Dual Output Reversing Speed Controller

Features

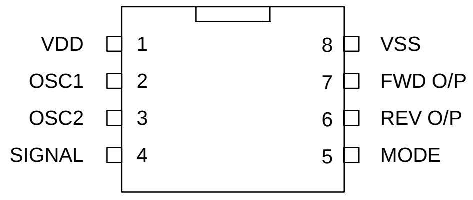
- Separate Direction Outputs
- Dead-Band at Centre Stick
- Choice of Two Control Laws
- Fine Control of Motor Speed
- Lost Signal Motor Shut-Off
- Switch-on Safe State
- Input Signal Noise Filter
- Out-of-Spec Signal Rejection
- Double Output Lock-out

Applications

- Model Boats
- Model Cars/Trucks/Buggies
- Robot Wars
- Industrial Control
- Domestic Automation

Pin Diagram

8 pin D.I.L. or S.O.I.C. packages



MSC100

General Description

The MSC100 Electronic Motor Speed Control IC has been designed specifically for Radio Control (R/C) applications to provide 'Forward-and-Reverse' control of an electric motor when used in conjunction with a suitable application circuit but it may also be utilised for any purpose that provides an appropriate control signal. Typical R/C systems provide a positive going logic level control pulse with a width that lies between 1.0ms and 2.0ms at a frame rate of 20ms. The MSC100 interprets this signal and provides either of two positive going logic level output signals of between 0ms and 20ms duration related to the input pulse width.

The MSC100 operates by measuring and assessing the width of each input signal pulse. Any pulses that do not meet the required specification are rejected, and the drive outputs are shut down, thus preventing erratic motor behaviour. During normal operation there is a choice of two control laws available - the first being a simple linear relationship between input and output pulse widths and the second providing a 'logarithmic' relationship. This alternative law has the effect of providing a 'slow-start' and thus gives finer control over motor rotation at low speeds.

Included in the MSC100 design are a number of features related to safety and reliability which, in the event of detecting an out-of-spec input signal, will either reject the input signal and/or shut down the motor drive outputs. An additional safety feature is the 'Safe-Start' arming capability that prevents either of the motor drive outputs going active until a period of 'dead-stick' has been detected. This prevents motor rotation at power-up.

Absolute Maximum Ratings

Supply Voltage (V_{CC})	0 to +7V
Max. Voltage on I/O pins	-0.5V to (V_{CC}+0.5V)
I/O Pin Clamp Current	±20mA
Output Source Current (single pin)	-25mA
Output Source Current (total on all pins)	-75mA
Output Sink Current (single pin)	+25mA
Output Sink Current (total on all pins)	+75mA
Total Power Dissipation	500mW
Operating Ambient Temperature Range	0°C to 70°C
Junction Temperature	150°C
Storage Temperature Range	-65°C to 150°C
Lead Temp. during Soldering (10sec)	300°C

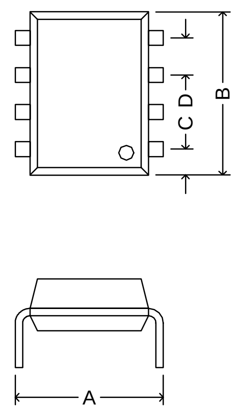
NOTES:
Exceeding the values in this table may impair or destroy the device.
Currents with a negative sign are said to flow out of the device.
All voltages are measured with respect to the V_{SS} pin.

Package Availability

The MSC100 is available in an 8 pin 0.3" (7.62mm) Dual-in-Line (DIL) package. See Package Data for details.

Package Data

8 pin D.I.L.



Dimension		in	mm
Pin Width	A	0.30	7.62
Length	B	0.38	9.65
Pin Offset	C	0.04	1.00
Pin Pitch	D	0.10	2.54

Pin-out Description

Pin No.	Name	Type	Description
1	VDD	P	Positive power supply pin for internal logic and I/O pins
2	OSC1	X	Connection to external 4MHz XTAL or Ceramic Resonator
3	OSC2	X	Connection to external 4MHz XTAL or Ceramic Resonator
4	SIGNAL	I	Control Signal Input (0.8ms to 2.2ms)
5	MODE	I	Control Law selection (0 = Linear, 1 = Logarithmic)
6	REV	O	Active high Reverse Drive output
7	FWD	O	Active high Forward Drive output
8	VSS	P	Ground reference supply pin for internal logic and I/O pins

Detailed Description

Overview

The MSC100 Motor Speed Control IC is a pre-programmed micro-controller product based on the Arizona Microchip PIC12C508-04P device and, as such, shares the same basic electrical characteristics.

It is designed to be used with external power handling circuitry suitable for driving the intended motor. The motor will be chosen by the user to suit the application but may range from a small device, appropriate for driving a model radar antenna, to a much more powerful motor more suited to traction applications.

A standard R/C receiver may be used to provide a typical input signal although any circuitry capable of providing the appropriate type of signal is suitable. Typical radio control systems provide a train of pulses with widths ranging from 1.0ms to 2.0ms with a frame, or repetition, rate of about 20ms or 50Hz. The MSC100 interprets the input pulse train and generates an output signal, suitable for driving an external amplifier, with characteristics related to the width of the input pulse as described below.

When a logic 1 is detected on the input signal line it is assumed that this represents the start of a control pulse and a short timer is started. At the expiry of the timer the input level is re-checked. If it is found to be at a logic 0 it is assumed that the 'pulse' was, in fact, a glitch and it is rejected. Should the logic 1 still be present the appropriate output pin is set active and another timer loaded with a value, calculated using the input pulse width from the previous frame, that determines the duration of the output drive pulse. Should the previous input pulse have failed to meet the required specification neither output is set active so, in this way, erratic motor behaviour is avoided.

Input Signal Specification

The operating software of the MSC100 device measures every input pulse and compares its width with internally programmed parameters. Any pulse whose width fails to meet all the criteria is rejected and the motor drive outputs are set inactive at the start of the next frame.

The following table presents brief details of the relationship between input pulse width and output drive pulse width for the MSC100 device.

I/P Width (ms)	Output Signal	
0.000 - 0.791	Error	Motor Off
0.792 - 1.127	Normal	Full Reverse
1.128 - 1.451	Normal	Controlled Rev.
1.452 - 1.547	Normal	Off (dead-band)
1.548 - 1.871	Normal	Controlled Fwd.
1.872 - 2.200	Normal	Full Forward
2.201 - ?.???	Error	Motor Off

Input Signal Quantisation

The input signal is quantised with a resolution of 12us and thus the range of input widths for which a controlled output is produced, from 1.128ms to 1.871ms, is divided into 62 discrete widths or timeslots. Each of these 62 timeslots may be used to produce a distinct output pulse duration thus giving the capability of very fine control of the motor rotational speed.

In the MSC100 controller the 62 possible speeds are split evenly between the forward and reverse directions with a 'dead-band' of 4 timeslots in each direction around the 1.500ms point which provides a non-critical central motor off stick position. The remaining 54 speeds are allocated, 27 for each direction, to providing motor control in forward and reverse.

Output Pulse Generation

The output drive pulse is started shortly after the input pulse is detected as described above. Its duration is set by a calculation based on the width of the previous frames input pulse and it is timed by means of an internal timer. When the timer expires the output drive signal is set inactive and thus it is the ratio of 'active time' to 'inactive time' in a given frame that sets the motor speed. A special case exists where the input pulse from the following frame arrives before the output has been set inactive. This situation provides full power to the motor and, under these conditions, the internal timer is just reloaded with the new value and the output pulse timing procedure restarted.

Radio Control systems operate with a nominal frame rate of 20ms but there is no need for this to be tightly controlled as normal servos are relatively insensitive to frame rate variations. In order to allow the MSC100 to be used satisfactorily with less accurate products it is capable of producing output drive pulses approaching 21ms in length thus providing a 5% over-range capability for the full speed setting in either direction. The following table gives the detailed relationship between input pulse width values and the corresponding output pulse widths generated.

Reverse Output				Forward Output			
Input Pulse Width (ms)		Output Pulse Width (ms)		Input Pulse Width (ms)		Output Pulse Width (ms)	
From	To	Lin. Law	Log. Law	From	To	Lin. Law	Log. Law
0.000	0.791	0.000	0.000	1.500	1.511	0.000	0.000
0.792	1.127	20.736	20.736	1.512	1.523	0.000	0.000
1.128	1.139	20.736	20.736	1.524	1.535	0.000	0.000
1.140	1.151	19.968	19.072	1.536	1.547	0.000	0.000
1.152	1.163	19.200	17.408	1.548	1.559	0.768	0.384
1.164	1.175	18.432	15.744	1.560	1.571	1.536	0.768
1.176	1.187	17.644	14.080	1.572	1.583	2.304	1.152
1.188	1.199	16.896	12.416	1.584	1.595	3.072	1.536
1.200	1.211	16.128	10.752	1.596	1.607	3.840	1.920
1.212	1.223	15.360	9.984	1.608	1.619	4.608	2.304
1.224	1.235	14.592	9.216	1.620	1.631	5.376	2.688
1.236	1.247	13.824	8.448	1.632	1.643	6.144	3.072
1.248	1.259	13.056	7.680	1.644	1.655	6.912	3.456
1.260	1.271	12.288	6.912	1.656	1.667	7.680	3.840
1.272	1.283	11.520	6.144	1.668	1.679	8.448	4.224
1.284	1.295	10.752	5.376	1.680	1.691	9.216	4.608
1.296	1.307	9.984	4.992	1.692	1.703	9.984	4.992
1.308	1.319	9.216	4.608	1.704	1.715	10.752	5.376
1.320	1.331	8.448	4.224	1.716	1.727	11.520	6.144
1.332	1.343	7.680	3.840	1.728	1.739	12.288	6.912
1.344	1.355	6.912	3.456	1.740	1.751	13.056	7.680
1.356	1.367	6.144	3.072	1.752	1.763	13.824	8.448
1.368	1.379	5.376	2.688	1.764	1.775	14.592	9.216
1.380	1.391	4.608	2.304	1.776	1.787	15.360	9.984
1.392	1.403	3.840	1.920	1.788	1.799	16.128	10.752
1.404	1.415	3.072	1.536	1.800	1.811	16.896	12.416
1.416	1.427	2.304	1.152	1.812	1.823	17.644	14.080
1.428	1.439	1.536	0.768	1.824	1.835	18.432	15.744
1.440	1.451	0.768	0.384	1.836	1.847	19.200	17.408
1.452	1.463	0.000	0.000	1.848	1.859	19.968	19.072
1.464	1.475	0.000	0.000	1.860	1.871	20.736	20.736
1.476	1.487	0.000	0.000	1.872	2.200	20.736	20.736
1.488	1.499	0.000	0.000	2.201	?.???	0.000	0.000

Software Features

There are a number of useful features built in to the software for the MSC100, most of which are included to increase operational safety.
The following paragraphs describe these features in detail.

Control Law Selection

The logic level present at the MODE pin (pin 5) of the MSC100 is used to select between the normal ‘Linear’ law and the special ‘Logarithmic’ law. The relationship between the input servo control pulse and the output PWM pulse for both options is shown in the table above. The Linear option is suitable for general use while the Logarithmic option is ideal for applications where a ‘slow-start’ is needed and/or finer control of motor rotation in the lower speed range is required. The selection of control law is made by connecting the MODE pin as follows:-

Selected Control Law	MODE pin level
Linear	Logic 0 (0V)
Logarithmic	Logic 1 (5V)

Startup Protection and Arming

In order to provide safety at power-up the software switches off the motor drive outputs and then examines the input signal and checks its pulse width. It will keep the outputs inactive until it has found a continuous stream of input pulses, lasting for about half a second, with widths lying between about 1.45ms and 1.55ms. If this stream is interrupted by a pulse that does not meet the required specification the ‘timer’ is reset and the process restarts from the beginning. This feature ensures the chance of unexpected motor rotation is minimised.

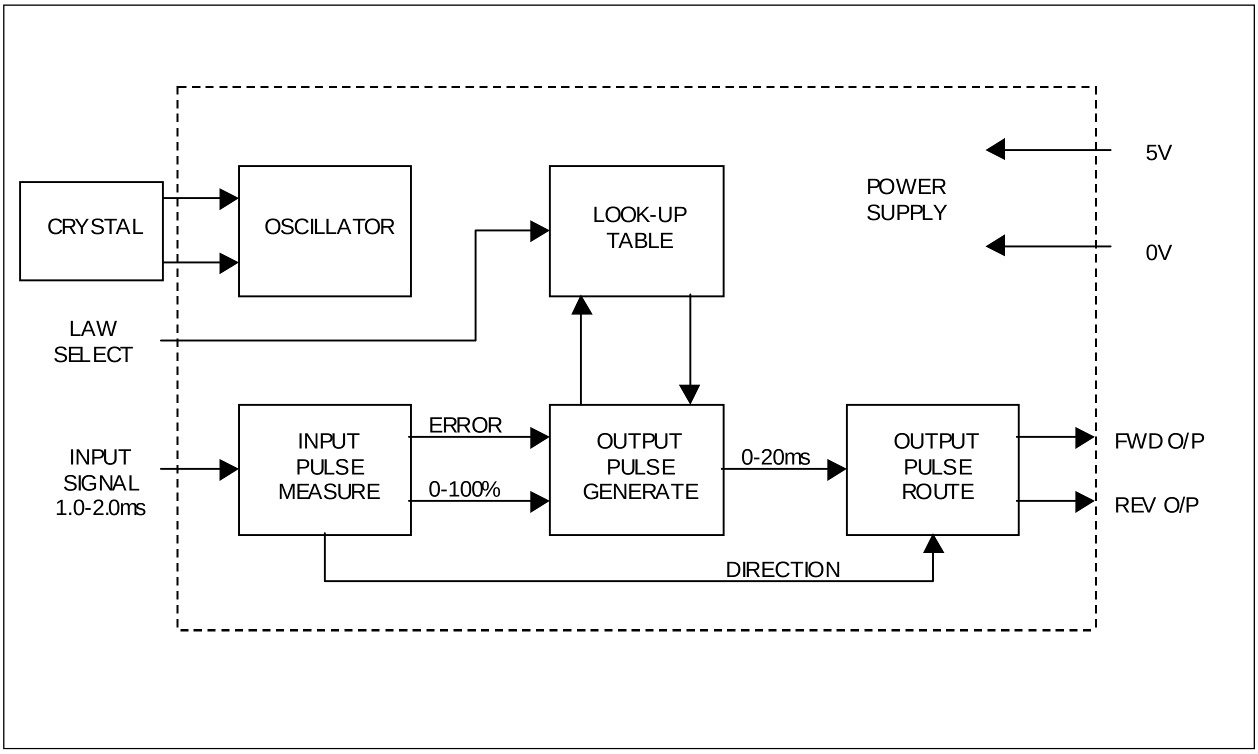
Lost Signal Motor Shut-Off

In the event the model exceeds radio range, and the input signal disappears, the software switches off the motor drive outputs until a suitable signal is restored whereupon normal operation resumes automatically. In order to accommodate the possible range of behaviour of receivers under lost signal conditions the software considers any signal present on the input that fails to meet the required specification as invalid and shuts down the motor.

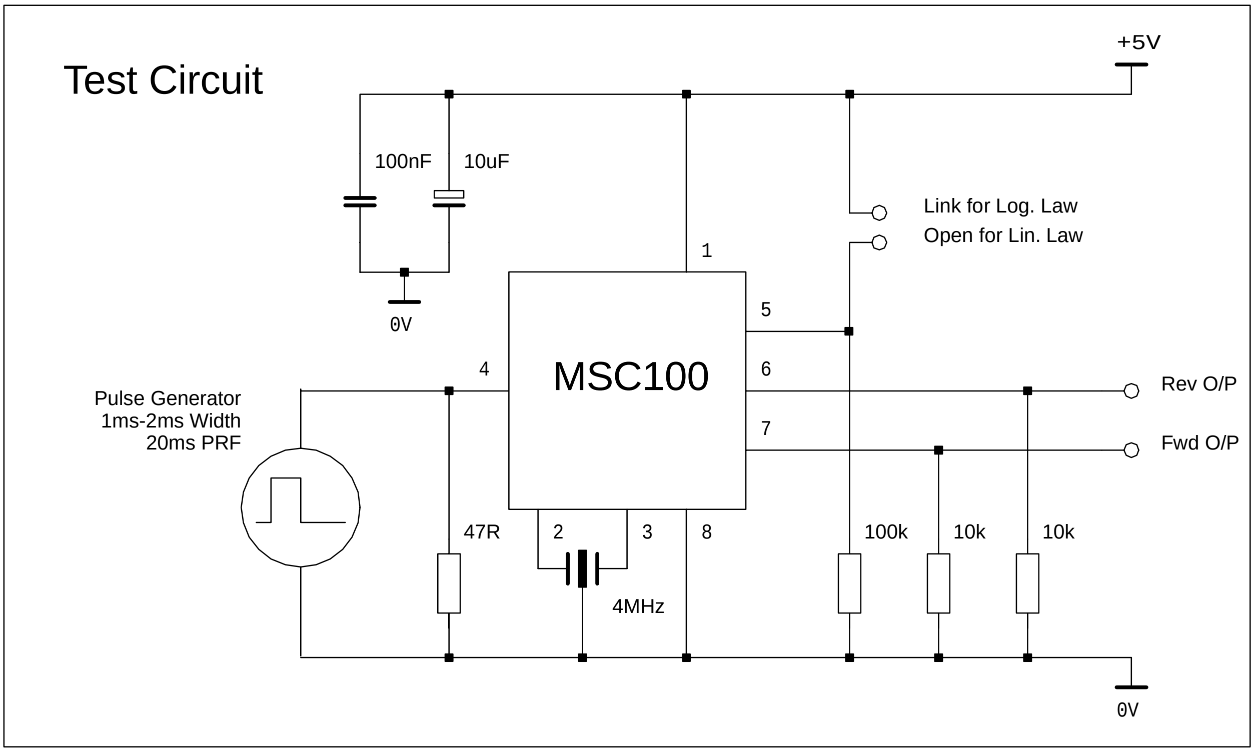
Double Output Lock-Out

Under normal operating conditions the central dead-band will ensure that, when changing the motor direction, there is a short period while neither output is active as that portion of the control range is traversed. However it is possible that with a very fast stick movement, or equivalent from a non R/C control system, that the two outputs could be simultaneously activated. The MSC100 software expressly prevents this condition in order to prevent any possible motor drive problems due to both outputs being active.

Block Diagram



Test Circuit and Waveforms



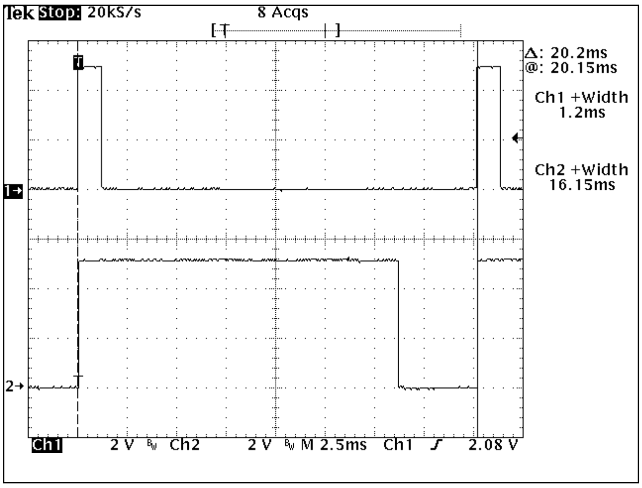


Figure 1

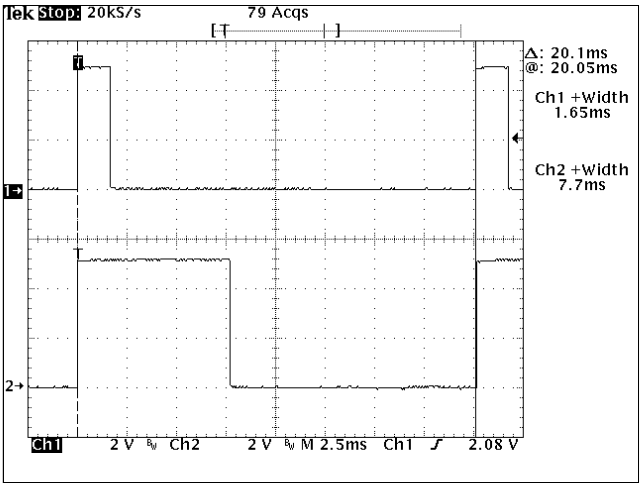


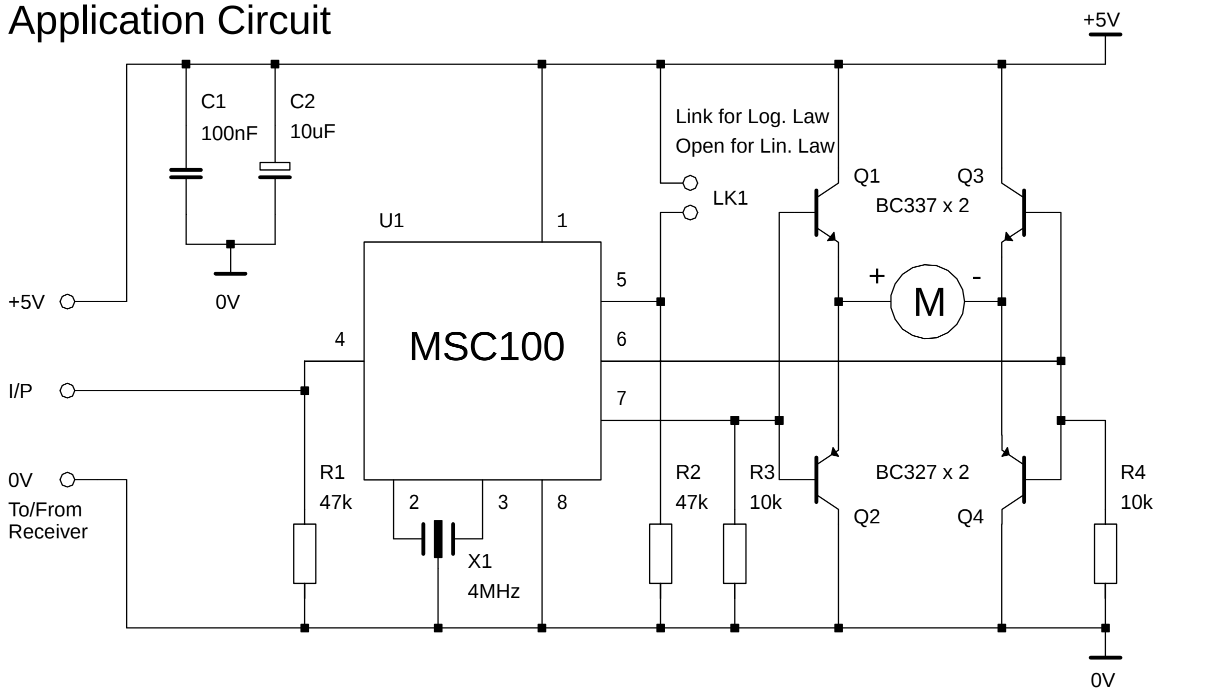
Figure 2

Figure 1 shows the response of the MSC100 with an input pulse of 1.200ms, depicted on Ch1, and the Linear control law selected. The Reverse direction output is active and producing pulse widths of 16.15ms as depicted by Ch2. The Forward direction output is idle and not shown.

Figure 2 shows the response of the MSC100 with an input pulse of 1.650ms, depicted on Ch1, and the Linear control law selected. The Forward direction output is active and producing pulse widths of 7.70ms as depicted by Ch2. The Reverse direction output is idle and not shown.

Application Information and Hints

Application Circuit



The application circuit above gives details of a schematic suitable for use with small motors requiring up to about 0.25A of running current under load. It is offered only as a guide and is not warranted to be suitable for a given application so it is essential that the user verify its suitability.

Oscillator Frequency

The various timing functions operating within the MSC100 are dependent on the oscillator frequency and thus it is important to ensure the accuracy, and stability, of the resonant device. The resonant device may be either a 3 terminal ceramic resonator as shown above or, as an alternative, a two terminal device in association with two small capacitors may be used. It is essential for correct operation that the nominal frequency be 4MHz.

Supply Decoupling

It is important to decouple the supply to the MSC100 device particularly if driving MOSFET power devices. The recommended circuit values are shown in the Application Circuit.

Power-up Safety

Immediately after power-up a hardware timer within the MSC100 prevents the software from running for approximately 20ms. During this brief period the two output terminals are configured as inputs. In order to prevent spurious motor rotation the fitting of two resistors, R3 and R4 on the Application Circuit above, is recommended.

Output Drive Current

As stated in the Absolute Maximum Ratings section the drive capability of the two output terminals is limited to about ±25mA. Care should be taken when driving bipolar transistors to ensure that the transistor base current requirements do not exceed this limit. MOSFET devices have an essentially zero gate current requirement under steady-state conditions but larger devices often present a significant input capacitance which needs to be charged before the device can conduct. Exceeding the drive capability of the MSC100 will slow down the MOSFET turn-on and lead to higher device dissipation.

0V PCB Trace Routing

In many applications the motor running currents involved will be large. The following notes will help ensure a reliable design:-

- Keep the PCB traces that carry the motor currents as short as practical and also make them as wide as possible.
- Place the DC power connections to the PCB at the same end of the board as the motor connections. This helps ensure that the high currents do not flow in the traces associated with the control circuitry.
- If it is necessary to take power off the PCB to another device place the 'power output' connector adjacent to that bringing the power in.
- In order to reduce the effects of PCB trace voltage drops attempt to route the control circuit 0V trace directly to the supply input connector 0V connection. Any PCB trace voltage drops will subtract from the MSC100 output drive signal and possibly degrade circuit performance.

Notes

This Datasheet is issued by :-

The Model Electronics Company
68 Kentsford Road
Grange-over-Sands
Cumbria LA11 7BB

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