

## DMOS DUAL FULL BRIDGE DRIVER

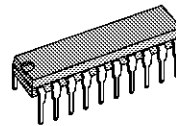
ADVANCE DATA

- SUPPLY VOLTAGE UP TO 48V
- $R_{DS(ON)}$  1.2 $\Omega$  (25°C)
- CROSS CONDUCTION PROTECTION
- THERMAL SHUTDOWN
- 0.5A DC CURRENT
- TTL/CMOS COMPATIBLE DRIVER
- HIGH EFFICIENCY CHOPPING

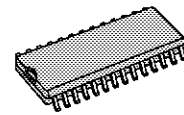
### DESCRIPTION

The L6204 is a dual full bridge driver for motor control applications realized in BCD technology which combines isolated DMOS power transistors with CMOS and Bipolar circuits on the same chip. By using mixed technology it has been possible to optimize the logic circuitry and the power stage to achieve the best possible performance. The logic inputs are TTL/CMOS compatible. Both channels are controlled by a separate Enable. Each bridge has a sense resistor to control the current level.

### MULTIPOWER BCD TECHNOLOGY



Powerdip 16+2+2



SO 24+2+2

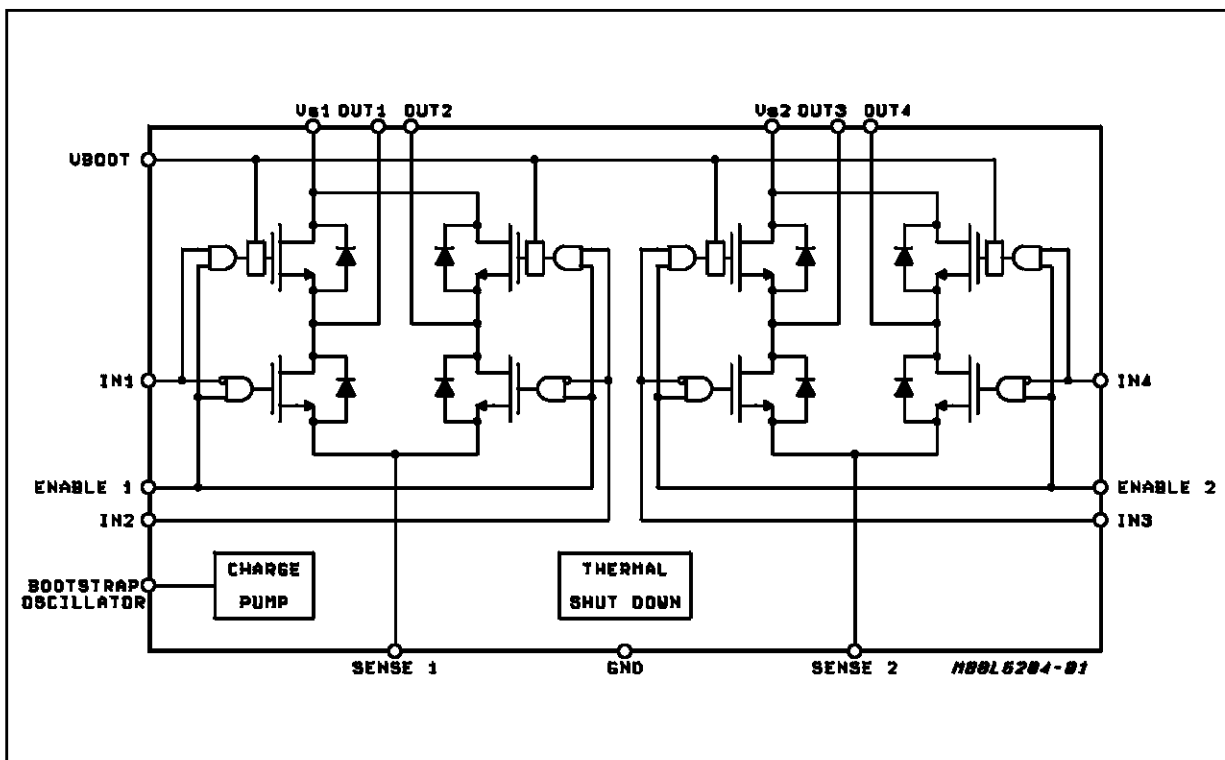
#### ORDERING NUMBERS:

L6204

L6204D

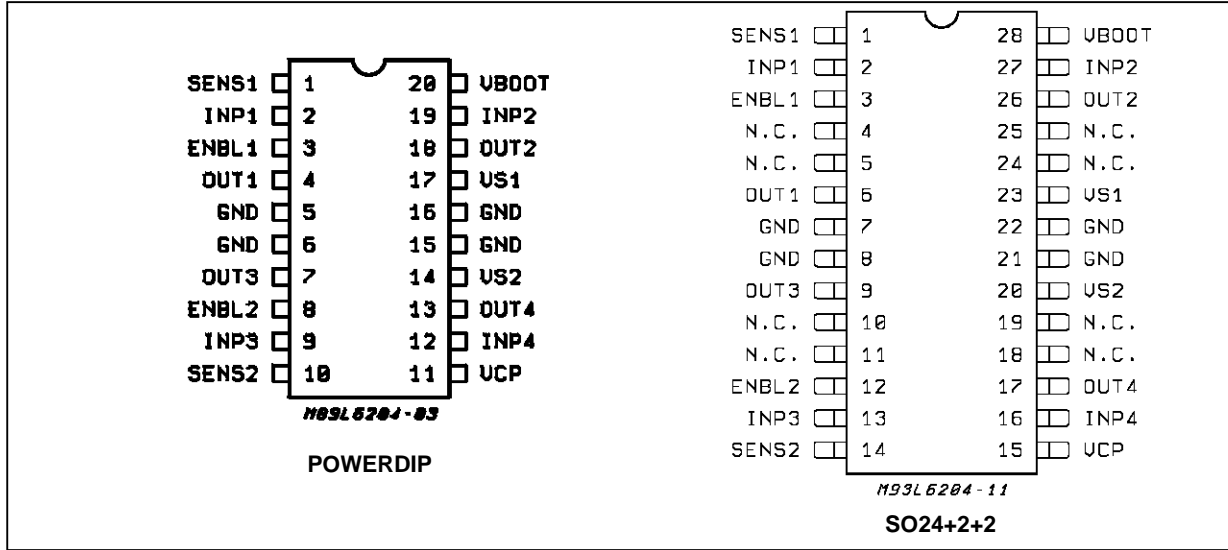
The L6204 is mounted in an 20-lead Powerdip and SO 24+2+2 packages and the four center pins are used to conduct heat to the PCB. At normal operating temperatures no external heatsink is required.

### BLOCK DIAGRAM



# L6204

## PIN CONNECTIONS (Top view)



## PIN FUNCTIONS

| SO Pin (*) | DIP Pin | Symbols           | Functions  |
|------------|---------|-------------------|--|
| 1          | 1       | SENSE 1           | Sense resistor to provide the feedback for motor current control of the bridge A |
| 2          | 2       | IN1               | Digital input from the motor controller (bridge A)                               |
| 3          | 3       | ENABLE 1          | A logic level low on this pin disable the bridge A                               |
| 4          | 4       | OUT 1             | Output of one half bridge of the bridge A  |
| 5          | 5       | GND               | Common Power Ground  |
| 6          | 6       | GND               | Common Power Ground  |
| 7          | 7       | OUT 3             | Output of one half bridge of the bridge B  |
| 8          | 8       | ENABLE 2          | A logic level low on this pin disable the bridge B                               |
| 9          | 9       | IN 3              | Digital input from the motor controller (bridge B)                               |
| 10         | 10      | SENSE 2           | Sense resistor to provide the feedback for motor current control of the bridge B |
| 11         | 11      | BOOSTRAP OSC. VCP | Oscillator output for the external charge pump                                   |
| 12         | 12      | IN 4              | Digital input from the motor controller (bridge B)                               |
| 13         | 13      | OUT 4             | Output of one half bridge of the bridge B  |
| 14         | 14      | V <sub>S2</sub>   | Supply voltage bridge B  |
| 15         | 15      | GND               | Common Power Ground  |
| 16         | 16      | GND               | Common Power Ground  |
| 17         | 17      | V <sub>S1</sub>   | Supply Voltage bridge A  |
| 18         | 18      | OUT 2             | Output of one half bridge of the bridge A  |
| 19         | 19      | IN 2              | Digital input from the motor controller (bridge A)                               |
| 20         | 20      | VBOOT             | Oversvoltage input for driving of the upper DMOS                                 |

(\*) For SO package the pins 4, 5, 10, 11, 18, 19, 24 and 25 are not connected.

## ABSOLUTE MAXIMUM RATINGS

| Symbol                            | Parameter   | Test Conditions   | Unit |   |
|-----------------------------------|---|---|------|---|
| V <sub>S</sub>                    | Supply Voltage                                      | 50  | V    |   |
| V <sub>IN</sub> , V <sub>EN</sub> | Input or Enable Voltage Range                       | -0.3 to +7  | V    |   |
| I <sub>o</sub>                    | Pulsed Output Current                               | 3   | A    |   |
| V <sub>SENSE</sub>                | Sensing Voltage                                     | -1 to 4   | V    |   |
| V <sub>BOOT</sub>                 | Bootstrap Supply                                    | 60  | V    |   |
| P <sub>tot</sub>                  | Total power dissipation: (T <sub>pins</sub> = 80°C) | (T <sub>amb</sub> = 70°C no copper area on PCB)               | 5    | W |
|                                   |   | (T <sub>amb</sub> = 70°C 8cm <sup>2</sup> copper area on PCB) | 1.23 | W |
|                                   |   |   | 2    | W |
| T <sub>stg</sub> , T <sub>j</sub> | Storage and Junction Temperature                    | -40 to 150  | °C   |   |

## THERMAL DATA

| Symbol           | Description                         |     | SO | DIP | Unit                        |
|------------------|-------------------------------------|-----|----|-----|-----------------------------|
| $R_{th\ j-pins}$ | Thermal Resistance Junction-pins    | Max | 16 | 14  | $^{\circ}\text{C}/\text{W}$ |
| $R_{th\ j-amb}$  | Thermal Resistance Junction-ambient | Max | 73 | 65  | $^{\circ}\text{C}/\text{W}$ |

ELECTRICAL CHARACTERISTICS ( $V_s = 42\text{V}$ ,  $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Symbol | Parameter               | Test Condition                                | Min. | Typ. | Max.     | Unit               |
|--------|-------------------------|---|------|------|----------|--------------------|
| $V_s$  | Supply Voltage          |   | 12   |      | 48       | V                  |
| $I_s$  | Total Quiescent Current | EN1=EN2=H; IN1=IN2=IN3=IN4=L<br>EN1 = EN2 = L |      |      | 10<br>10 | mA<br>mA           |
| $f_c$  | Commutation Frequency   |   |      | 20   |          | KHz                |
| $T_J$  | Thermal Shutdown        |   |      | 150  |          | $^{\circ}\text{C}$ |
| $T_d$  | Dead Time Protection    |   |      | 500  |          | ns                 |

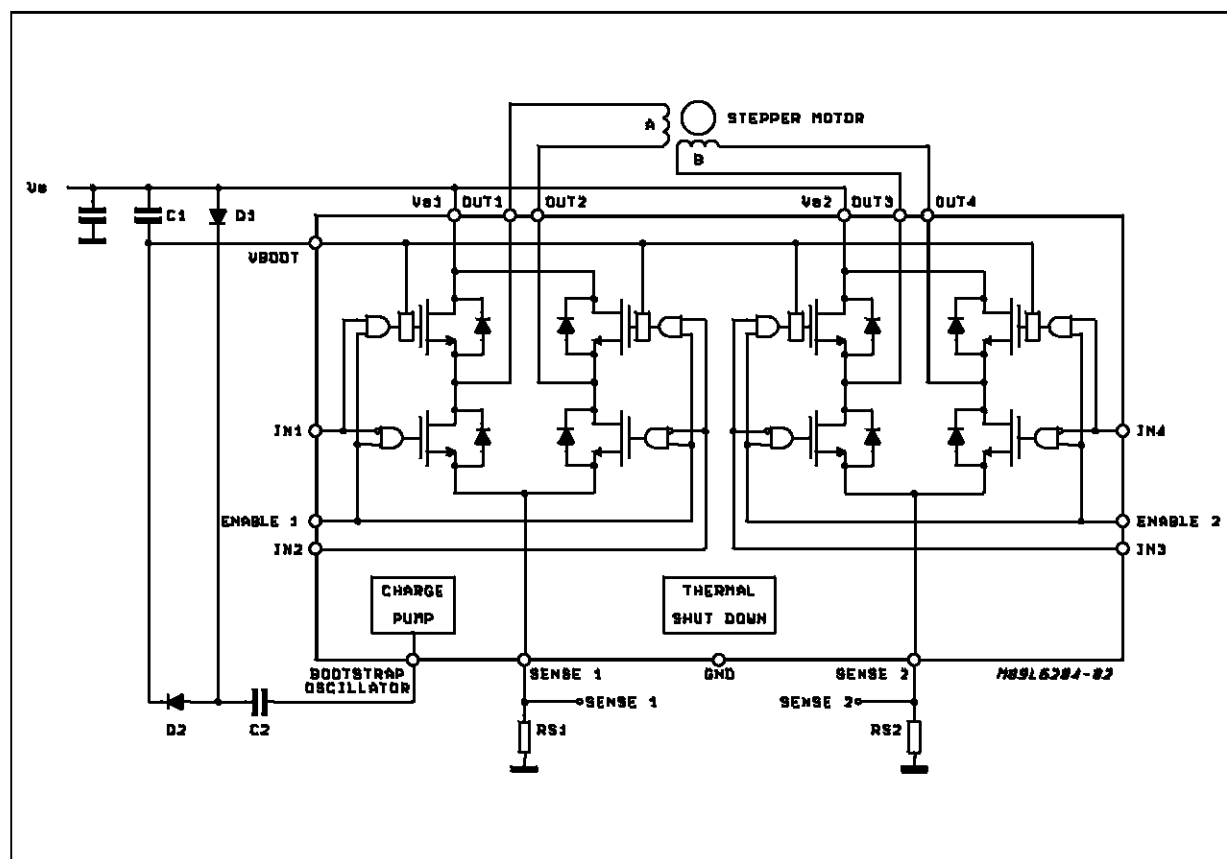
## TRANSISTORS

|           |                 |     |  |     |  |          |
|-----------|-----------------|-----|--|-----|--|----------|
| $I_{DSS}$ | Leakage Current | OFF |  | 1   |  | mA       |
| $R_{DS}$  | On Resistance   | ON  |  | 1.2 |  | $\Omega$ |

## LOGIC LEVELS

|                    |                    |                                       |      |    |     |               |
|--------------------|--------------------|---------------------------------------|------|----|-----|---------------|
| $V_{INL}, V_{ENL}$ | Input Low Voltage  |                                       | -0.3 |    | 0.8 | V             |
| $V_{INH}, V_{ENH}$ | Input High Voltage |                                       | 2    |    | 7   | V             |
| $I_{INL}, I_{ENL}$ | Input Low Current  | IN1 = IN2 = IN3 = IN4 = EN1 = EN2 = L |      |    | -10 | $\mu\text{A}$ |
| $I_{INH}, I_{ENH}$ | Input High Current | IN1 = IN2 = IN3 = IN4 = EN1 = EN2 = H |      | 50 |     | $\mu\text{A}$ |

## APPLICATION DIAGRAM



**CIRCUIT DESCRIPTION**

L6204 is a dual full bridge IC designed to drive DC motors, stepper motors and other inductive loads. Each bridge has 4 power DMOS transistor with  $R_{DS(on)} = 1.2\Omega$  and the relative protection and control circuitry. (see fig. 3)

The 4 half bridges can be controlled independently by means of the 4 inputs IN1, IN2, IN3, IN4 and 2 enable inputs ENABLE1 and ENABLE2.

External connections are provided so that sensing resistors can be added for constant current chopper applications.

**LOGIC DRIVE (\*)**

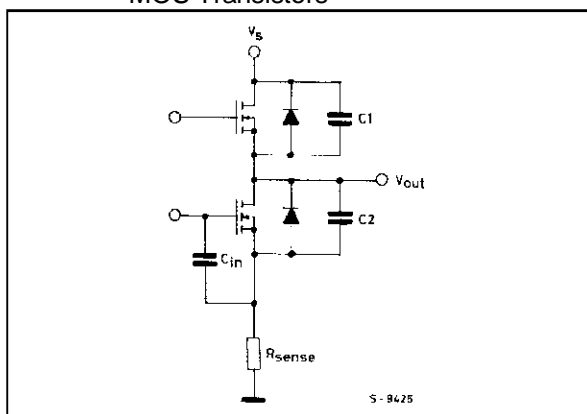
|           | INPUTS     |            | OUTPUT MOSFETS            |
|-----------|------------|------------|---------------------------|
|           | IN1<br>IN3 | IN2<br>IN4 |                           |
| EN1=EN2=H | L          | L          | Sink 1, Sink 2            |
|           | L          | H          | Sink 1, Source 2          |
|           | H          | L          | Source 1, Sink 2          |
|           | H          | H          | Source 1, Source 2        |
| EN1=EN2=L | X          | X          | All transistor turned OFF |

L = Low H = High X = Don't care  
 (\*) True table for the two full bridges

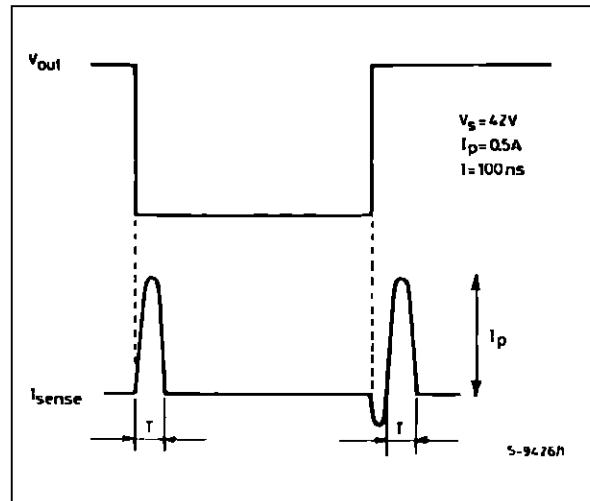
**CROSS CONDUCTION**

Although the device guarantees the absence of cross-conduction, the presence of the intrinsic diodes in the POWER DMOS structure causes the generation of current spikes on the sensing terminals. This is due to charge-discharge phenomena in the capacitors C1 & C2 associated with the drain source junctions (fig. 1). When the output switches from high to low, a current spike is generated associated with the capacitor C1. On the low-to-high transition a spike of the same polarity is generated by C2, preceded by a spike of the opposite polarity due to the charging of the input capacity of the lower POWER DMOS transistor (see fig. 2).

**Figure 1: Intrinsic Structures in the POWER MOS Transistors**



**Figure 2: Current Typical Spikes on the Sensing Pin**



**TRANSISTOR OPERATION ON STATE**

When one of the POWER DMOS transistors is ON it can be considered as a resistor  $R_{DS(ON)} = 1.2\Omega$  at a junction temperature of 25°C.

In this condition the dissipated power is given by :

$$P_{ON} = R_{DS(ON)} \cdot I_{DS}^2$$

The low  $R_{DS(ON)}$  of the Multipower-BCD process can provide high currents with low power dissipation.

**OFF STATE**

When one of the POWER DMOS transistor is OFF the  $V_{DS}$  voltage is equal to the supply voltage and only the leakage current  $I_{DSS}$  flows. The power dissipation during this period is given by :

$$P_{OFF} = V_s \cdot I_{DSS}$$

**TRANSITIONS**

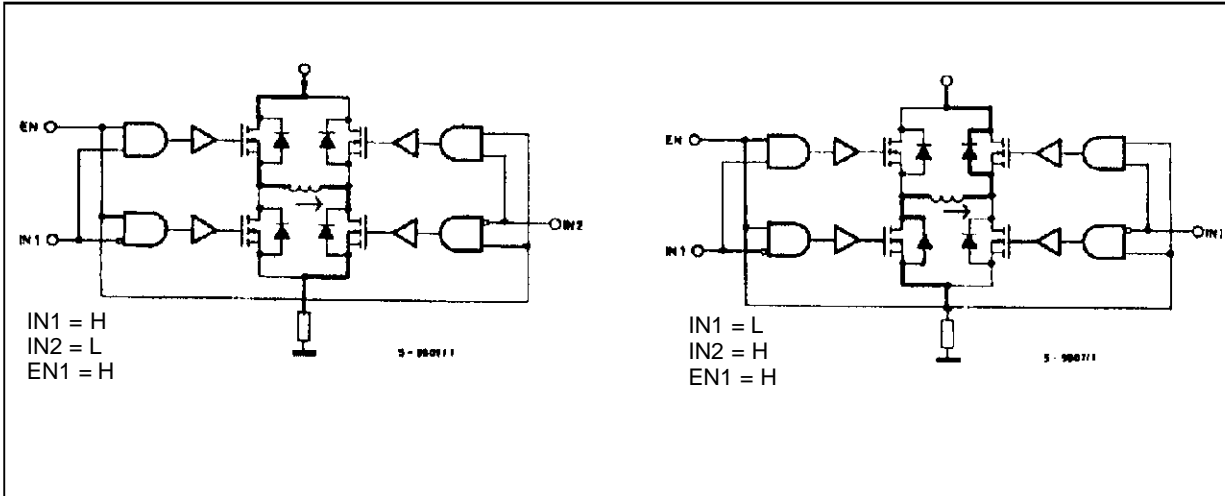
Like all MOS power transistors the DMOS POWER transistors have as intrinsic diode between their source and drain that can operate as a fast freewheeling diode in switched mode applications. During recirculation with the ENABLE input high, the voltage drop across the transistor is  $R_{DS(ON)} \cdot I_D$  and when the voltage reaches the diode voltage it is clamped to its characteristic. When the ENABLE input is low, the POWER MOS is OFF and the diode carries all of the recirculation current. The power dissipated in the transitional times in the cycle depends upon the voltage and current waveforms in the application.

$$P_{trans.} = I_{DS}(t) \cdot V_{DS}(t)$$

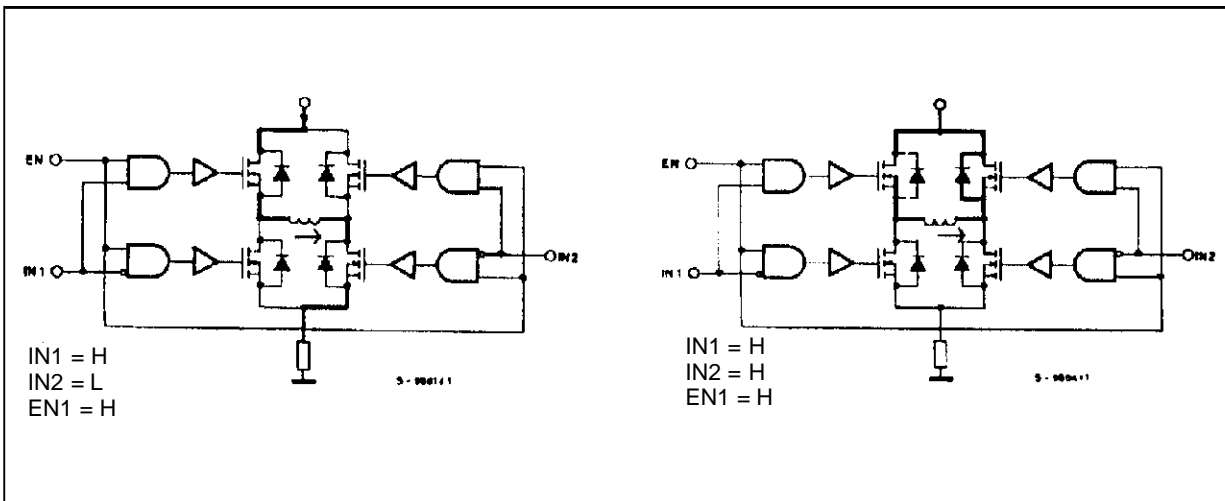
**BOOTSTRAP CAPACITORS**

To ensure the correct driving of high side drivers

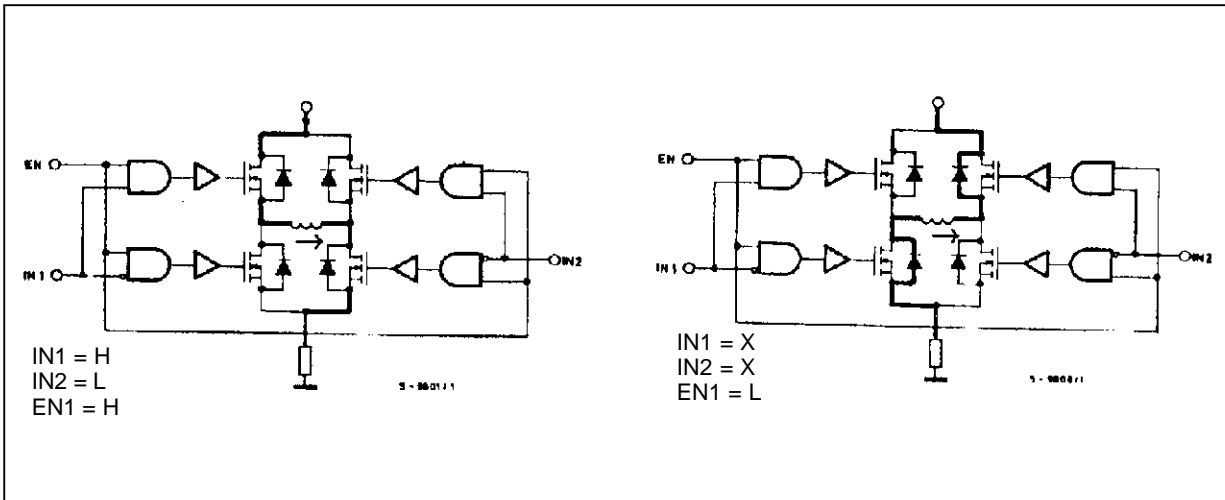
**Figure 3a: Two Phase Chopping**



**Figure 3b: One Phase Chopping**

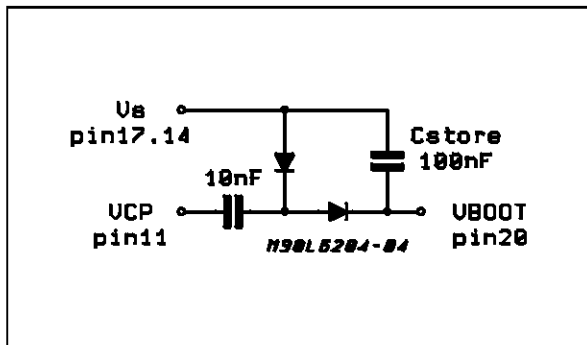


**Figure 3c: Enable Chopping**



a voltage higher than  $V_S$  is supplied on pin 20 ( $V_{boot}$ ). This bootstrap voltage is not needed for the lower power DMOS transistor because their sources are grounded. To produce this voltage a charge pump method is used and made by two external capacitors and two diodes. It can supply the 4 driving blocks of the high side drivers. Using an external capacitor the turn-on speed of the high side driver is very high; furthermore with different capacitance values it is possible to adapt the device to different switching frequencies. It is also possible to operate two or more L6204s using only 2 diodes and 2 capacitance for all the ICs; all the  $V_{boot}$  pins are connected to the  $C_{store}$  capacitance while the pin 11 (VCP) of just one L6204 is connect to  $C_{pump}$ , obviously all the L6204 ICs have to be connected to the same  $V_S$ . (see fig. 4)

Figure 4



DEAD TIME

To protect the device against simultaneous conduction in both arms of the bridge and the resulting rail-to-rail short, the logic circuits provide a dead time.

THERMAL PROTECTION

A thermal protection circuit has been included that will disable the device if the junction temperature reaches 150 °C. When the temperature has fallen to a safe level the device restarts under the control of the input and enable signals.

APPLICATION INFORMATION

RECIRCULATION

During recirculation with the ENABLE input high, the voltage drop across the transistor is  $R_{DS(ON)}$ .  $I_L$  for voltages less than 0.7 V and is clamped at a voltage depending on the characteristics of the source-drain diode for greater voltages. Although the device is protected against cross conduction, current spikes can appear on the current sense pin due to charge/discharge phenomena in the intrinsic source drain capacitances. In the application this does not cause any problems because

the voltage created across the sense resistor is usually much less than the peak value, although a small RC filter can be added if necessary.

POWER DISSIPATION (each bridge)

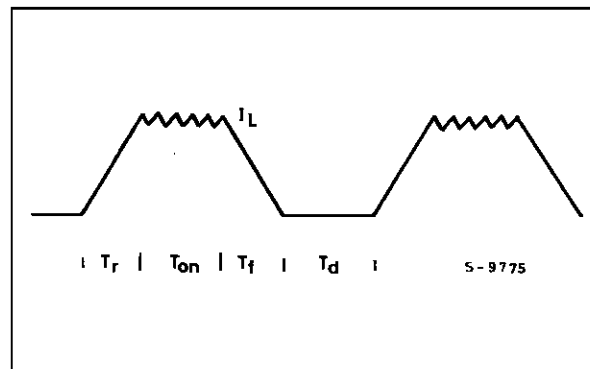
In order to achieve the high performance provided by the L6204 some attention must be paid to ensure that it has an adequate PCB area to dissipate the heat. The first stage of any thermal design is to calculate the dissipated power in the application, for this example the half step operation shown in figure 5 is considered.

RISE TIME  $T_r$

When an arm of the half bridge is turned on current begins to flow in the inductive load until the maximum current  $I_L$  is reached after a time  $T_r$ . The dissipated energy  $E_{OFF/ON}$  is in this case :

$$E_{OFF/ON} = [R_{DS(ON)} \cdot I_L^2 \cdot T_r] \cdot 2/3$$

Figure 5



ON TIME  $T_{ON}$

During this time the energy dissipated is due to the ON resistance of the transistors  $E_{ON}$  and the commutation  $E_{COM}$ . As two of the POWER DMOS transistors are ON  $E_{ON}$  is given by :

$$E_{ON} = I_L^2 \cdot R_{DS(ON)} \cdot 2 \cdot T_{ON}$$

In the commutation the energy dissipated is :

$$E_{COM} = V_S \cdot I_L \cdot T_{COM} \cdot f_{SWITCH} \cdot T_{ON}$$

Where :

$T_{COM}$  = Commutation Time and it is assumed that ;

$T_{COM} = T_{TURN-ON} = T_{TURN-OFF} = 100 \text{ ns}$

$f_{SWITCH}$  = Chopper frequency

FALL TIME  $T_f$

For this example it is assumed that the energy dissipated in this part of the cycle takes the same form as that shown for the rise time :

$$E_{ON/OFF} = [R_{DS(ON)} \cdot I_L^2 \cdot T_f] \cdot 2/3$$

**QUIESCENT ENERGY**

The last contribution to the energy dissipation is due to the quiescent supply current and is given by :

$$E_{\text{QUIESCENT}} = I_{\text{QUIESCENT}} \cdot V_s \cdot T$$

**TOTAL ENERGY PER CYCLE**

$$E_{\text{TOT}} = (E_{\text{OFF/ON}} + E_{\text{ON}} + E_{\text{COM}} + E_{\text{ON/OFF}})_{\text{bridge 1+}} + (E_{\text{OFF/ON}} + E_{\text{ON}} + E_{\text{COM}} + E_{\text{ON/OFF}})_{\text{bridge 2+}} + E_{\text{QUIESCENT}}$$

The Total Power Dissipation  $P_{\text{DIS}}$  is simply :

$$P_{\text{DIS}} = E_{\text{TOT}}/T$$

$T_r$  = Rise time

$T_{\text{ON}}$  = ON time

$T_f$  = Fall Time

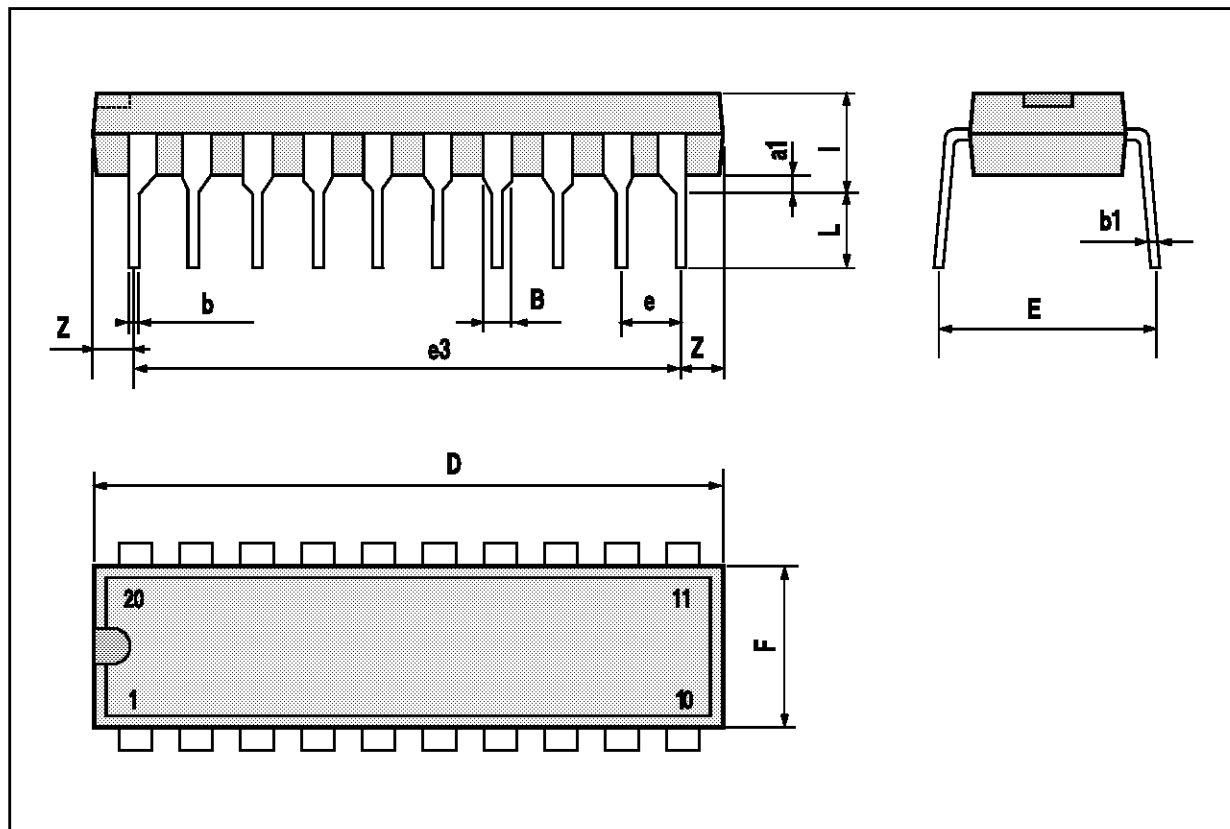
$T_d$  = Dead time

$T$  = Period

$$T = T_r + T_{\text{ON}} + T_f + T_d$$

POWERDIP-20 PACKAGE MECHANICAL DATA

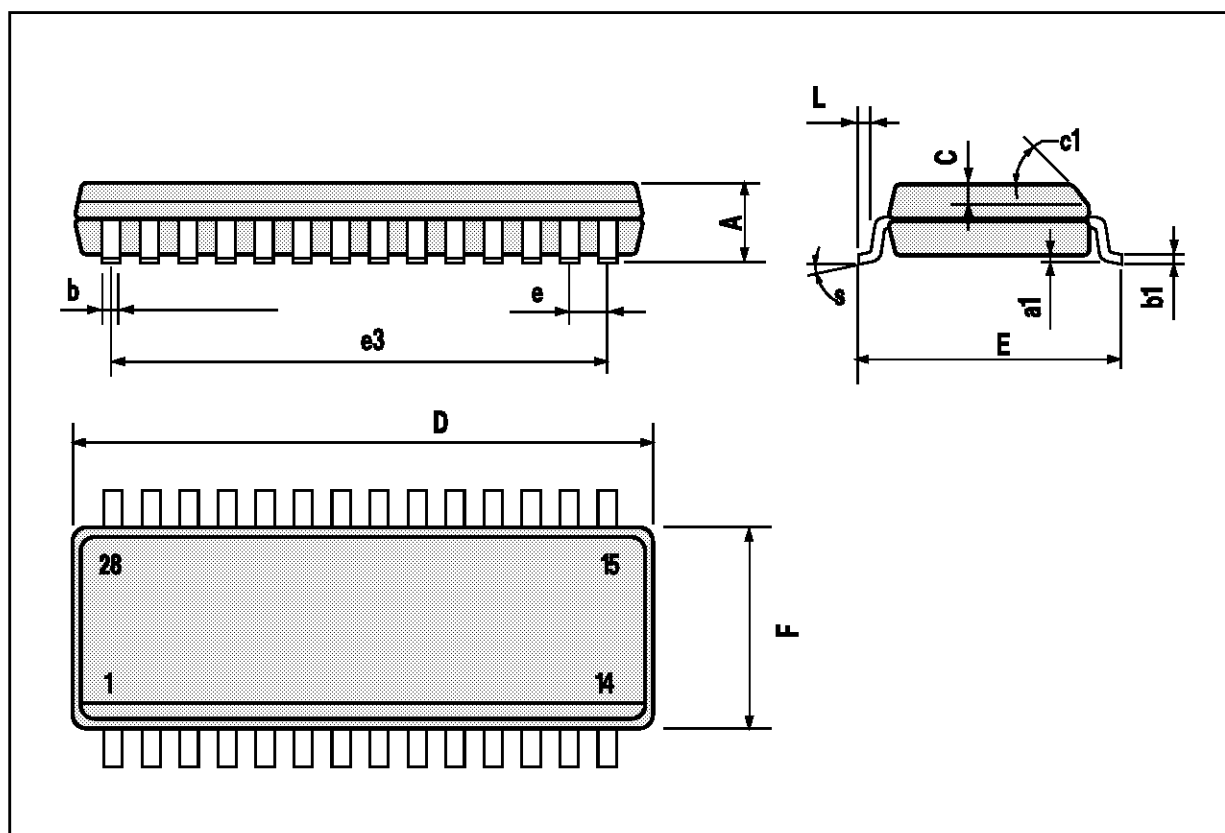
| DIM. | mm   |       |       | inch  |       |       |
|------|------|-------|-------|-------|-------|-------|
|      | MIN. | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| a1   | 0.51 |       |       | 0.020 |       |       |
| B    | 0.85 |       | 1.40  | 0.033 |       | 0.055 |
| b    |      | 0.50  |       |       | 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   |      | 22.86 |       |       | 0.900 |       |
| F    |      |       | 7.10  |       |       | 0.280 |
| l    |      |       | 5.10  |       |       | 0.201 |
| L    |      | 3.30  |       |       | 0.130 |       |
| Z    |      |       | 1.27  |       |       | 0.050 |





## SO28 PACKAGE MECHANICAL DATA

| DIM. | mm         |       |       | inch  |       |       |
|------|------------|-------|-------|-------|-------|-------|
|      | MIN.       | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| A    |            |       | 2.65  |       |       | 0.104 |
| a1   | 0.1        |       | 0.3   | 0.004 |       | 0.012 |
| b    | 0.35       |       | 0.49  | 0.014 |       | 0.019 |
| b1   | 0.23       |       | 0.32  | 0.009 |       | 0.013 |
| C    |            | 0.5   |       |       | 0.020 |       |
| c1   | 45° (typ.) |       |       |       |       |       |
| D    | 17.7       |       | 18.1  | 0.697 |       | 0.713 |
| E    | 10         |       | 10.65 | 0.394 |       | 0.419 |
| e    |            | 1.27  |       |       | 0.050 |       |
| e3   |            | 16.51 |       |       | 0.65  |       |
| F    | 7.4        |       | 7.6   | 0.291 |       | 0.299 |
| L    | 0.4        |       | 1.27  | 0.016 |       | 0.050 |
| S    | 8° (max.)  |       |       |       |       |       |



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