^\circ C$     | -  |
|                 | Hysteresis                                    |  |           | 30  |     | $^\circ C$     | -  |

**DC CHARACTERISTICS**

|       |                         |                            |                                       |  |    |    |    |    |
|-------|-------------------------|----------------------------|---------------------------------------|--|----|----|----|----|
| $I_q$ | Quiescent Drain Current | $V_i = 46V$<br>$I_o = 0mA$ | $V_{16} = V_{12} = 0$                 |  | 14 | 20 | mA | 3a |
|       |                         |                            | $V_{16} = V_{ref}$<br>$V_{12} = 5.3V$ |  | 11 | 16 | mA | 3a |

**INHIBIT**

|           |                                       |                    |     |    |     |         |   |
|-----------|---------------------------------------|--------------------|-----|----|-----|---------|---|
| $V_{16L}$ | Low Input Voltage                     | $V_i = 9$ to $46V$ | 0.3 |    | 0.8 | V       | 2 |
| $V_{16H}$ | High Input Voltage                    | $V_i = 9$ to $46V$ | 2   |    | 5.5 | V       | 2 |
| $I_{16L}$ | Input Current with Low Input Voltage  | $V_{16} = 0.8V$    |     | 50 | 100 | $\mu A$ | 2 |
| $I_{16L}$ | Input Current with High Input Voltage | $V_{16} = 2V$      |     | 10 | 20  | $\mu A$ | 2 |

## ELECTRICAL CHARACTERISTIC (Continued)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit | Fig. |
|--------|-----------|-----------------|------|------|------|------|------|
|--------|-----------|-----------------|------|------|------|------|------|

## RESET

|            |                                 |                                    |                   |                   |                   |         |    |
|------------|---------------------------------|------------------------------------|-------------------|-------------------|-------------------|---------|----|
| $V_{12}$   | Rising Threshold Voltage        | $V_i = 9$ to 46V                   | $V_{ref}$<br>-150 | $V_{ref}$<br>-100 | $V_{ref}$<br>-50  | mV      | 3b |
| $V_{12}$   | Falling Threshold Voltage       | $V_i = 9$ to 46V                   | $V_{ref}$<br>-150 | $V_{ref}$<br>-200 | $V_{ref}$<br>-250 | mV      | 3b |
| $V_{9D}$   | Delay Rising Threshold Voltage  | $V_7 = OPEN$                       | 4.3               | 4.5               | 4.7               | V       | 3b |
| $V_{9F}$   | Delay Falling Threshold Voltage |                                    | 1                 | 1.5               | 2                 | V       | 3b |
| $-I_{9SO}$ | Delay Source Current            | $V_9 = 4.7V$ $V_{12} = 5.3V$       | 70                | 110               | 140               | $\mu A$ | 3b |
| $I_{9SI}$  | Delay Sink Current              | $V_9 = 4.7V$ $V_{12} = 4.7V$       | 10                |                   |                   | mA      | 3b |
| $I_{10}$   | Output Leakage Current          | $V_i = 46V$ $V_7 = 8.5V$           | 50                |                   |                   | $\mu A$ | 3b |
| $V_{10}$   | Output Saturation Volt.         | $I_{10} = 15mA$ ; $V_i = 3$ to 46V |                   |                   | 0.4               | V       | 3b |

## POWER FAIL

|       |                           |             |       |     |       |         |    |
|-------|---------------------------|-------------|-------|-----|-------|---------|----|
| $V_R$ | Rising Threshold Voltage  | Pin7 = open | 17.5  | 19  | 20.5  | V       | 3C |
| $V_F$ | Falling Threshold Voltage | Pin7 = open | 14.25 | 15  | 15.75 | V       | 3c |
| $V_7$ | Rising Threshold Voltage  | $V_i = 20V$ | 4.14  | 4.5 | 4.86  | V       | -  |
| $V_7$ | Falling Threshold Voltage | $V_i = 20V$ | 3.325 | 3.5 | 3.675 | V       | -  |
| $V_s$ | Output Saturation Volt.   | $I_a = 5mA$ |       |     | 0.4   | V       | 3c |
| $I_s$ | Output Leakage Current    | $V_i = 46V$ |       |     | 50    | $\mu A$ | 3c |

## OSCILLATOR

|   |                      |   |    |    |    |     |   |
|---|----------------------|---|----|----|----|-----|---|
| f | Oscillator Frequency | $R_T = 51K\Omega$   | 46 | 60 | 79 | kHz | - |
| f | Oscillator Frequency | $V_i = 9$ to 46V<br>$T_j = 0$ to 125°C<br>$R_T = 51K\Omega$ | 42 |    | 83 | kHz | - |

Figure 2: Test Circuit

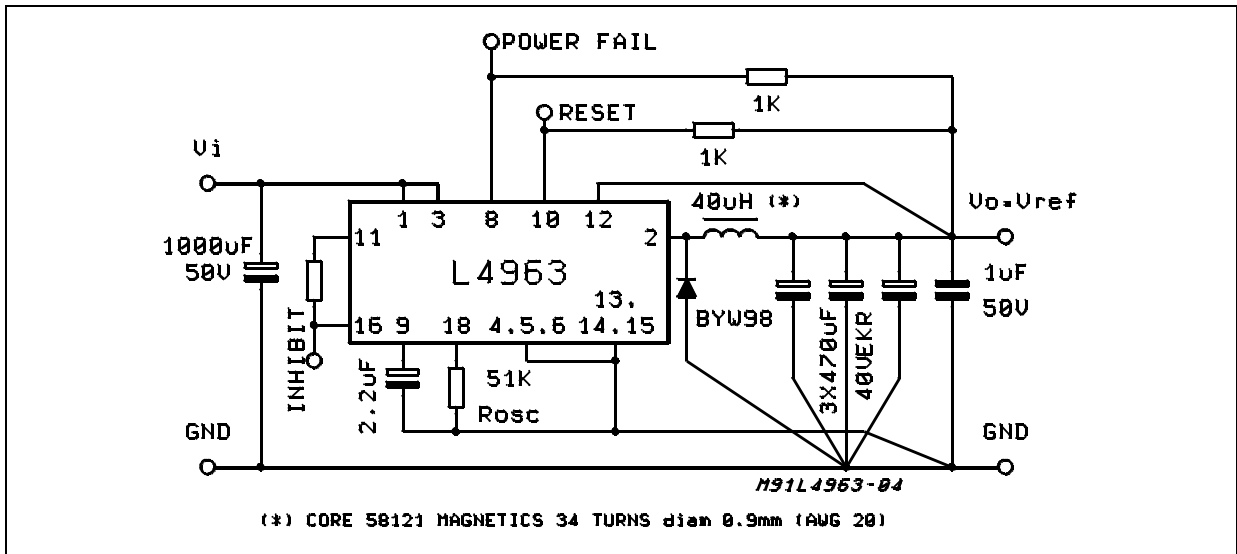


Figure 3: DC Test Circuit

Figure 3a

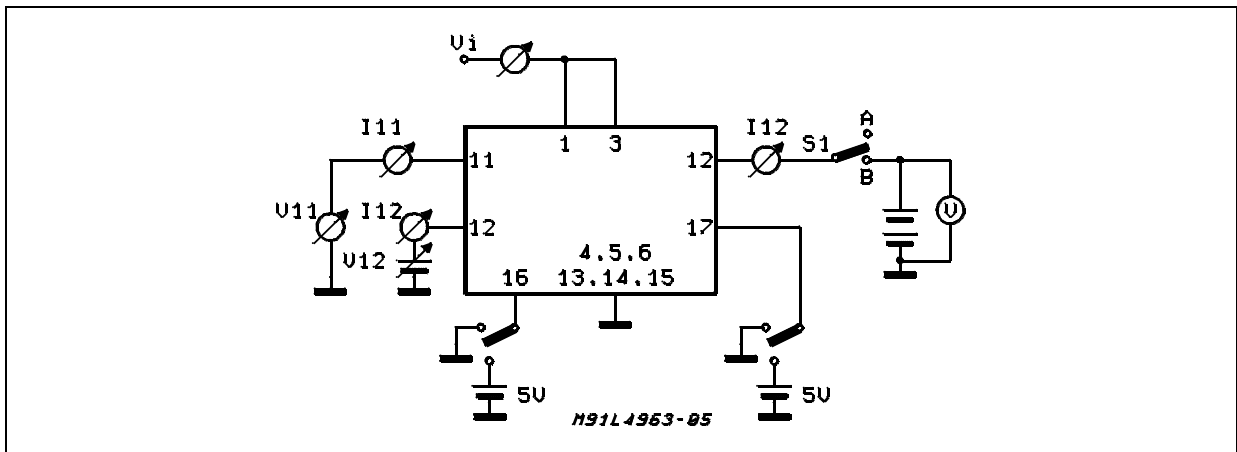


Figure 3b

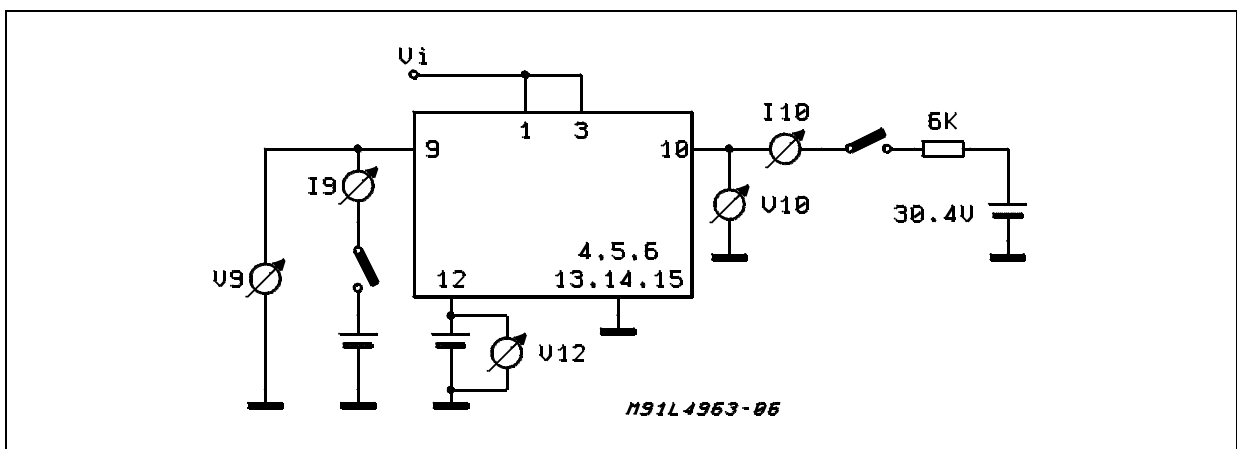


Figure 3c

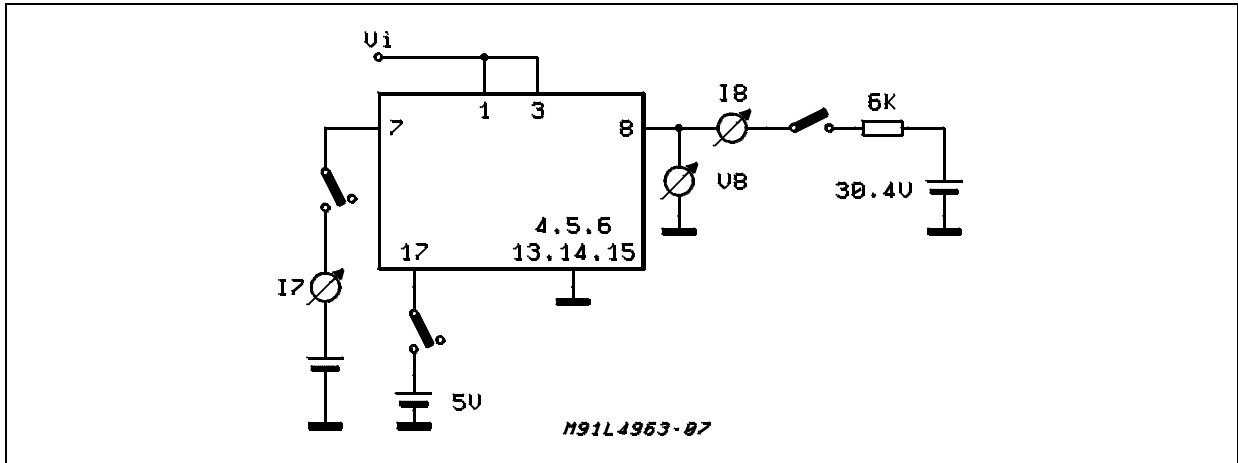


Figure 4: Quiescent Drain Current vs. Supply Voltage (0% Duty Cycle)

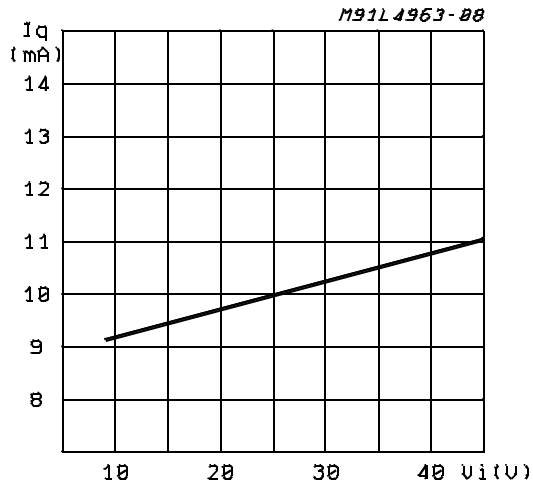


Figure 5: Quiescent Drain Current vs. Supply Voltage (100% Duty Cycle)

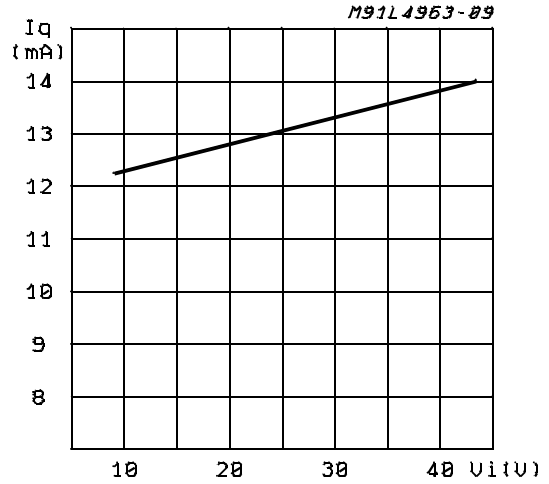


Figure 6: Quiescent Drain Current vs. Junction Temperature (0% Duty Cycle)

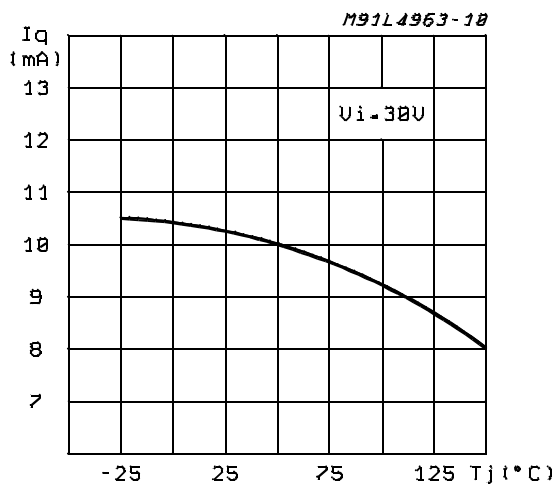


Figure 7: Quiescent Drain Current vs. Junction Temperature (100% Duty Cycle)

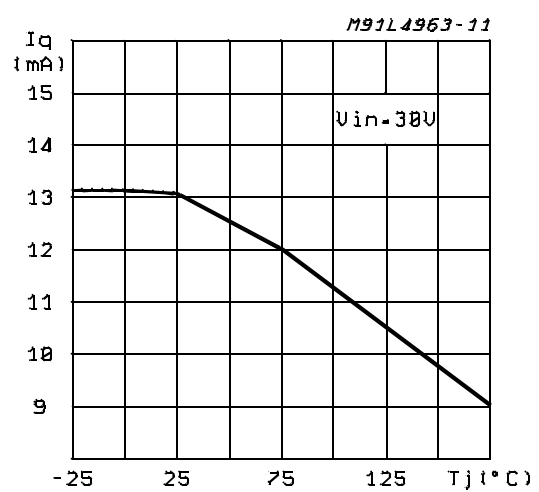




Figure 8: Reference Voltage vs.  $V_i$

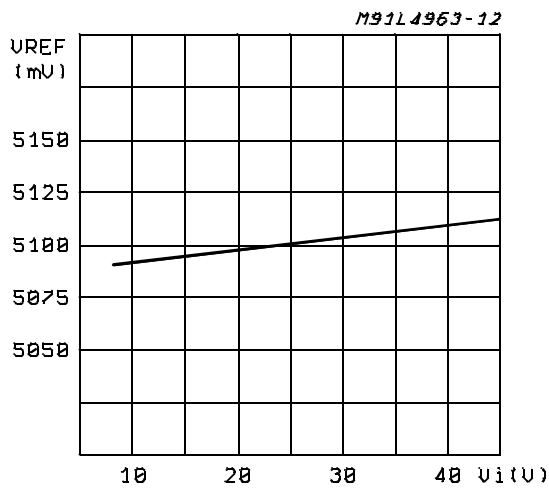


Figure 9: Reference Voltage vs.  $T_j$

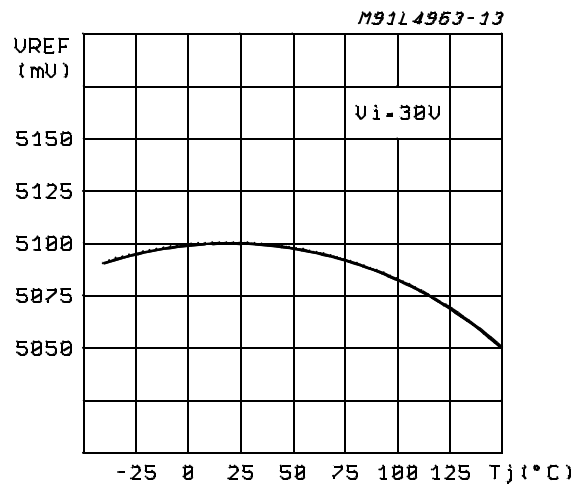


Figure 10: Line Transient Response

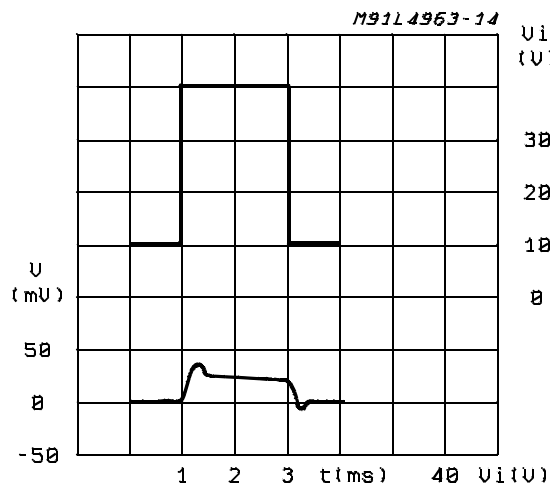


Figure 11: Load Transient

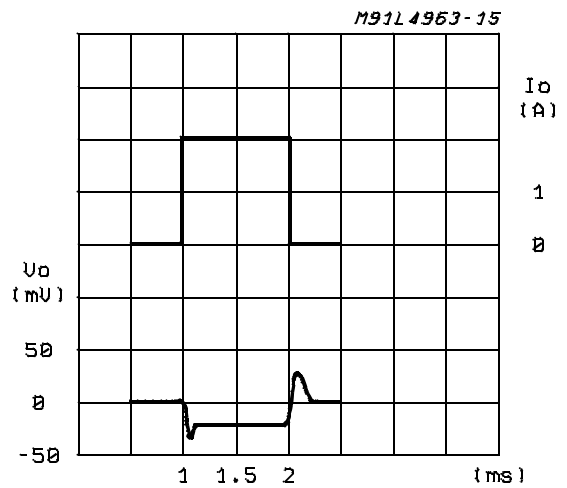


Figure 12: Supply Voltage Ripple Rejection vs. Frequency

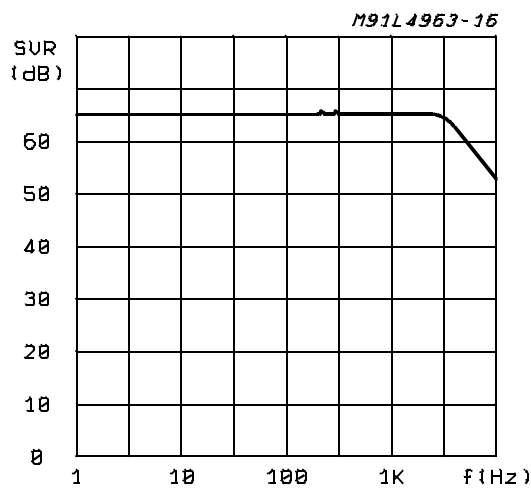
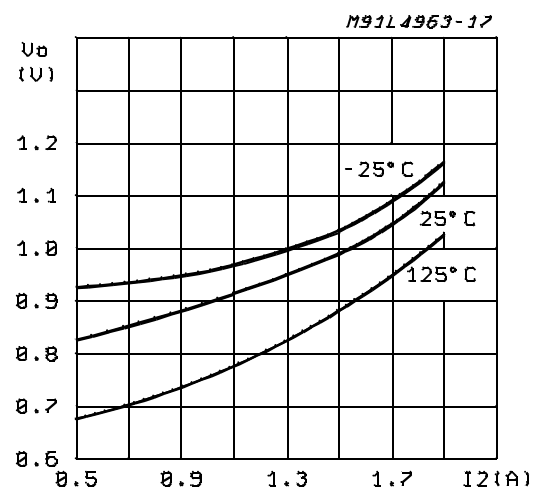
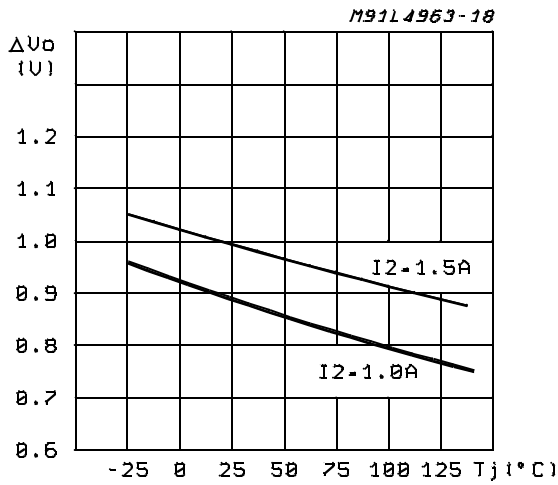


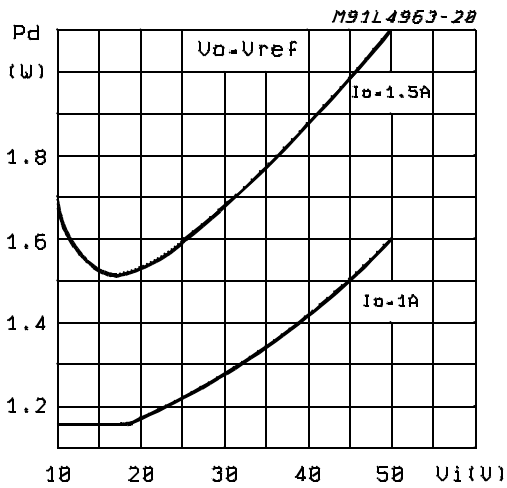
Figure 13: Dropout Voltage Between pin3 and 2 vs. Current at pin2



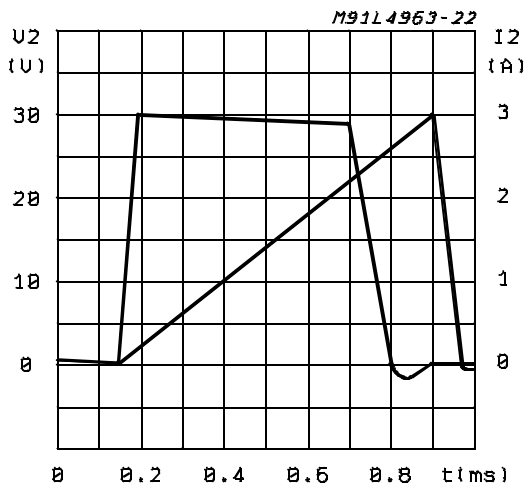
**Figure 14:** Dropout Voltage Between pin3 and 2 vs. Junction Temperature



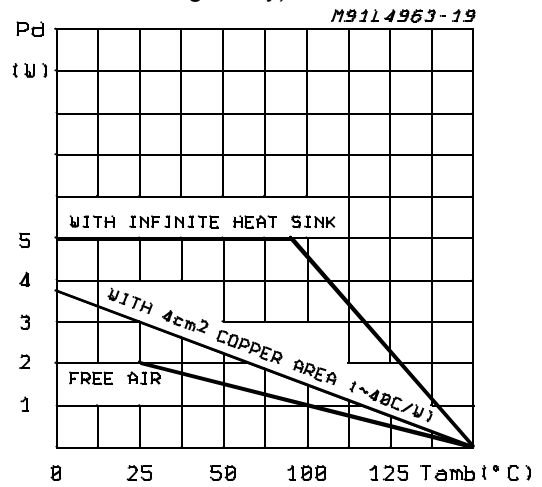
**Figure 16:** Power Dissipation (device only) vs. Input Voltage (Powerdip Package Only)



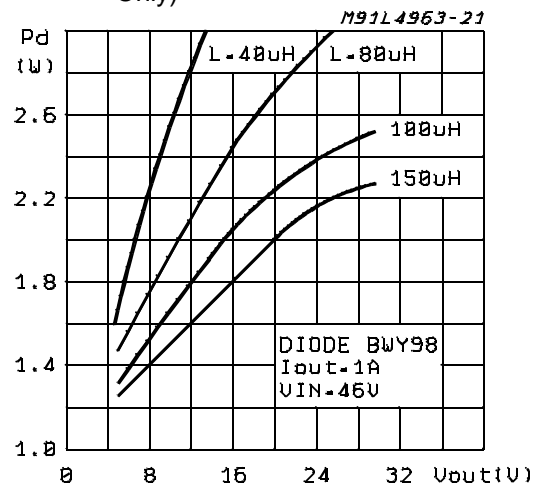
**Figure 18:** Voltage and Current Waveform at pin2



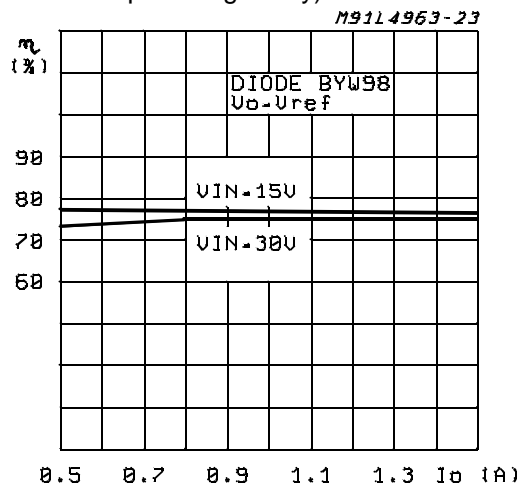
**Figure 15:** Maximum Allowable Power Dissipation vs. Ambient Temperature (Powerdip Package Only)



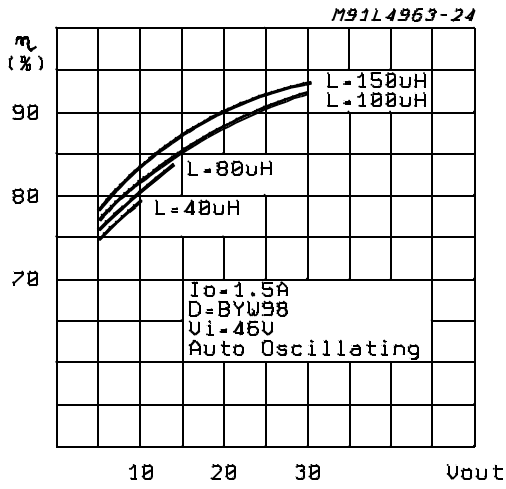
**Figure 17:** Power Dissipation (device only) vs. Output Voltage (Powerdip Package Only)



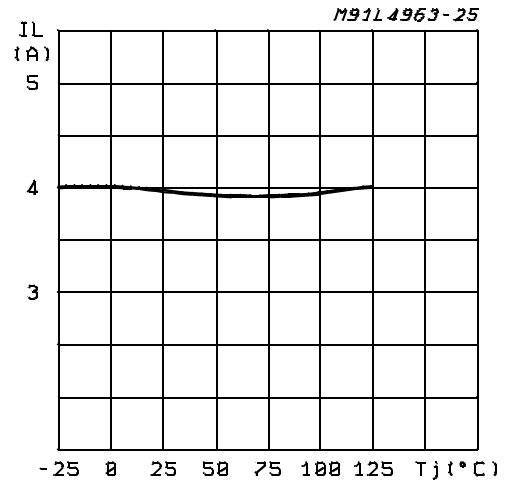
**Figure 19:** Efficiency vs. Output Current (Powerdip Package Only)



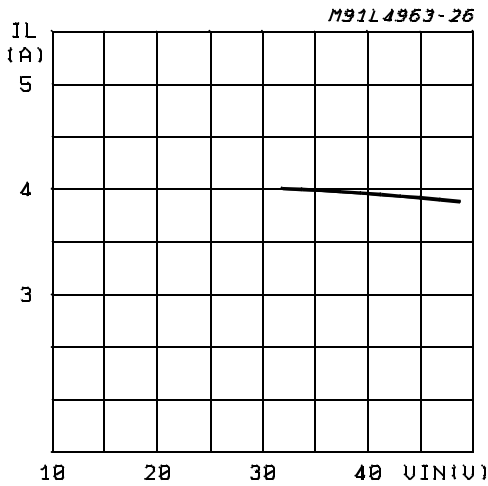
**Figure 20:** Efficiency vs. Output Voltage (Power-dip Package Only)



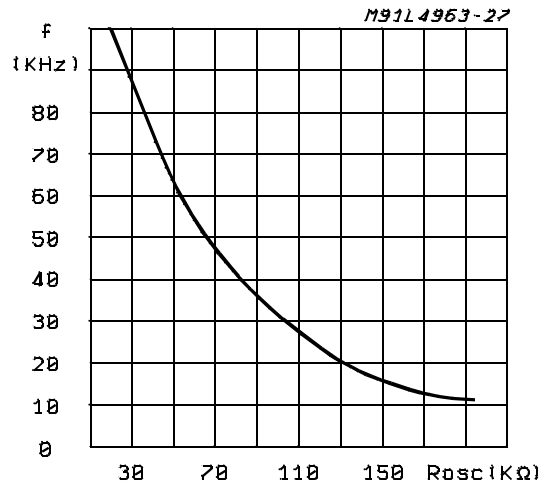
**Figure 21:** Current Limit vs. Junction Temperature  $V_i = 30V$



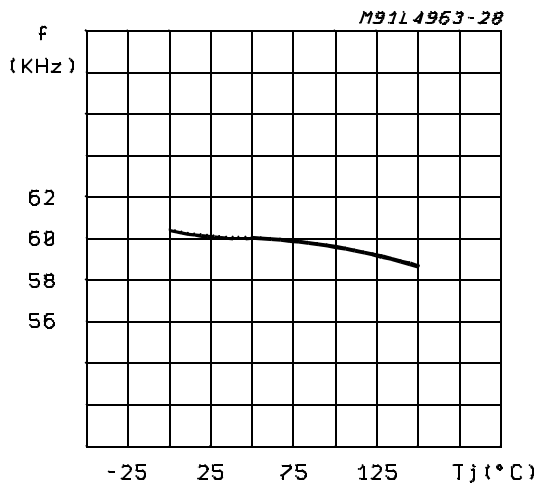
**Figure 22:** Current Limit vs. Input Voltage



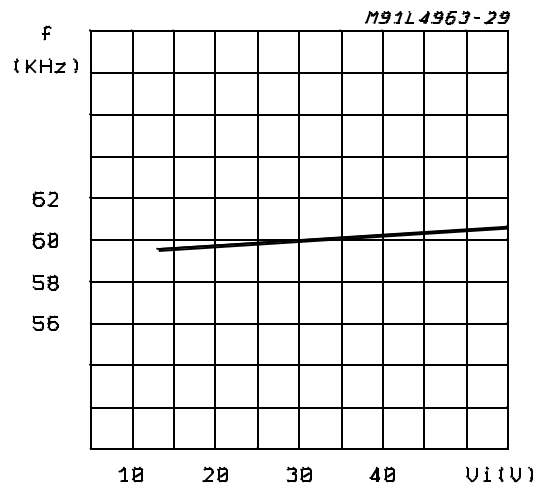
**Figure 23:** Oscillator Frequency vs. R2 (see fig. 26)



**Figure 24:** Oscillator Frequency vs. Junction Temperature

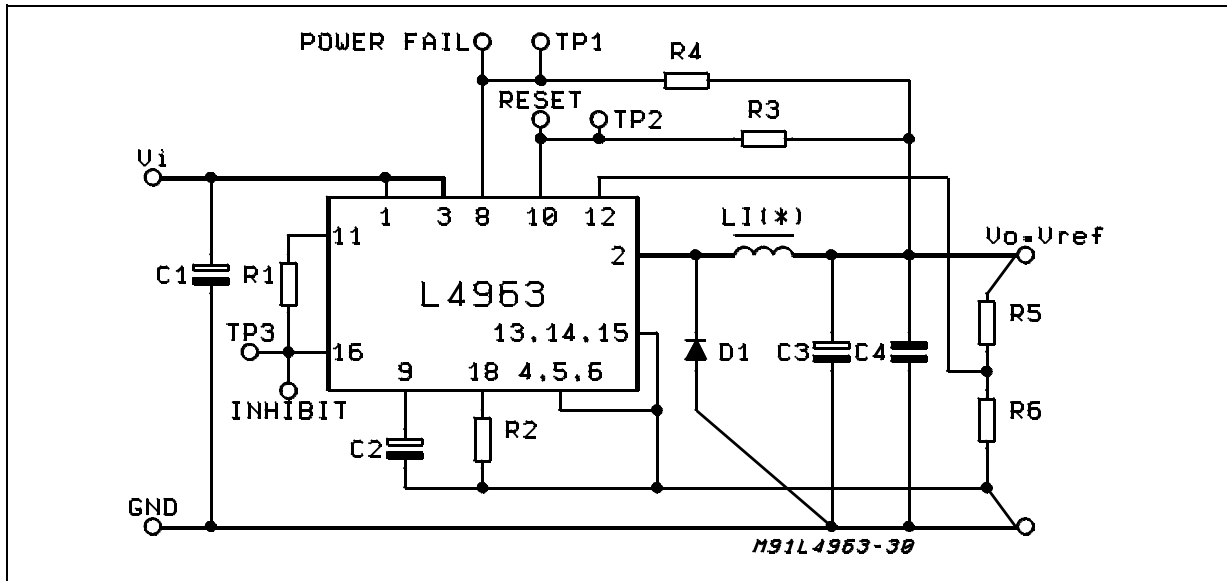


**Figure 25:** Oscillator Frequency vs. Input Voltage



## L4963 - L4963D

Figure 26: Evaluation Board Circuit



### PART LIST

| CAPACITOR |                               |
|-----------|-------------------------------|
| C1        | 1000 $\mu$ F 50V EKR (*)      |
| C2        | 2.2mF 16V                     |
| C3        | 1000 $\mu$ F 40V with low ESR |
| C4        | 1 $\mu$ F 50V film            |
| RESISTOR  |                               |
| R1        | 1K $\Omega$                   |
| R2        | 51K $\Omega$                  |
| R3        | 1K $\Omega$                   |
| R4        | 1K $\Omega$                   |
| R5, R6    | see table                     |

| Resistor Values for Standard Output Voltages |               |               |
|--|---------------|---------------|
| Vo   | R6            | R5            |
| 12   | 4.7K $\Omega$ | 6.2K $\Omega$ |
| 15   | 4.7K $\Omega$ | 9.1KW         |
| 18   | 4.7K $\Omega$ | 12KW          |
| 24   | 4.7K $\Omega$ | 18KW          |

**Diode:** BYW98

**Core:** L = 40 $\mu$ H Magnetics 58121-A2MPP 34 Turns  
0.9mm (20AWG)

(\*) Minimum 100 $\mu$ F if  $V_i$  is a preregulated offline SMPS output or 1000 $\mu$ F if a 50Hz transformer plus rectifiers is used.

Figure 27: P.C. Board and Component Layout of the Circuit of fig. 26 (Powerdip Package) (1:1 scale).

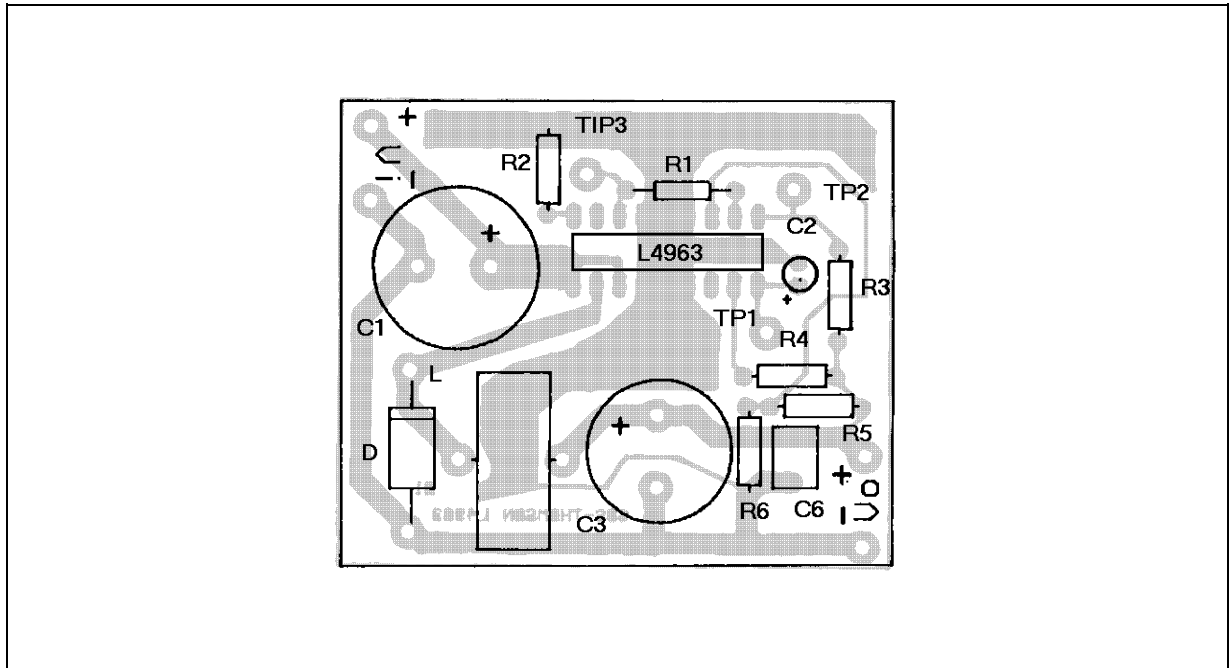


Figure 28: Thermal Characteristics

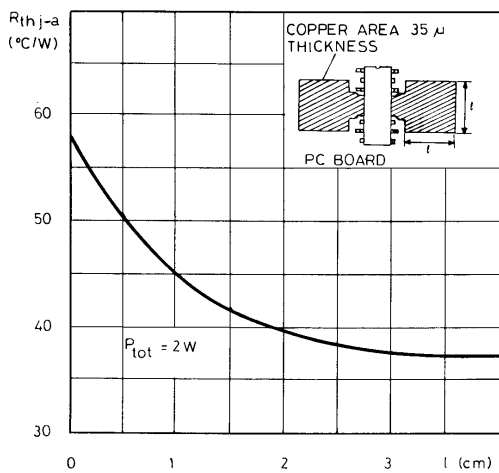
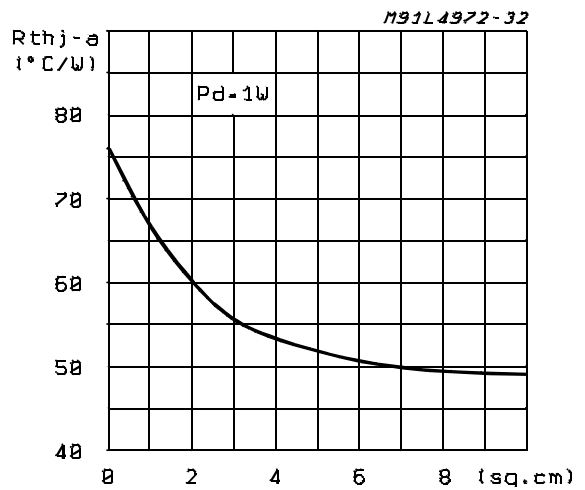


Figure 29: Junction to Ambient Thermal Resistance vs. Area on Board Heatsink (SO20)



## L4963 - L4963D

Figure 30: A Minimal 5.1 Fixed Regulator — Very Few Components are Required

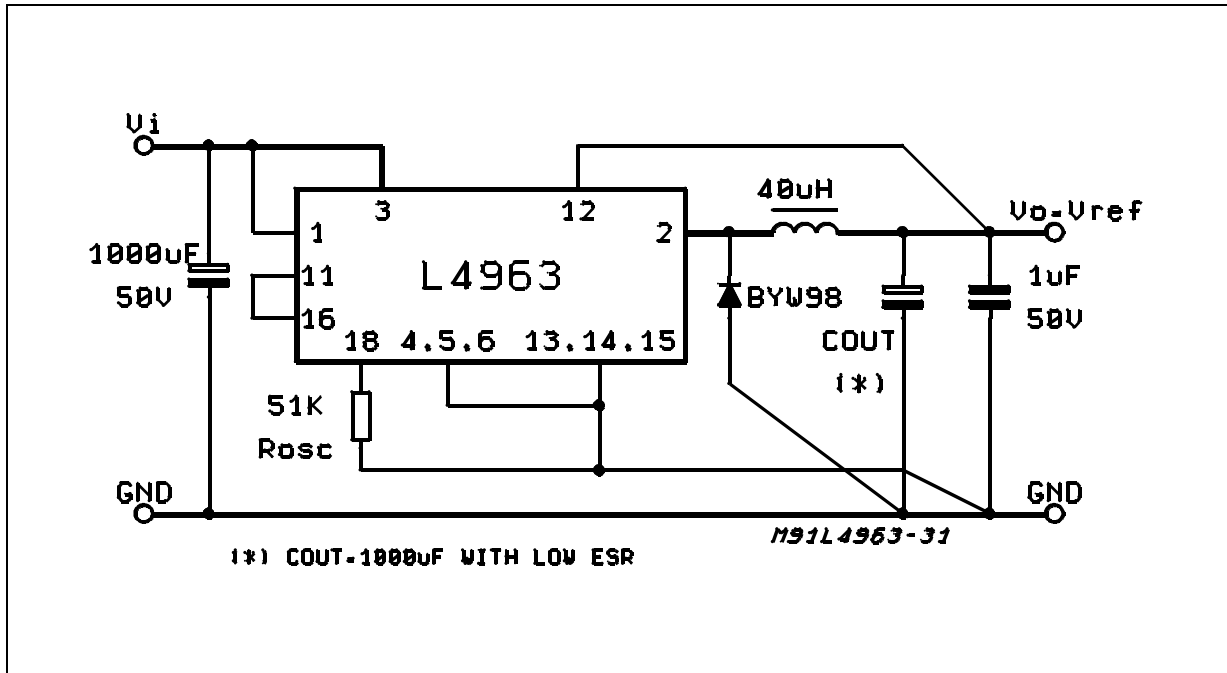
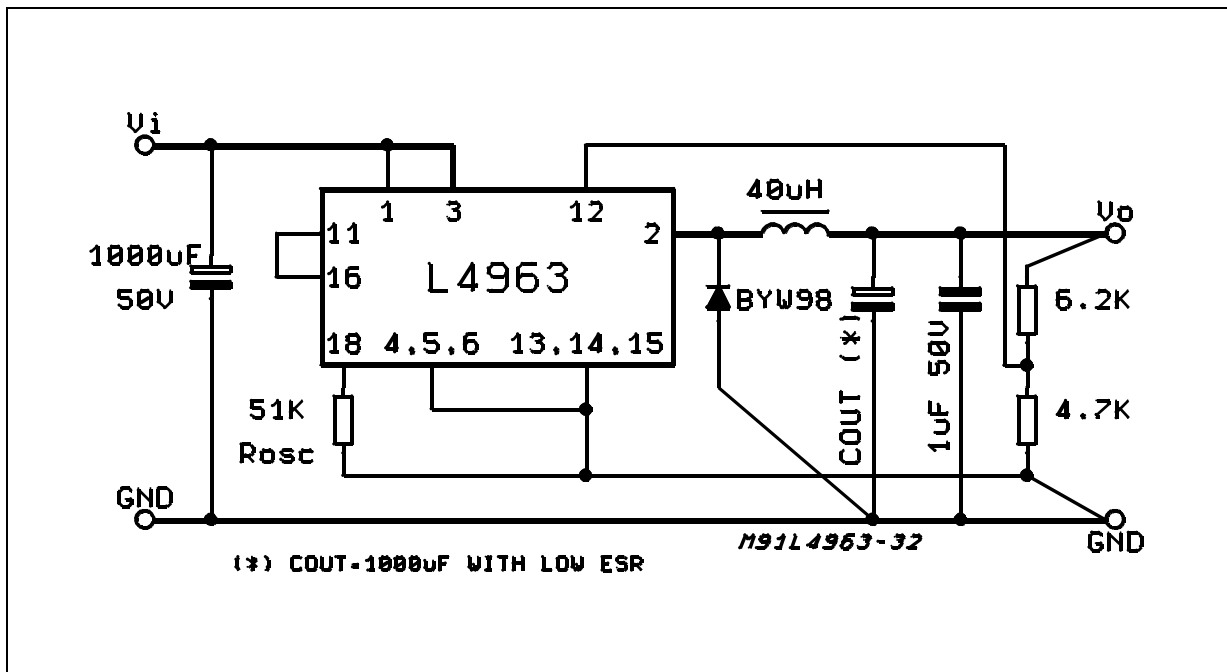
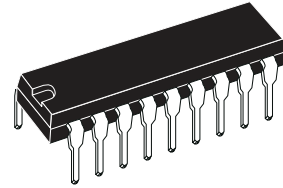


Figure 31: A Minimal Components count for  $V_O = 12V$

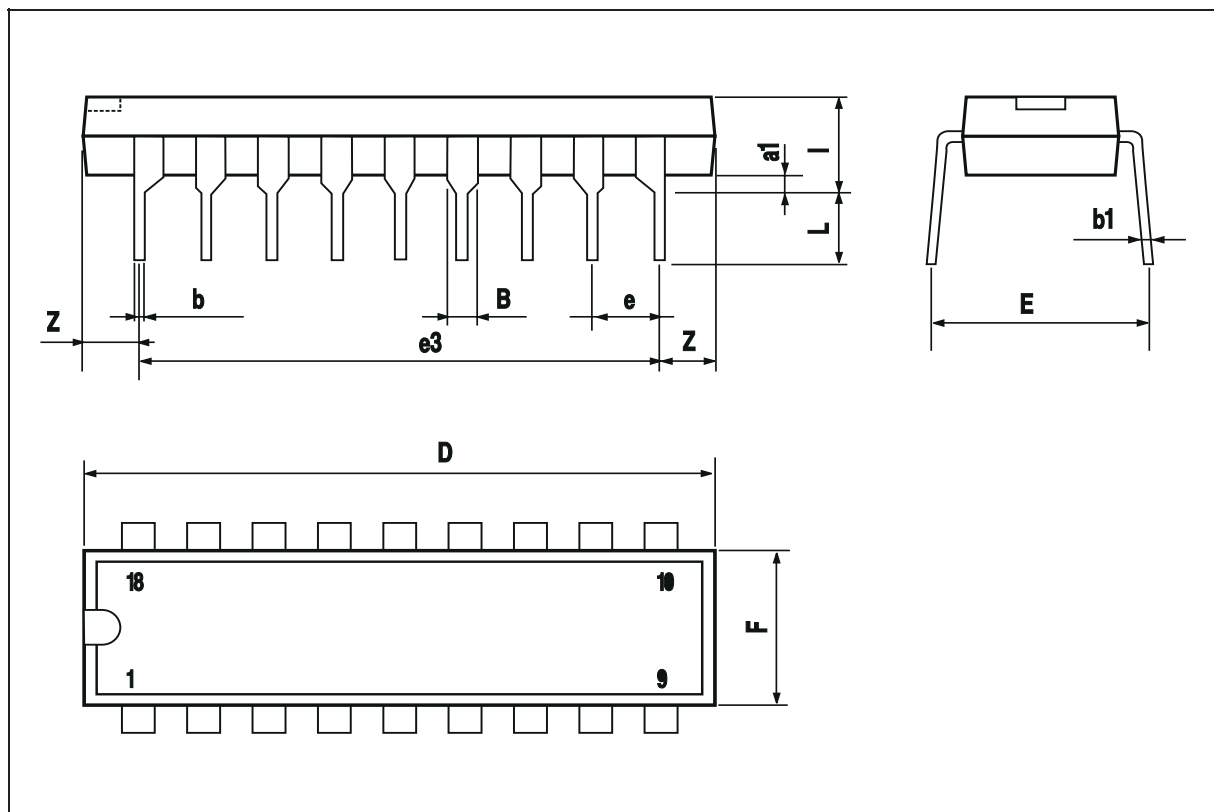


| DIM. | mm   |       |       | inch  |       |       |
|------|------|-------|-------|-------|-------|-------|
|      | MIN. | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| a1   | 0.51 |       |       | 0.020 |       |       |
| B    | 0.85 |       | 1.40  | 0.033 |       | 0.055 |
| b    |      | 0.50  |       |       | 0.020 |       |
| b1   | 0.38 |       | 0.50  | 0.015 |       | 0.020 |
| D    |      |       | 24.80 |       |       | 0.976 |
| E    |      | 8.80  |       |       | 0.346 |       |
| e    |      | 2.54  |       |       | 0.100 |       |
| e3   |      | 20.32 |       |       | 0.800 |       |
| F    |      |       | 7.10  |       |       | 0.280 |
| I    |      |       | 5.10  |       |       | 0.201 |
| L    |      | 3.30  |       |       | 0.130 |       |
| Z    |      |       | 2.54  |       |       | 0.100 |

## OUTLINE AND MECHANICAL DATA



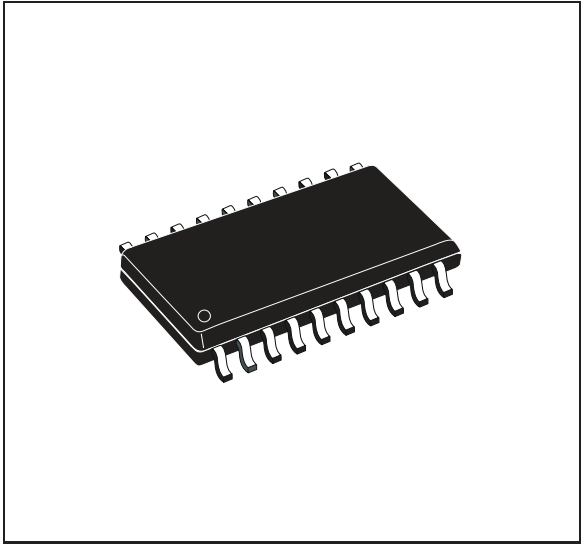
**Powerdip 18**



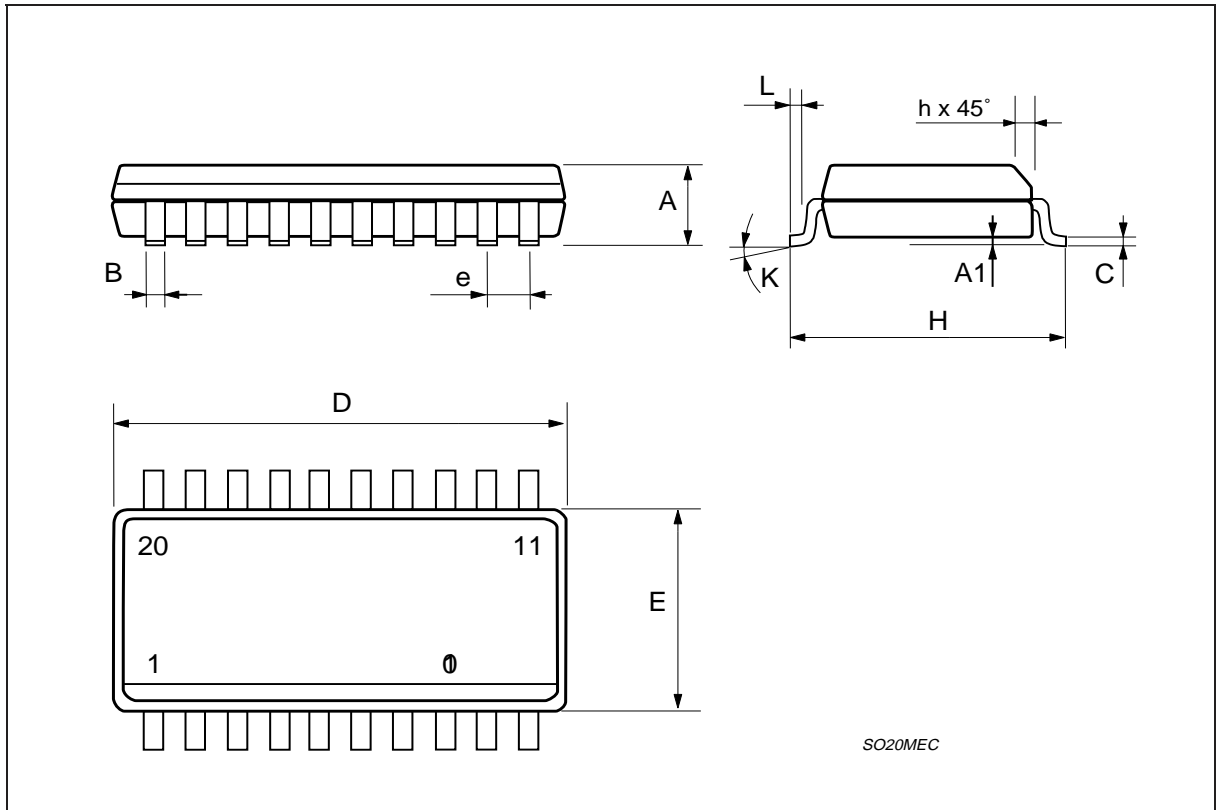
**L4963 - L4963D**

| DIM. | mm                 |      |       | inch  |       |       |
|------|--------------------|------|-------|-------|-------|-------|
|      | MIN.               | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 2.35               |      | 2.65  | 0.093 |       | 0.104 |
| A1   | 0.1                |      | 0.3   | 0.004 |       | 0.012 |
| B    | 0.33               |      | 0.51  | 0.013 |       | 0.020 |
| C    | 0.23               |      | 0.32  | 0.009 |       | 0.013 |
| D    | 12.6               |      | 13    | 0.496 |       | 0.512 |
| E    | 7.4                |      | 7.6   | 0.291 |       | 0.299 |
| e    |                    | 1.27 |       |       | 0.050 |       |
| H    | 10                 |      | 10.65 | 0.394 |       | 0.419 |
| h    | 0.25               |      | 0.75  | 0.010 |       | 0.030 |
| L    | 0.4                |      | 1.27  | 0.016 |       | 0.050 |
| K    | 0° (min.)8° (max.) |      |       |       |       |       |

**OUTLINE AND MECHANICAL DATA**



**SO20**



SO20MEC



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