●新特器件应用

汽车专用交流发电机稳压器 MC33092

南京航空航天大学 纪宗南

Automobile Alternator Regulator MC33092

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摘要：MC33092是motorola公司生产的汽车专用交流发电机稳压器，它能在汽车行驶过程中对汽车的交流发电机充电系统实施良好的电压调整和负载控制。并具有欠压、过压、相位故障和负载断开保护功能。文中介绍了MC33092的主要性能和工作原理，并给出了具体的应用电路。

关键词：稳压器；发电机；汽车专用 ；MC33092；

分类号：TM44　　**文献标识码：**B　　**文章编号：**1006－6977(2000)12－0008－04

1　概述

在汽车使用过程中，经常由于外界因素和内部参数变化的影响而导致汽车速度不稳定，影响汽车的运行质量，严重时还会产生不良后果。为此应在汽车供电线路中安装交流发电机稳压器，以改善和消除上述现象。MC33092是一种专用的汽车交流发电机稳压器，它能给交流发电机充电系统提供良好的电压调整和负载响应控制功能，从而排除突然增加的电气负载所引起的发动机速度的不稳定和振动，特别在低速运行时，因为低速时，这种现象更为严重(突加的转矩负载)。

在对充电系统稳压过程中，MC33092能够监测系统电池电压，并把它与外部编程的设置值进行比较，然后对其一个N沟道MOSFET进行脉宽调制，以控制交流发电机平均励磁电流，从而实现电压控制，达到稳压的目的。

2　芯片简介

MC33092的主要性能如下：

●稳压输出电压为14.85V；

●稳压精度为±0.1V(在25℃时)；

●在低速运行时，具有重负载渐增的强制响应控制功能；

●用一个外接电阻即可实现工作频率的选择；

●输出电压随发电机的输出和转速变化小；

●外部负载电流最小值为1.0A；

●具有欠压、过压和相位故障（皮带断开）检测功能；

●具有灯、负载和励磁控制器件断开保护功能；

●具有占空比极限保护功能；

●室温下（25℃）的电池输出待机电流小于2.0mA；

●在工作温度范围内，电池输出待机电流小于3.0mA；

●当f＝280kHz时，能选择2.5s和10s两种负载响应控制(LRC)；

●MOSFET和回扫二极管具有极小的射频干扰(RFI)恢复特性；

●能给高边MOSFET提供一个以地为基准的励磁绕组；

MC330932为20引脚封装，引脚图如图1所示。引脚功能如表1所列。

3　工作原理

MC33092内部功能框图如图2所示。现对主要电路进行说明。

3.1 负载响应控制

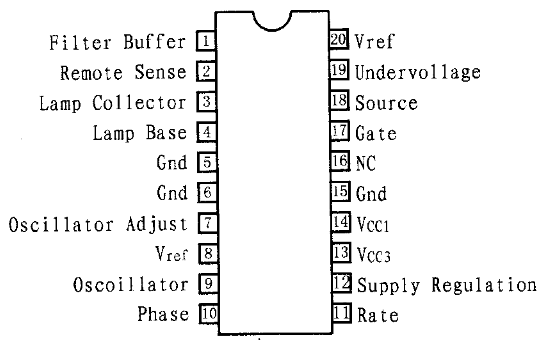

图1　MC33092的引脚排列图

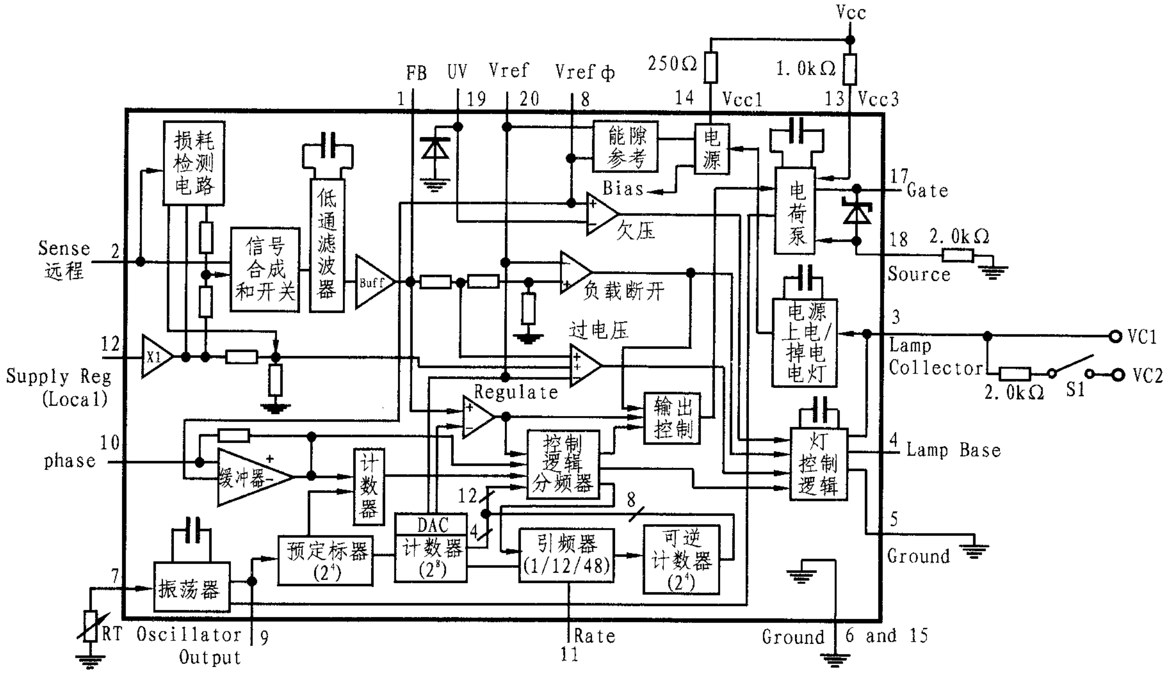

图 2　MC33092 的内部功能框图

负载响应控制（Load Response Control～LRC）是 MC33092 稳压器的独特功能，可产生调整电压用的数字控制信号。当定子输出交流信号（引脚器）的频率比低/高转速转换频率低时，该电路动作。此时，负载响应控制电路能够控制基本的模拟电路（预定标器、分频器和可逆计数器等）。当负载电流突然增加时，它能减慢交流发电机对它的影响，从而防止交流发电机将一个突然发生的高转矩负载加到汽车发动机上。当定子输出交流信号的频率比低/高速转换频率高时，LRC 电路不动作，此时，基本模拟电路仍能控制交流发电机，并可输出与负载电流无关的稳定电压。

LRC 电路还可提供延迟时间和控制交流发电机给系统增加的负载响应时间。响应时间可以通过引脚 11 的两种速率进行编程，从而将分频器变为 12 分频或 48 分频。当引脚 11 接地时，馈入可逆计数器的信号被 12 分频，其响应时间为基本模拟时间的 12 倍；当引脚 11 悬空，则送到可逆计数器的信号被 48 分频，响应时间为 48 倍。

LRC 和模拟控制电路利用脉宽调制器（PWM）使交流发电机励磁电流接通和断开，从而对系统电压进行控制。PWM 能控制占空比的大小、可逆计数器的状态和平均励磁电流。当负载增加使占空比达到 100%时，可逆计数器是递增的（正数）；当负载减小使占空比达到最小值（29%）时，可逆计数器是递减的（负数）。另外，当 LRC 电路动作时（灯集电极引脚电压超过上电门限值），集成电路（IC）上电。

3.2 低通滤波器、数模转换器和调整比较器

当检测电压加到检测引脚 2 时，该电压与另一路信号一起馈入合成器，经合成器的输出信号进入低通滤波器（LPF），从而滤掉高频系统的噪声。LPF 的输出信号经缓冲器后分三路输出，其中一个输出加到调整比较器，并与片内 DAC 产生的下降型锯齿波进行比较。当两个电压相等时，调整比较器的输出状态发生改变，利用控制逻辑可使 MOSFET 的栅极为低电平（关断状态）。在下一个输出频率时钟周期的开始点上，DAC 输出下降型锯齿波，并使 MOSFET 导通，直到调整器的输出再次改变状态为止 。这种连续不断的周期性循环以 PWM 形式控制系统的电压。

3.3 故障检测电路

故障检测电路是 MC33092 稳压器的另一个重要电路，它能对欠压、过压、负载断开、转速异常等故障进行快速检测，并由故障灯显示。

低通滤波器的输出信号通过外接分压器分压后进入欠压比较器，利用分压器中的可调电位器可实现欠压比较器检测电平的调节。在欠压期间，故障灯不亮，只有当相位缓冲器输入信号的频率比低/高

表1 引脚功能

引脚数	符号	功能说明
1	FB	滤波器缓冲输入引脚。在检测输入时,该引脚为滤波后的检测输入;在非检测输入时,该引脚为电源调整输入。
2	Remote Sense	远程检测输入引脚。可作为远程低电流电池电压参考输入,也可作为监视过压或负载断开的输入。
3	Lamp Collector	灯集电极输入引脚。该引脚与晶体管 Q_2 的集电极相连,也可用于检测闭合点开关,以检测加在集成电路(IC)的供电电压。
4	Lamp Base	灯基极输出引脚。用于向故障灯的驱动晶体管 Q_2 提供基极电流。
5	Ground	地线,用于为故障灯控制逻辑电路提供地线回路。
6	Ground	地线,为集成电路地线回路。
7	Oscillator Adjust	振荡器调节输入引脚。该引脚的接地电阻(外接)用来调节振荡频率。
8	Vref	参考电压测试引脚 。该引脚的参考电压为1.1V~1.4V,也可作为欠压和相位检测时的参考电压。
9	Oscillator	测试引脚。用于检测振荡器的工作状态。
10	Phase	相位输入引脚。用于检测交流发电机内部磁场的旋转情况。
11	Rate	速率选择引脚 。当引脚悬空时,负载响应控制为慢速方式;当引脚接地时,负载响应控制为快速方式。
12	Supply Regulation	电源调节引脚。该引脚的电压为交流发电机输出电压,也可监视过压和负载断开的发生。
13	V_{CC3}	正电源引脚 。为片内电荷泵提供正电源。
14	V_{CC1}	正电源引脚。它为集成电路(除电荷泵外)提供正电源。
15	Ground	地线引脚。为集成电路(IC)提供地线回程。
16	NC	空脚。不连。
17	Gate	栅极引脚。用于能控制励磁线圈通电 MOSFET 管的栅极。
18	Source	源极引脚。控制 MOSFET 的源极。
19	Undervo -ltoge	欠压引脚 。当该引脚电压低于1.0V时,则能保证故障灯点亮,这时的集成电路仍能工作,但性能较差。
20	Vref	能隙参考电压测试引脚。用于输出具有负温度系数(-11mV/℃)的参考电压(1.7~2.3V)。

转速转换频率高时,故障灯才点亮,从而保证故障真正是欠压产生的,而不是由于交流发电机转速低所产生的。

在欠压时,为了使系统的电压达到稳定,输出波形占空比将自动增加到100%。这样,即使欠压时故障灯点亮,MC33092仍能继续工作,但此时的性能要差一些。

低通滤波器的输出信号通过片内分压器加到过压比较器的输入端,通过比较即可监视输出电压的过压故障。若超过过压电压的门限值,则故障灯点亮,此时 MOSFET 驱动输出(引脚17)的占空比被限制在4%(最大值)。虽然负载断开比较器和过压比较器使用的是同一个片内分压器,但由于分压比值不同,从而使负载断开比较器的检测电压门限高于过压比较器的电压门限值,这样,两个比较器均在监视同一个低通滤波器的输出信号,但却能各负其责,正确预报自己检测的故障。

如果超过负载断开检测的门限电压值 ,则系统将禁止故障灯和 MOSFET 的驱动输出,从而使 MOSFET 故障灯和励磁线圈得以保护。

3.4 电源上电复位电路

上电复位电路能为 MC33092 片内的所有计数器提供复位或置位信号。另外,片内的延迟电路能克服不稳定上电信号对电路的影响 ,从而进一步提高芯片的可靠性。

3.5 电池和交流发电机输出电压的检测

在汽车使用过程中,电池的供电电压和交流发电机的输出电压是很重要的,为了能使汽车正常运

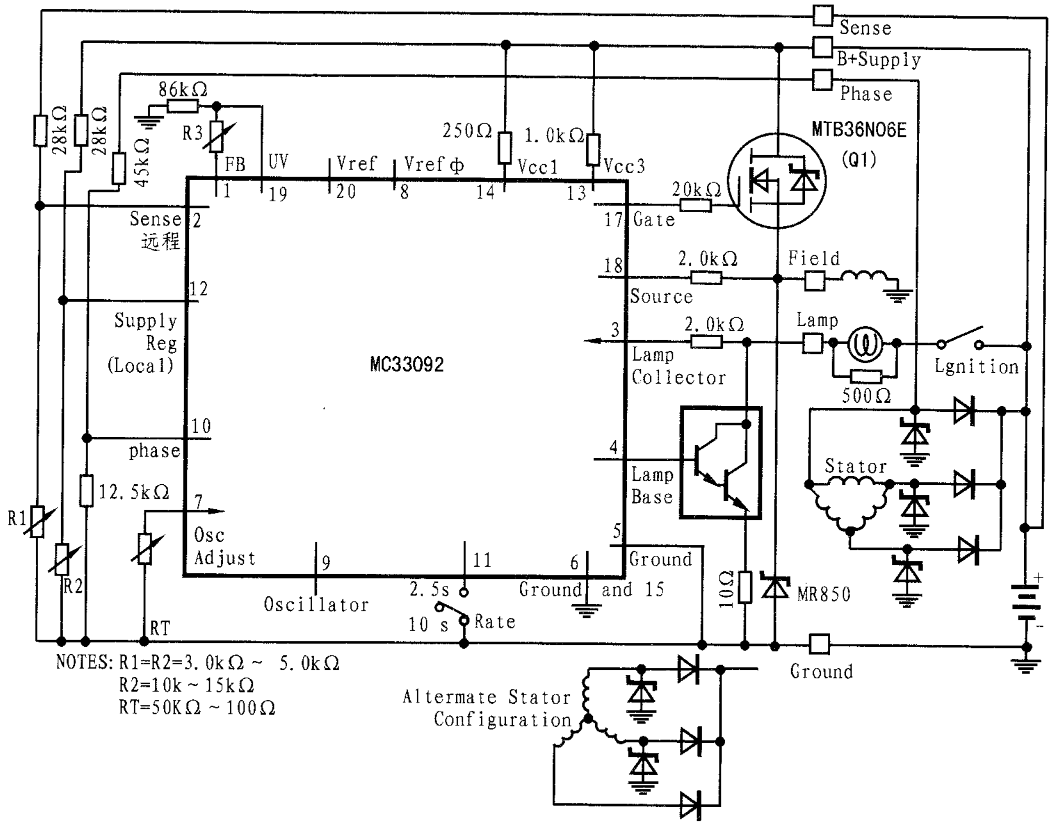

图 3 交流发电机稳压器

行，必须对这两个电压实行连续检测。MC33092 稳压器通过远程引脚 2 和本地输入缓冲器（引脚 12）的外接分压器来实现对这两个电压的检测。而稳定系统的电压由分压电阻的值来确定。

正常供电时，远程引脚上的电压能确定电池电压调节值，在不使用远程引脚的某些情况下，如 $V_{引脚2}<0.6V$，检测损耗功能也允许本地引脚的电压来确定电池电压的调节值(无衰减)。使用远程引脚时，该引脚上的电压比本地引脚上的电压小 25%，但大于 0.6V。通过信号合成器/开关控制电路，能把电池电压调节值转换为本地引脚的检测电压值。

4 典型应用电路

由 MC33092 组成的交流发电机稳压器实际线路如图 3 所示。片内振荡器能够产生频率为 280KHz 的波形，以满足电荷泵和预定标器时钟信号的要求。振荡器的某一频率由外接可调电位器 RT(50kΩ～100kΩ)调节设置，使用特别方便。为了对电池电压实施监控，特在引脚 12(本地电压调整)外接分压电阻（28kΩ 和 R2）。其中 R_2 为 10kΩ～15kΩ，调节 R2，即可为监控电池电压设置门限值。为了检测远程电压，应在引脚 2 外接分压电阻（28kΩ 和 R1），其中 R_1 的取值范围为 30kΩ～50kΩ，调节 R1 能为检测远程电压设置门限值。汽车在行驶过程中，经常会因内部和外部因素出现故障，特在引脚 3 和 4 之间外接一个故障灯，以指示电路出现的各种故障(如欠压、过压、负载断开、转速慢或停转等)。由于脚 3 和脚 4 的驱动能力较小，所以必须外接一个达林顿晶体管（Q2）才能可靠地驱动故障灯。

收稿日期：2000－05－12
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MOTOROLA

Alternator Voltage Regulator

MC33092

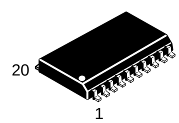
ALTERNATOR VOLTAGE REGULATOR

SEMICONDUCTOR TECHNICAL DATA

The MC33092 is specifically designed for voltage regulation and Load Response Control (LRC) of diode rectified alternator charging systems, as commonly found in automotive applications. The MC33092 provides load response control of the alternator output current to eliminate engine speed hunting and vibration due to sudden electrical loads which cause abrupt torque loading of the engine at low RPM. Two load response rates are selectable using Pin 11. The timing of the response rates is dependent on the oscillator frequency.

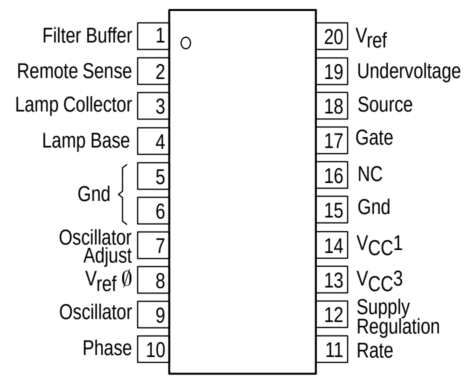
In maintaining system voltage, the MC33092 monitors and compares the system battery voltage to an externally programmed set point value and pulse width modulates an N–channel MOSFET transistor to control the average alternator field current.

- Forced Load Response Control (LRC) with Heavy Load Transitions at Low RPM
- Capable of Regulating Voltage to ± 0.1 V @ 25°C
- Operating Frequency Selectable with One External Resistor
- < 0.1 V Variation over Speed Range of 2000 to 10,000 RPM
- < 0.4 V Variation over 10% to 95% of Maximum Alternator Output
- Maintains Regulation with External Loads as Low as 1.0 A
- Load Dump Protection of Lamp, Field Control Devices, and Loads
- Duty Cycle Limit Protection
- Provides High Side MOSFET Control of a Ground Referenced Field Winding
- Controlled MOSFET and Flyback Diode Recovery Characteristics for Minimum RFI
- < 2.0 mA Standby Current from Battery @ 25°C
- < 3.0 mA Standby Current from Battery Over Temperature Range
- Optional 2.5 or 10 sec. LRC Rate Control (Osc. Freq. = 280 kHz)
- Undervoltage, Overvoltage and Phase Fault (Broken Belt) Detection



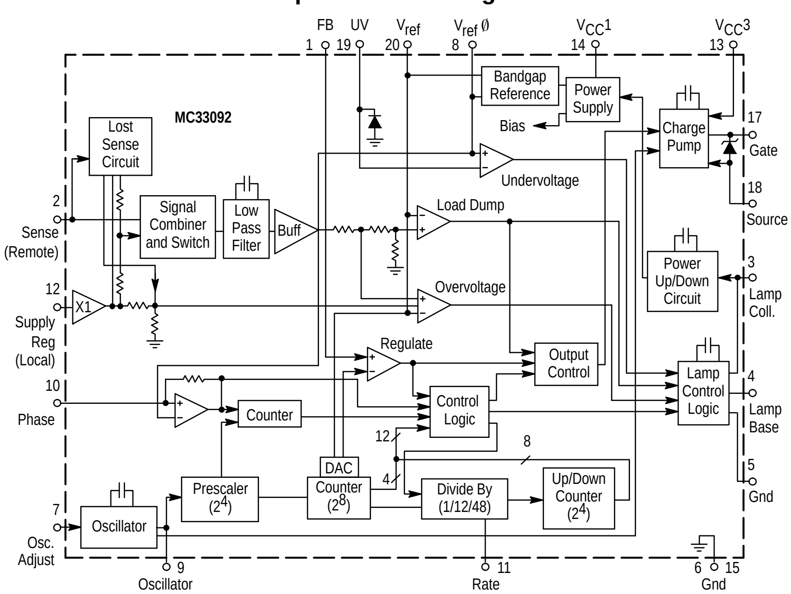
DW SUFFIX
PLASTIC PACKAGE
CASE 751D
(SO–20L)

PIN CONNECTIONS



(Top View)

Simplified Block Diagram



ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC33092DW	T_A = – 40° to +125°C	SO–20L

 Rev 0

MAXIMUM RATINGS

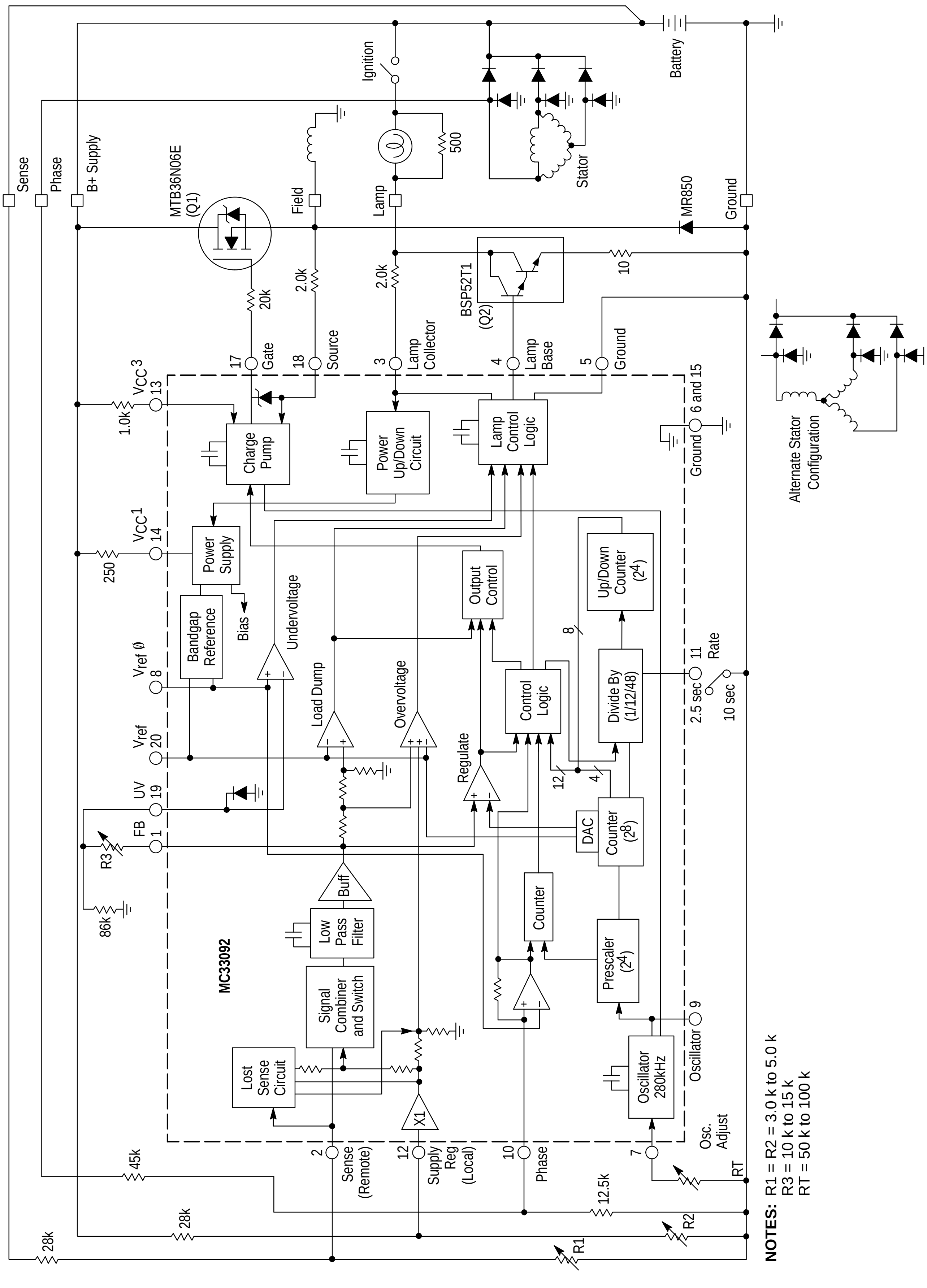
Rating	Symbol	Value	Unit
Power Supply Voltage Load Dump Transient Voltage (Note 1) Negative Voltage (Note 2)	V_{bat} $+V_{max}$ $-V_{min}$	24 40 – 2.5	V V V
Power Dissipation and Thermal Characteristics Maximum Power Dissipation @ T_A = 125°C Thermal Resistance, Junction–to–Ambient	 P_D $R_{\theta JA}$	 867 75	 mW °C/W
Operating Junction Temperature	T_J	+150	°C
Operating Ambient Temperature Range	T_A	– 40 to +125	°C
Storage Temperature Range	T_{stg}	– 45 to +150	°C

ELECTRICAL CHARACTERISTICS (External components per Figure 1, T_A = 25°C, unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
DC CHARACTERISTICS					
Regulation Voltage (Determined by external resistor divider)	V_{Reg}	–	14.85	–	V
Regulation Voltage Temperature Coefficient	T_C	–13	–11	– 9.0	mV/°C
Suggested Battery Voltage Operating Range	V_{bat}	11.5	14.85	16.5	V
Power Up/Down Threshold Voltage (Pin 3)	V_{Pwr}	0.5	1.2	2.0	V
Standby Current, V_{bat} = 12.8 V, Ignition off, T_A = 25°C V_{bat} = 12.8 V, Ignition off, – 40°C≤T_A≤125°C	 I_{Q1} I_{Q2}	 – –	 1.3 –	 2.0 3.0	 mA mA
Zero Temperature Coefficient Reference Voltage, (Pin 8)	$V_{ref\ \emptyset}$	1.1	1.25	1.4	V
Band Gap Reference Voltage (Pin 20)	V_{ref}	1.7	2.0	2.3	V
Band Gap Reference Temperature Coefficient	TC	–13	–11	– 9.0	mV/°C
Sense Loss Threshold (Pin 2)	$S_{Loss(th)}$	–	0.6	1.0	V
Phase Detection Threshold Voltage (Pin 10)	P_{Th}	1.0	1.25	1.5	V
Phase Rotation Detection Frequency (Pin 10)	P_{Rot}	–	36	–	Hz
Undervoltage Threshold (Pin 19)	V_{UV}	1.0	1.25	1.5	V
Overvoltage Threshold (Pin 2, or Pin 12 if Pin 2 is not used)	V_{OV}	1.09(V_{ref})	1.12(V_{ref})	1.16(V_{ref})	V
Load Dump Threshold (Pin 2, or Pin 12 if Pin 2 is not used)	V_{LD}	1.33(V_{ref})	1.4(V_{ref})	1.48(V_{ref})	V
SWITCHING CHARACTERISTICS					
Fundamental Regulation Output Frequency, (Pin 17) (Clock oscillator frequency divided by 4096)	f	–	68	–	Hz
Suggested Clock Oscillator Frequency Range, (Pin 9) (Determined by external resistor, R_T, see Figure 6)	f_{osc}	205	280	350	kHz
Duty Cycle (Pin 17) At Start–up During Overvoltage Condition	 $Start_{DC}$ OV_{DC}	 27 3.5	 29 4.7	 31 5.5	 % %
Low/High RPM Transition Frequency (Pin 10)	LRC_{Freq}	247	273	309	Hz
LRC Duty Cycle Increase Rate Low RPM Mode (LRC_{Freq} < 247 Hz), Pin 11 = Open (Slow Rate) Low RPM Mode (LRC_{Freq} < 247 Hz), Pin 11 = Grounded (Fast Rate) High RPM Mode (LRC_{Freq} > 309 Hz), Pin 11 = Don't Care (LRC Mode is disabled)	 LRC_S LRC_F LRC_H	 8.5 34 409	 9.5 38 455	 10.5 42 501	 %/sec %/sec %/sec

NOTES: 1. 125 ms wide square wave pulse.
2. Maximum time = 2 minutes.

Figure 1. Simplified Application



NOTES: R1 = R2 = 3.0 k to 5.0 k
R3 = 10 k to 15 k
RT = 50 k to 100 k

Figure 2. Standby Current versus Temperature

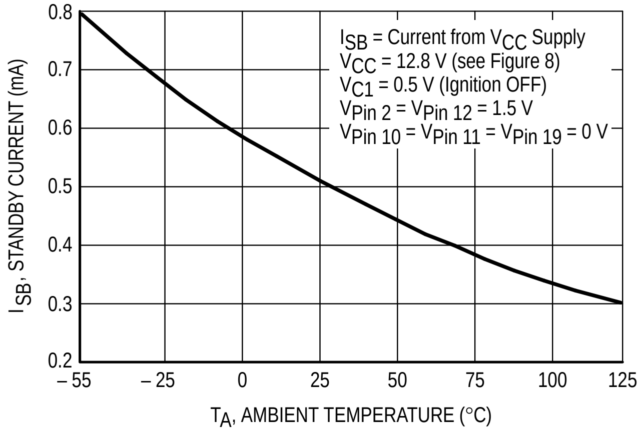


Figure 3. Turn–On Voltage versus Temperature

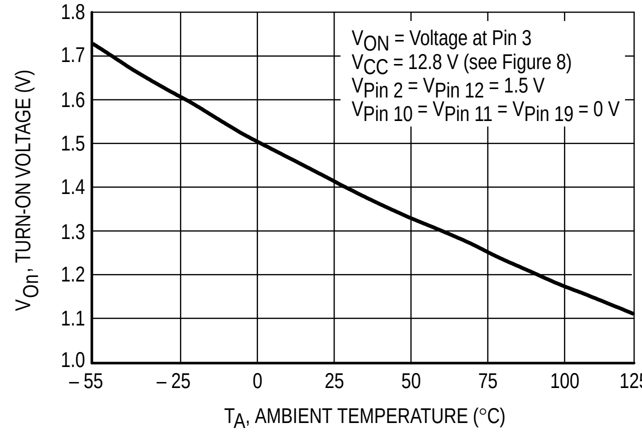


Figure 4. Reference Voltage versus Temperature

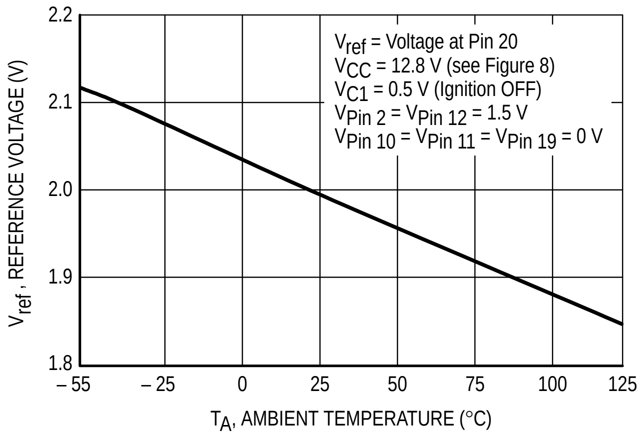


Figure 5. 0TC Reference Voltage versus Temperature

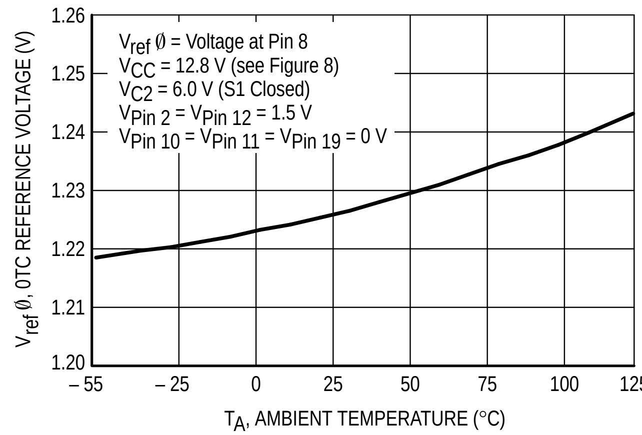


Figure 6. Oscillator Frequency versus Timing Resistor

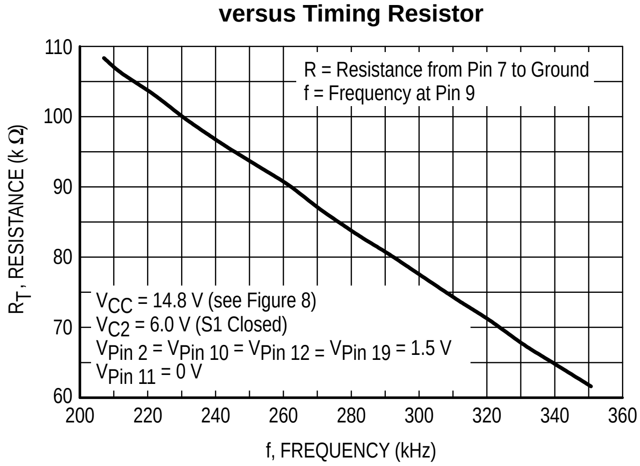


Figure 7. Input Voltage versus Output Duty Cycle

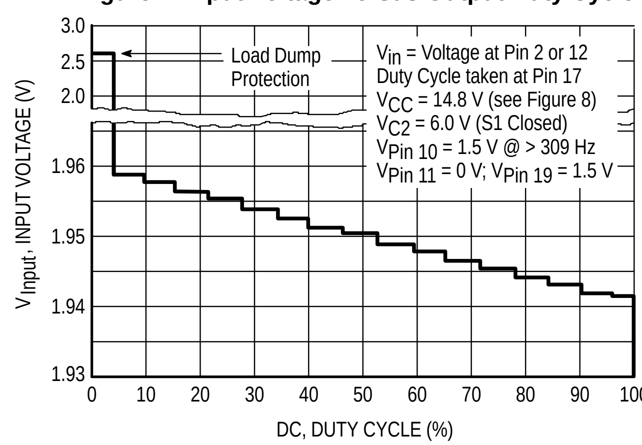
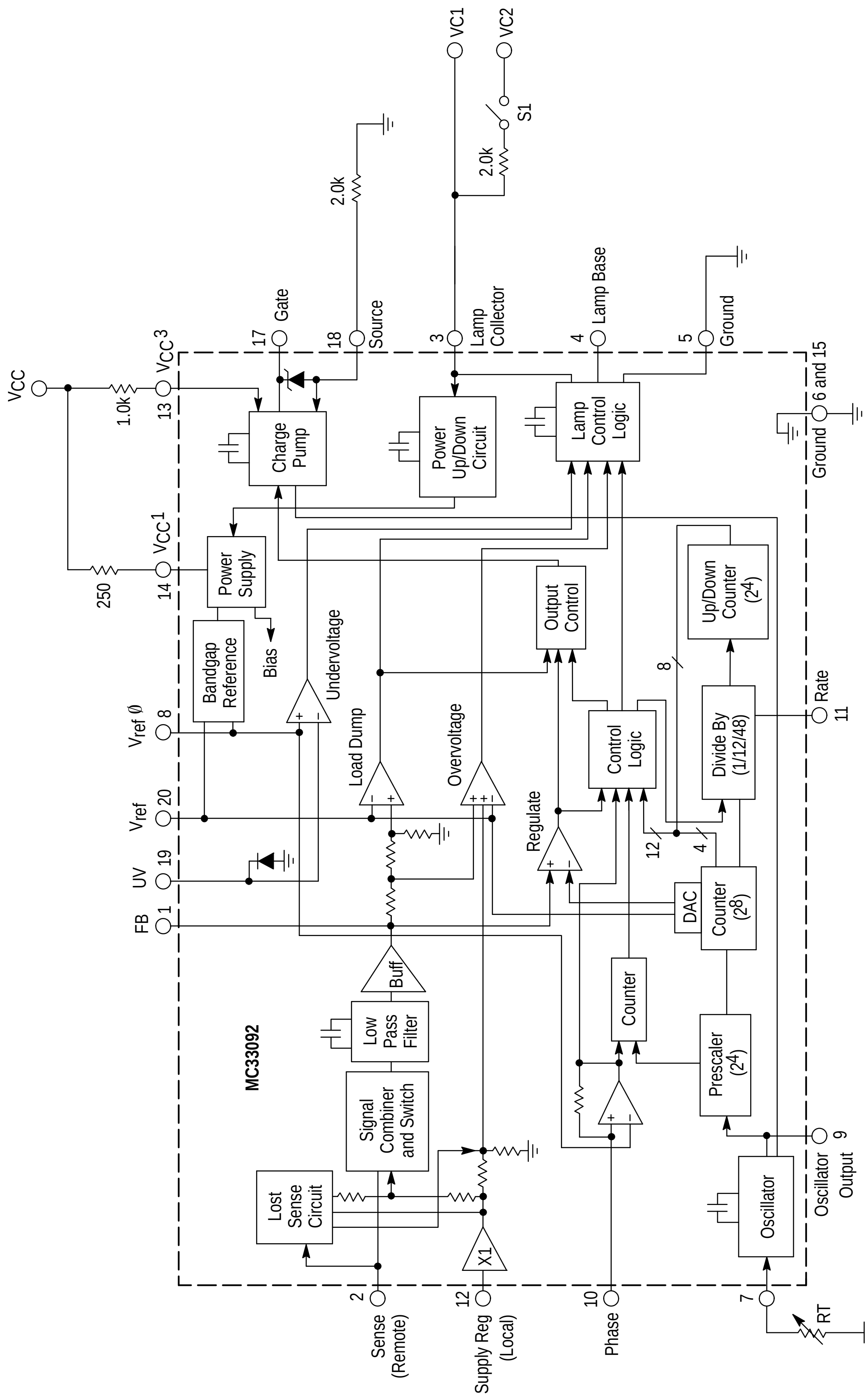


Figure 8. Typical Test Circuit



PIN FUNCTION DESCRIPTION

Pin No.	Function	Description
1	FB	This pin provides a filtered result of the Sense input (if the Sense input is used) or the Supply Regulation input (if the Sense input is not used).
2	Sense	The Sense input is a remote (Kelvin), low current battery voltage reference input used to give an accurate representation of the true battery voltage. This input is also used to monitor overvoltage or load dump conditions.
3	Lamp Collector and Power–Up/Down	This pin connects to the collector of the transistor (Q2) used to drive the fault lamp. It is also used to sense a closed ignition switch (voltage sense) which then turns power on to the IC.
4	Lamp Base	The Lamp Base pin provides base current to the fault lamp drive transistor (Q2).
5	Ground	Grounded to provide a ground return for the fault lamp control logic circuit.
6, 15	Ground	IC ground reference pins.
7	Oscillator Adjust	A resistor to ground on this pin adjusts the internal oscillator frequency (see Figure 6).
8	* $V_{ref\emptyset}$	This is a test point for the 1.1 V to 1.4 V reference voltage. It has a zero temperature coefficient. The reference is used internally for phase signal and undervoltage detection.
9	* Oscillator	Test point for checking the operation of the internal oscillator.
10	Phase	The Phase input detects the existence of a magnetic field rotating within the alternator.
11	Rate	The Rate pin is used to select a slow mode (floating) or fast mode (ground) Load Response Control recovery rate.
12	Supply Regulation	The voltage on the Supply Regulation pin is used as a representation of the alternator output voltage. This input also used to monitor overvoltage or load dump conditions.
13	$V_{CC}3$	Positive supply for the internal Charge Pump.
14	$V_{CC}1$	Positive supply for the entire IC except for the Charge Pump.
15, 6	Ground	Ground reference for the IC.
16	N/C	No connection.
17	Gate	Controls the Gate of the MOSFET used to energize the field winding.
18	Source	Field winding control MOSFET source reference.
19	Undervoltage	If the voltage at this pin goes below 1.0 V, the fault lamp is guaranteed to turn on. The IC will continue to function, but with limited performance.
20	* V_{ref}	Test point for the 1.7 V to 2.3 V Bandgap reference voltage. This voltage has a negative temperature coefficient of approximately –11 mV/°C.

***NOTE:** Pins 8, 9 and 20 are test points only.

APPLICATION CIRCUIT DESCRIPTION

Introduction

The MC33092, designed to operate in a 12 V system, is intended to control the voltage in an automotive system that uses a 3 phase alternator with a rotating field winding. The system shown in Figure 1 includes an alternator with its associated field coil, stator coils and rectifiers, a battery, a lamp and an ignition switch. A tap is connected to one corner of the stator windings and provides an AC signal for rotation (phase) detection.

A unique feature of the MC33092 is the Load Response Control (LRC) circuitry. The LRC circuitry is active when the stator winding AC signal frequency (phase buffer input signal, Pin 10) is lower than the Low/High RPM transition frequency. When active, the LRC circuitry dominates the basic analog control circuitry and slows the alternator response time to sudden increases in load current. This prevents the alternator from placing a sudden, high torque load on the automobile engine when a high current accessory is switched on.

The LRC circuitry is inactive when the stator winding AC signal frequency is higher than the Low/High RPM transition frequency. When the LRC circuitry is inactive, the basic analog control circuitry controls the alternator so it will supply a constant voltage that is independent of the load current.

Both the LRC and analog control circuits control the system voltage by switching ON and OFF the alternator field current using Pulse Width Modulation (PWM). The PWM approach controls the duty cycle and therefore the average field current. The field current is switched ON and OFF at a fixed frequency by a MOSFET (Q1) which is driven directly by the IC. The MC33092 uses a charge pump to drive the MOSFET in a high side configuration for alternators having a grounded field winding.

A fault detector is featured which detects overvoltage, undervoltage, slow rotation or non–rotation (broken alternator belt) conditions and indicates them through a fault lamp drive output (Pin 4).

A Load Dump protection circuit is included. During a load dump condition, the MOSFET gate drive (Pin 17) and the fault lamp drive output are disabled to protect the MOSFET, field winding and lamp.

Power–Up/Down

Power is continuously applied to the MC33092 through $V_{CC}1$ and $V_{CC}3$. A power–up/down condition is determined by the voltage on the Lamp Collector pin (Pin 3). When this voltage is below 0.5 V the IC is guaranteed to be in a low current standby mode. When the voltage at Pin 3 is above 2.0 V, the IC is guaranteed to be fully operational. The power–up voltage is applied to Pin 3 via the ignition switch and fault lamp. In case the fault lamp opens, a 500 Ω bypass resistor should be used to ensure regulator IC power–up.

A power–up reset circuit provides a reset or set condition for all digital counter circuitry. There is also a built–in power–up delay circuit that protects against erratic power–up signals.

Battery and Alternator Output Voltage Sensing

The battery and the alternator output voltage are sensed by the remote (Sense, Pin 2), and the local (Supply Regulator, Pin 12) input buffer pins, respectively, by way of external voltage dividers. The regulated system voltage is determined by the voltage divider resistor values.

Normally the remote pin voltage determines the value at which the battery voltage is regulated. In some cases the remote pin is not used. When this condition ($V_{Pin\ 2}$ < 0.6 V typically) exists, a sense loss function allows the local pin voltage to determine the regulated battery voltage with no attenuation of signal. If, however, when the remote pin is used, and the voltage at this pin is approximately 25% less than the voltage at the local sense pin (but greater than 0.6 V, typically), the value at which the battery voltage is regulated is switched to the local sense pin voltage (minus the 25%). The signal combiner/switch controls this transfer function.

Low Pass Filter, DAC & Regulator Comparator

The output of the combiner/switch buffer feeds a low pass filter block to remove high frequency system noise. The filter output is buffered and compared by the regulator comparator to a descending ramp waveform generated by an internal DAC. When the two voltages are approximately equal, the output of the regulator comparator changes state and the gate of the MOSFET is pulled low (turned OFF) by the output control logic for the duration of the output frequency clock cycle. At the beginning of the next output clock cycle, the DAC begins its descending ramp waveform and the MOSFET is turned ON until the regulator comparator output again changes state. This ongoing cycle constitutes the PWM technique used to control the system voltage.

Oscillator

The oscillator block provides the clock pulses for the prescaler–counter chain and the charge control for the charge pump circuit. The oscillator frequency is set by an external resistor from Pin 7 to ground as presented in Figure 6.

The prescaler–counter divides the oscillator frequency by 2^{12} (4096) and feeds it to the output control logic and divider–up/down counter chain. The output control logic uses it as the fundamental regulation output frequency (Pin 17).

Load Response Control

The Load Response Control (LRC) circuit generates a digital control of the regulation function and is active when the stator output AC signal (Pin 10) frequency is lower than the Low/High RPM transition frequency. The LRC circuit takes the output signal of the prescaler–counter chain and with a subsequent divider and up/down counter to provide delay, controls the alternator response time to load increases on the system. The response time is pin programmable to two rates. Pin 11 programs the divider to divide by 12 or divide by 48. If Pin 11 is grounded, the signal fed to the up/down counter is divided by 12 and the response time is 12 times slower than the basic analog response time. If Pin 11 is left floating, the signal to the up/down counter is divided by 48 and the response time is 48 times slower.

The basic analog (LRC not active) and digital duty cycle control (LRC active) are OR'd such that either function will terminate drive to the gate of the MOSFET device with the shortest ON–time, i.e., lower duty cycle dominating.

The digital ON–time is determined by comparing the output of the up/down counter to a continuous counter and decoding when they are equal. This event will terminate drive to the MOSFET. A count direction shift register requires three consecutive clock pulses with a state change on the data input of the register to result in an up/down count direction change. The count will increase for increasing system load up to 100% duty cycle and count down for decreased loading to a minimum of 29% duty cycle. The analog control can provide a minimum duty cycle of 4 to 5%. The initial power–up duty cycle is 29% until the phase comparator input exceeds its input threshold voltage. Also, the IC powers up with the LRC circuit active, i.e., when the Lamp Collector pin exceeds the power–up threshold voltage.

Fault Lamp Indicator

Pins 3 and 4 control the external Darlington transistor (Q2) that drives the fault indicator lamp. A 10 Ω resistor should be placed in series with the transistor's emitter for current limiting purposes. The fault lamp is energized during any of the following fault conditions: 1) No Phase buffer (Pin 10) input due to slow or no alternator rotation, shorted phase winding, etc.; 2) Phase buffer input AC voltage less than the phase detect threshold; 3) Overvoltage on Pin 2, or Pin 12 if Pin 2 is not used, or 4) Undervoltage on Pin 19 with the phase buffer input signal higher than the Low/High RPM transition frequency.

Phase Buffer Input

A tap is normally connected to one corner of the alternator's stator winding to provide an AC voltage for rotation detection. This AC signal is fed into the phase buffer input (Pin 10) through a voltage divider. If the frequency of this signal is less than the phase rotation detect frequency (36 Hz, typically), the fault lamp is lit indicating an insufficient alternator rotation and the MOSFET drive (Pin 17) output duty cycle is restricted to approximately 29% maximum. Also, if the peak voltage of the AC signal is less than the phase detect threshold, the fault lamp is lit indicating an insufficient amount of field current and again the MOSFET drive (Pin 17) output duty cycle is restricted to approximately 29% maximum.

Undervoltage, Overvoltage and Load Dump

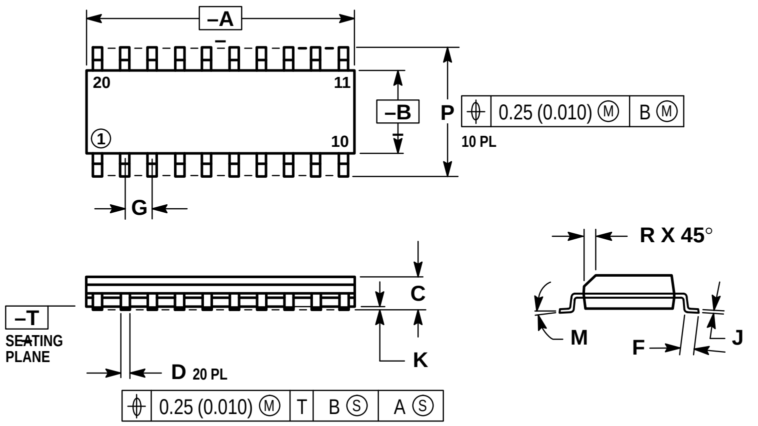
The low pass filter output feeds an undervoltage comparator through an external voltage divider. The voltage divider can be used to adjust the undervoltage detection level. During an undervoltage condition, the fault lamp will light only if the phase buffer input signal frequency is higher than the Low/High RPM transition frequency. This is to ensure that the undervoltage condition is caused by a true fault and not just by low alternator rotation. To help maintain system voltage regulation during an undervoltage condition, the output duty cycle is automatically increased to 100%. Even though the fault lamp may be energized for an undervoltage condition, the MC33092 will continue to operate but with limited performance.

Through an internal voltage divider, the low pass filter feeds an overvoltage comparator which monitors this output for an overvoltage condition. If the overvoltage threshold is exceeded, the fault lamp is lit and the MOSFET drive (Pin 17) output duty cycle is restricted to approximately 4% maximum.

The internal voltage divider on the input to the load dump comparator has a different ratio than the divider used on the overvoltage comparator. This allows the load dump detect threshold to be higher than the overvoltage threshold even though both comparators are monitoring the same low pass filter output. If the load dump detect threshold is exceeded, the fault lamp and MOSFET drive outputs are disabled to protect the MOSFET, field winding and lamp.

OUTLINE DIMENSIONS

DW SUFFIX
PLASTIC PACKAGE
CASE 751D
(SO–20L)



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. 751D–01, AND –02 OBSOLETE, NEW STANDARD 751D–03.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	12.65	12.95	0.499	0.510
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

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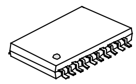
MFAX: RMFAX0@email.sps.mot.com – TOUCHTONE 602–244–6609
INTERNET: http://Design–NET.com

JAPAN: Nippon Motorola Ltd.; Tatsumi–SPD–JLDC, 6F Seibu–Butsuryu–Center, 3–14–2 Tatsumi Koto–Ku, Tokyo 135, Japan. 03–81–3521–8315

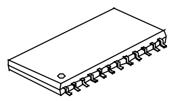
ASIA / PACIFIC: Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park, 51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852–26629298

UTC MC33092 LINEAR INTEGRATED CIRCUIT

ALTERNATOR VOLTAGE REGULATOR



SOP-20



SOP-24

DESCRIPTION

The MC33092 is specifically designed for voltage regulation and Load Response Control (LRC) of diode rectified alternator charging systems, as commonly found in automotive applications.

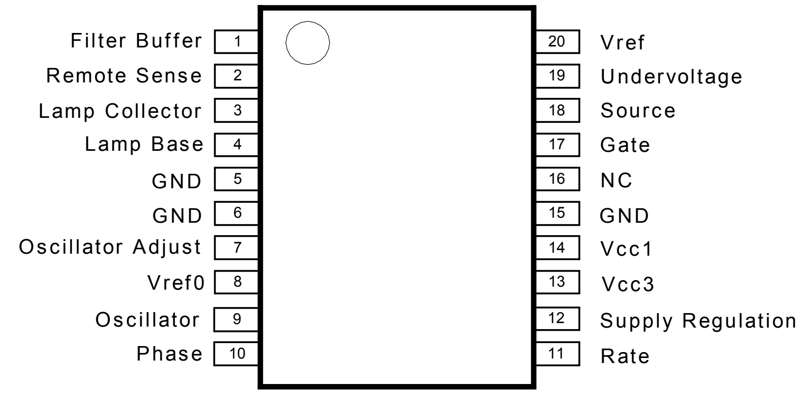
In maintaining system voltage, the MC33092 monitors and compares the system battery voltage to an externally programmed set point value and pulse width modulates an N–channel MOSFET transistor to control the average alternator field current.

FEATURE

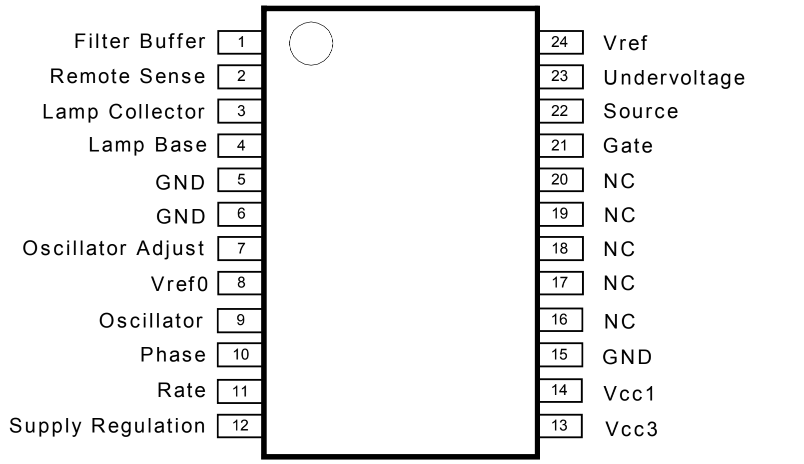
*Forced Load Response Control (LRC) with Heavy Load Transitions at Low RPM
*Capable of Regulating Voltage to ± 0.1 V @ 25°C
*Operating Frequency Selectable with One External Resistor
*< 0.1 V Variation over Speed Range of 2000 to 10,000 RPM
*< 0.4 V Variation over 10% to 95% of Maximum Alternator Output
*Maintains Regulation with External Loads as Low as 1.0 A
*Load Dump Protection of Lamp, Field Control Devices, and Loads
*Duty Cycle Limit Protection
*Provides High Side MOSFET Control of a Ground Referenced Field Winding
*Controlled MOSFET and Flyback Diode Recovery Characteristics for Minimum RFI
*Optional 2.5 or 10 sec. LRC Rate Control (Osc. Freq. = 280 kHz)
*Undervoltage, Overvoltage and Phase Fault (Broken Belt) Detection

PIN CONFIGURATION

20-pin Package



24-pin Package

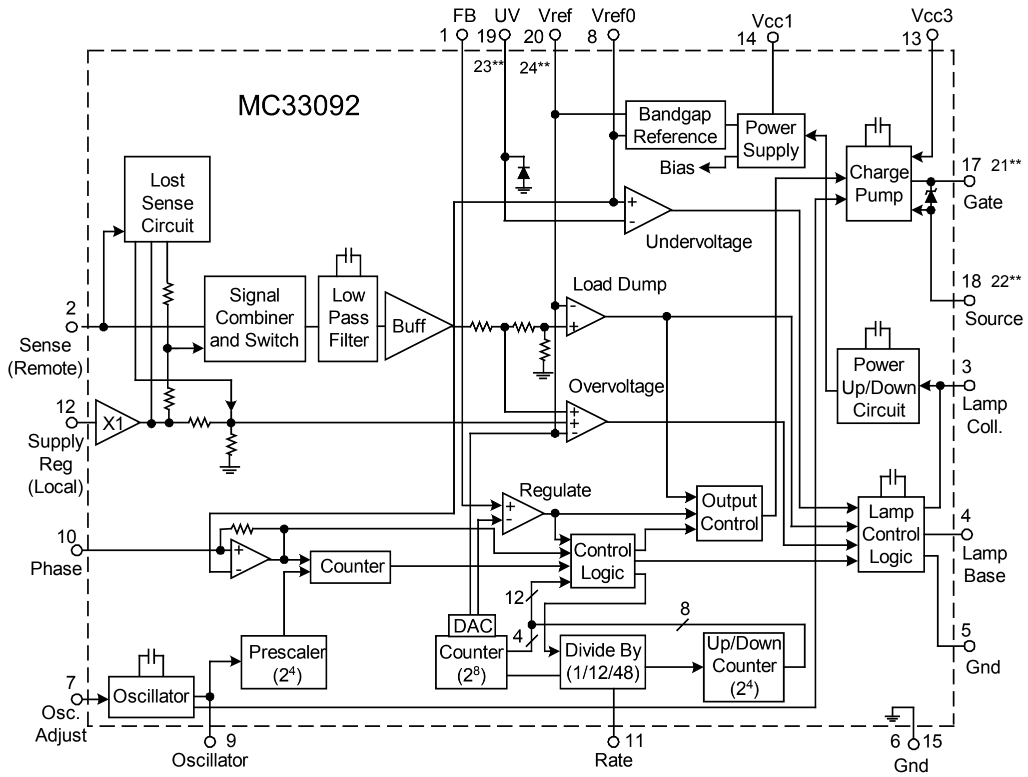


PIN DESCRIPTION

20-pin Package	24-pin Package	PIN NAME	DESCRIPTION
PIN No.			
1	1	FB	This pin provides a filtered result of the Sense input (if the Sense input is used) or the Supply Regulation input (if the Sense input is not used).
2	2	Sense	The Sense input is a remote, low current battery voltage reference input used to give an accurate representation of the true battery voltage. This input is also used to monitor overvoltage or load dump conditions.
3	3	Lamp Collector and Power-Up/Down	This pin connects to the collector of the transistor (Q2) used to drive the fault lamp. It is also used to sense a closed ignition switch (voltage sense) which then turns power on to the IC.
4	4	Lamp Base	The Lamp Base pin provides base current to the fault lamp drive transistor (Q2).
5	5	Ground	Grounded to provide a ground return for the fault lamp control logic circuit.
6, 15	6,15	Ground	IC ground reference pins.
7	7	Oscillator Adjust	A resistor to ground on this pin adjusts the internal oscillator frequency.
8	8	Vref0 *	This is a test point for the 1.1 V to 1.4 V reference voltage. It has a zero temperature coefficient. The reference is used internally for phase signal and undervoltage detection.
9	9	Oscillator *	Test point for checking the operation of the internal oscillator.
10	10	Phase	The Phase input detects the existence of a magnetic field rotating within the alternator.
11	11	Rate	The Rate pin is used to select a slow mode (floating) or fast mode (ground) Load Response Control recovery rate.
12	12	Supply Regulation	The voltage on the Supply Regulation pin is used as a representation of the alternator output voltage. This input also used to monitor overvoltage or load dump conditions.
13	13	VCC3	Positive supply for the internal Charge Pump.
14	14	VCC1	Positive supply for the entire IC except for the Charge Pump.
15,6	15,6	Ground	Ground reference for the IC.
16	16,17,18, 19,20	N/C	No connection.
17	21	Gate	Controls the Gate of the MOSFET used to energize the field winding.
18	22	Source	Field winding control MOSFET source reference.
19	23	Undervoltage	If the voltage at this pin goes below 1.0 V, the fault lamp is guaranteed to turn on. The IC will continue to function, but with limited performance.
20	24**	Vref *	Test point for the 1.7 V to 2.3 V Bandgap reference voltage. This voltage has a negative temperature coefficient of approximately –11 mV/°C.

NOTE: * Pins 8, 9 and 20(24**) are test points only.
** For 24-pin package.

BLOCK DIAGRAM



Note: ** For 24-pin package

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATINGS	UNIT
Power Supply Voltage	Vbat	24	V
Load Dump Transient Voltage (Note 1)	+Vmax	40	V
Negative Voltage (Note 2)	–Vmin	-2.5	V
Power Dissipation (Ta = 125°C) SOP-20	P_D	867	mW
SOP-24	P_D	1000	mW
Operating Ambient Temperature	Ta	-40 ~ +125	°C
Operating Junction Temperature	Tj	+150	°C
Storage Temperature	Tstg	-45 ~ +150	°C

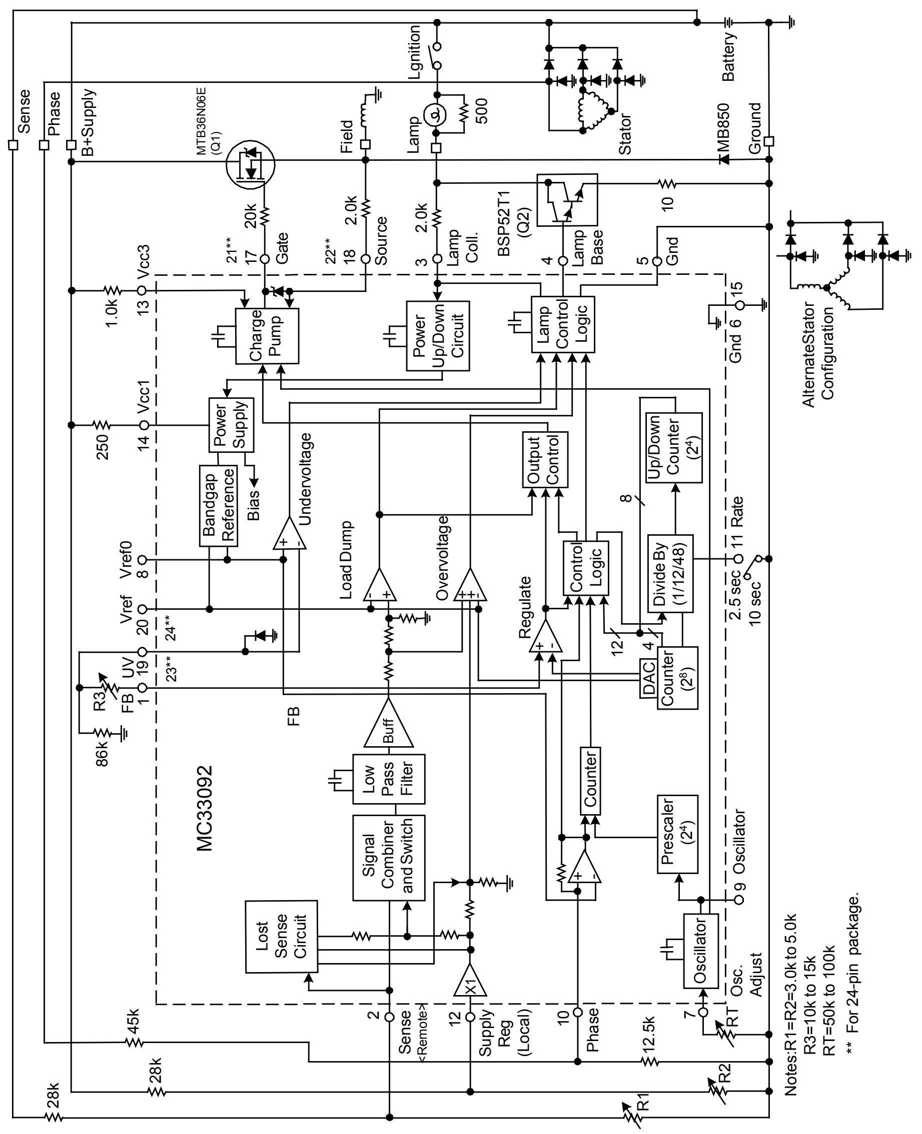
NOTES: 1. 125 ms wide square wave pulse.
2. Maximum time = 2 minutes.

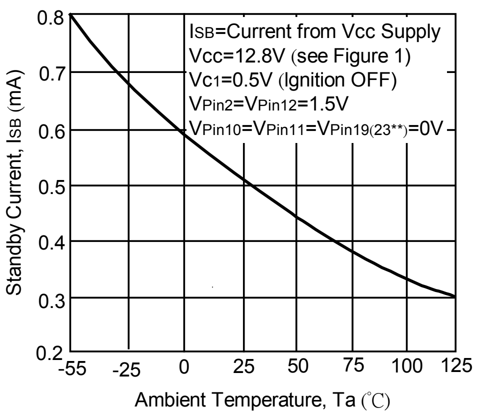
ELECTRICAL CHARACTERISTICS (Ta=25°C, unless otherwise specified)

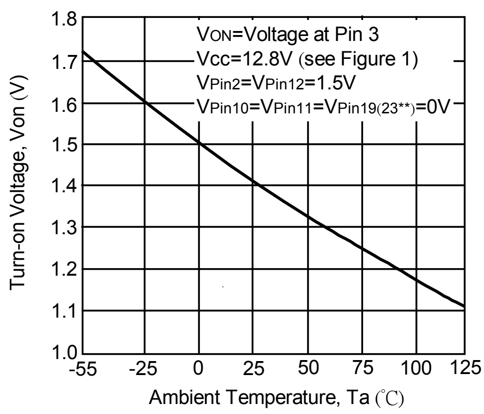
PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
DC CHARACTERISTICS					
Regulation Voltage (Determined by external resistor divider)	V_{Reg}		14.85		V
Regulation Voltage Temperature Coefficient	Tc	-13	-11	-9.0	mV/°C
Suggested Battery Voltage Operating Range	Vbat	11.5	14.85	16.5	V
Power Up/Down Threshold Voltage (Pin 3)	Vpwr	0.5	1.2	2.0	V
Standby Current, Vbat = 12.8 V, Ignition off, Ta = 25°C Vbat = 12.8 V, Ignition off, -40°C≦Ta≦125°C	 I_{Q1} I_{Q2}		 1.3	 2.0 3.0	 mA mA
Zero Temperature Coefficient Reference Voltage, (Pin 8)	Vref0	1.1	1.25	1.4	V
Band Gap Reference Voltage [Pin 20 (24**)]	Vref	1.7	2.0	2.3	V
Band Gap Reference Temperature Coefficient	TC	-13	-11	-9.0	mV/°C
Sense Loss Threshold (Pin 2)	$S_{Loss(th)}$		0.6	1.0	V
Phase Detection Threshold Voltage (Pin 10)	P_{Th}	1.0	1.25	1.5	V
Phase Rotation Detection Frequency (Pin 10)	P_{Rot}		36		Hz
Undervoltage Threshold [Pin 19 (23**)]	V_{UV}	1.0	1.25	1.5	V
Overvoltage Threshold (Pin 2, or Pin 12 if Pin 2 is not used)	V_{OV}	1.09(Vref)	1.12(Vref)	1.16(Vref)	V
Load Dump Threshold (Pin 2, or Pin 12 if Pin 2 is not used)	V_{LD}	1.33(Vref)	1.4(Vref)	1.48(Vref)	V
SWITCHING CHARACTERISTICS					
Fundamental Regulation Output Frequency, [Pin 17 (21**)] (Clock oscillator frequency divided by 4096)	f		68		Hz
Suggested Clock Oscillator Frequency Range, (Pin 9) (Determined by external resistor, RT)	fosc	205	280	350	kHz
Duty Cycle [Pin 17 (21**)] At Start–up During Overvoltage Condition	 $Start_{DC}$ OV_{DC}	 27 3.5	 29 4.7	 31 5.5	%
Low/High RPM Transition Frequency (Pin 10)	LRC_{Freq}	247	273	309	Hz
LRC Duty Cycle Increase Rate Low RPM Mode (LRCFreq < 247 Hz), Pin 11 = Open (Slow Rat) Low RPM Mode (LRCFreq < 247 Hz), Pin 11 = Grounded (Fast Rate) High RPM Mode (LRCFreq > 309 Hz), Pin 11 = Don't Care (LRC Mode is disabled)	 LRC_S LRC_F LRC_H	 8.5 34 409	 9.5 38 455	 10.5 42 501	%/sec

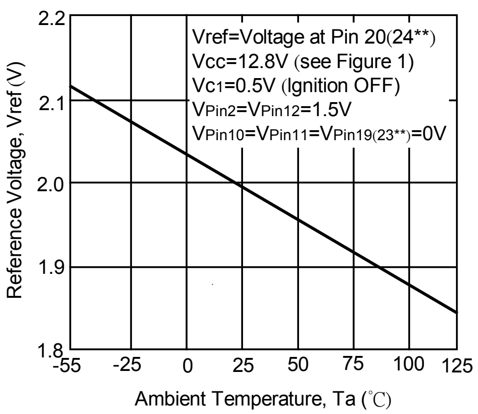
NOTE: ** For 24-pin package.

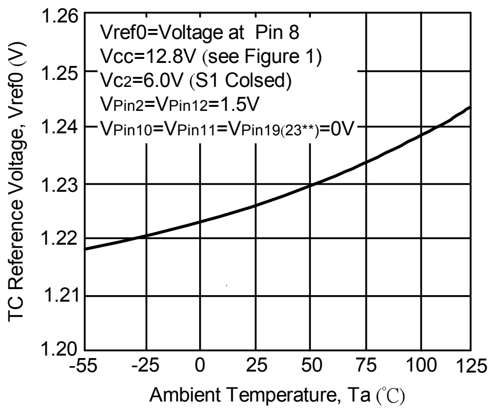
APPLICATION CIRCUIT

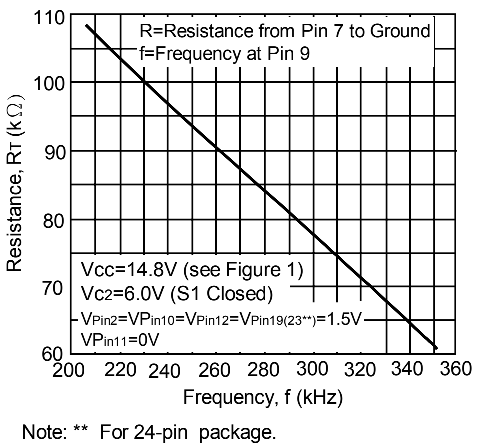


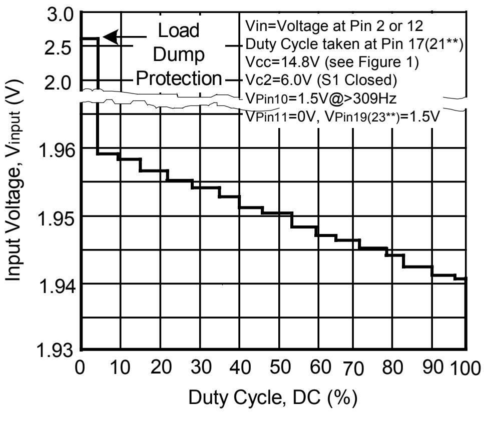






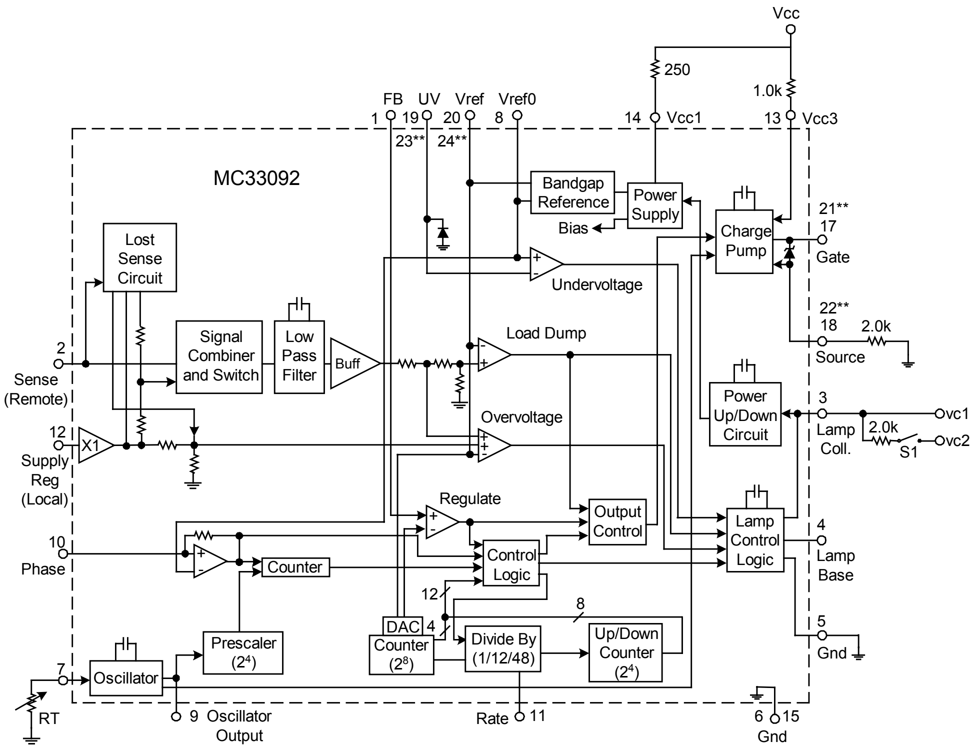






Note: ** For 24-pin package.

TYPICAL TEST CIRCUIT



Note: ** For 24-pin package

Figure 1.

MOTOROLA

Alternator Voltage Regulator

MC33092A

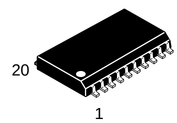
The MC33092A is specifically designed for voltage regulation and Load Response Control (LRC) of diode rectified alternator charging systems, as commonly found in automotive applications. The MC33092A provides load response control of the alternator output current to eliminate engine speed hunting and vibration due to sudden electrical loads which cause abrupt torque loading of the engine at low RPM. Two load response rates are selectable using Pin 11. The timing of the response rates is dependent on the oscillator frequency.

In maintaining system voltage, the MC33092A monitors and compares the system battery voltage to an externally programmed set point value and pulse width modulates an N–channel MOSFET transistor to control the average alternator field current.

- Forced Load Response Control (LRC) with Heavy Load Transitions at Low RPM
- Capable of Regulating Voltage to ± 0.1 V @ 25°C
- Operating Frequency Selectable with One External Resistor
- < 0.1 V Variation over Speed Range of 2000 to 10,000 RPM
- < 0.4 V Variation over 10% to 95% of Maximum Alternator Output
- Maintains Regulation with External Loads as Low as 1.0 A
- Load Dump Protection of Lamp, Field Control Devices, and Loads
- Duty Cycle Limit Protection
- Provides High Side MOSFET Control of a Ground Referenced Field Winding
- Controlled MOSFET and Flyback Diode Recovery Characteristics for Minimum RFI
- < 2.0 mA Standby Current from Battery @ 25°C
- < 3.0 mA Standby Current from Battery Over Temperature Range
- Optional 2.5 or 10 sec. LRC Rate Control (Osc. Freq. = 280 kHz)
- Undervoltage, Overvoltage and Phase Fault (Broken Belt) Detection

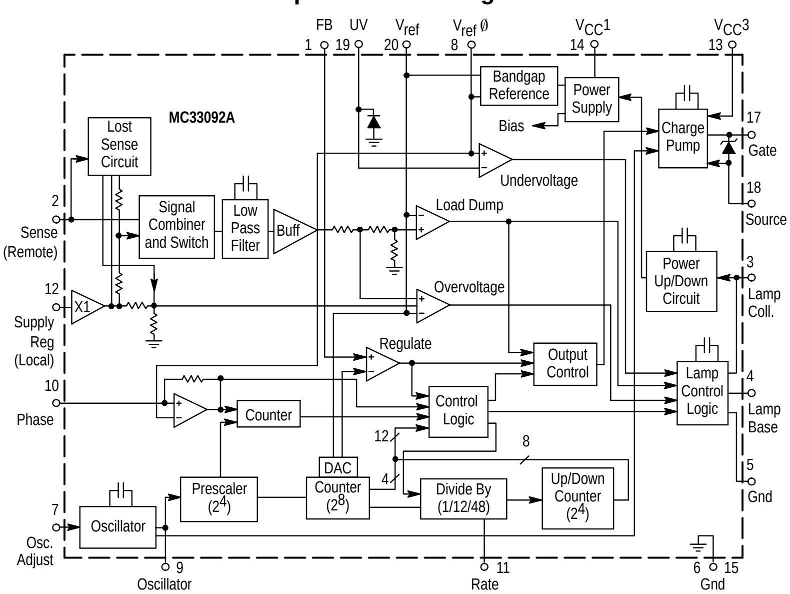
ALTERNATOR VOLTAGE REGULATOR

SEMICONDUCTOR TECHNICAL DATA

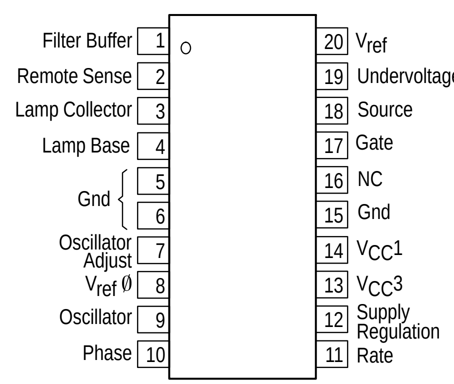


DW SUFFIX
PLASTIC PACKAGE
CASE 751D
(SO–20L)

Simplified Block Diagram



PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC33092ADW	T_A = – 35° to +125°C	SO–20L

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{bat}	24	V
Load Dump Transient Voltage (Note 1)	$+V_{max}$	40	V
Negative Voltage (Note 2)	$–V_{min}$	–2.5	V
Power Dissipation and Thermal Characteristics			
Maximum Power Dissipation @ T_A = 125°C	P_D	867	mW
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	75	°C/W
Operating Junction Temperature	T_J	+150	°C
Operating Ambient Temperature Range	T_A	–35 to +125	°C
Storage Temperature Range	T_{stg}	–45 to +150	°C

NOTE: ESD data available upon request.

ELECTRICAL CHARACTERISTICS (External components per Figure 1, T_A = 25°C, unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
DC CHARACTERISTICS					
Regulation Voltage (Determined by external resistor divider)	V_{Reg}	–	14.85	–	V
Regulation Voltage Temperature Coefficient	T_C	–13	–11	– 9.0	mV/°C
Suggested Battery Voltage Operating Range	V_{bat}	11.5	14.85	16.5	V
Power Up/Down Threshold Voltage (Pin 3)	V_{Pwr}	0.5	1.2	2.0	V
Standby Current,					
V_{bat} = 12.8 V, Ignition off, T_A = 25°C	I_{Q1}	–	1.3	2.0	mA
V_{bat} = 12.8 V, Ignition off, –35°C ≤ T_A ≤ 125°C	I_{Q2}	–	–	3.0	mA
Zero Temperature Coefficient Reference Voltage, (Pin 8)	$V_{ref\,\emptyset}$	1.1	1.25	1.4	V
Band Gap Reference Voltage (Pin 20)	V_{ref}	1.7	2.0	2.3	V
Band Gap Reference Temperature Coefficient	TC	–13	–11	– 9.0	mV/°C
Sense Loss Threshold (Pin 2)	$S_{Loss(th)}$	–	0.6	1.0	V
Phase Detection Threshold Voltage (Pin 10)	P_{Th}	1.0	1.25	1.5	V
Phase Rotation Detection Frequency (Pin 10)	P_{Rot}	–	36	–	Hz
Undervoltage Threshold (Pin 19)	V_{UV}	1.0	1.25	1.5	V
Overvoltage Threshold (Pin 2, or Pin 12 if Pin 2 is not used)	V_{OV}	1.09(V_{ref})	1.12(V_{ref})	1.16(V_{ref})	V
Load Dump Threshold (Pin 2, or Pin 12 if Pin 2 is not used)	V_{LD}	1.33(V_{ref})	1.4(V_{ref})	1.48(V_{ref})	V
SWITCHING CHARACTERISTICS					
Fundamental Regulation Output Frequency, (Pin 17) (Clock oscillator frequency divided by 4096)	f	–	68	–	Hz
Suggested Clock Oscillator Frequency Range, (Pin 9) (Determined by external resistor, R_T, see Figure 6)	f_{osc}	205	280	350	kHz
Duty Cycle (Pin 17)					
At Start–up	$Start_{DC}$	27	29	31	%
During Overvoltage Condition	OV_{DC}	3.5	4.7	5.5	%
Low/High RPM Transition Frequency (Pin 10)	LRC_{Freq}	247	273	309	Hz
LRC Duty Cycle Increase Rate					
Low RPM Mode (LRC_{Freq} < 247 Hz), Pin 11 = Open (Slow Rate)	LRC_S	8.5	9.5	10.5	%/sec
Low RPM Mode (LRC_{Freq} < 247 Hz), Pin 11 = Grounded (Fast Rate)	LRC_F	34	38	42	%/sec
High RPM Mode (LRC_{Freq} > 309 Hz), Pin 11 = Don't Care (LRC Mode is disabled)	LRC_H	409	455	501	%/sec

NOTES: 1. 125 ms wide square wave pulse.
2. Maximum time = 2 minutes.

Figure 1. Simplified Application

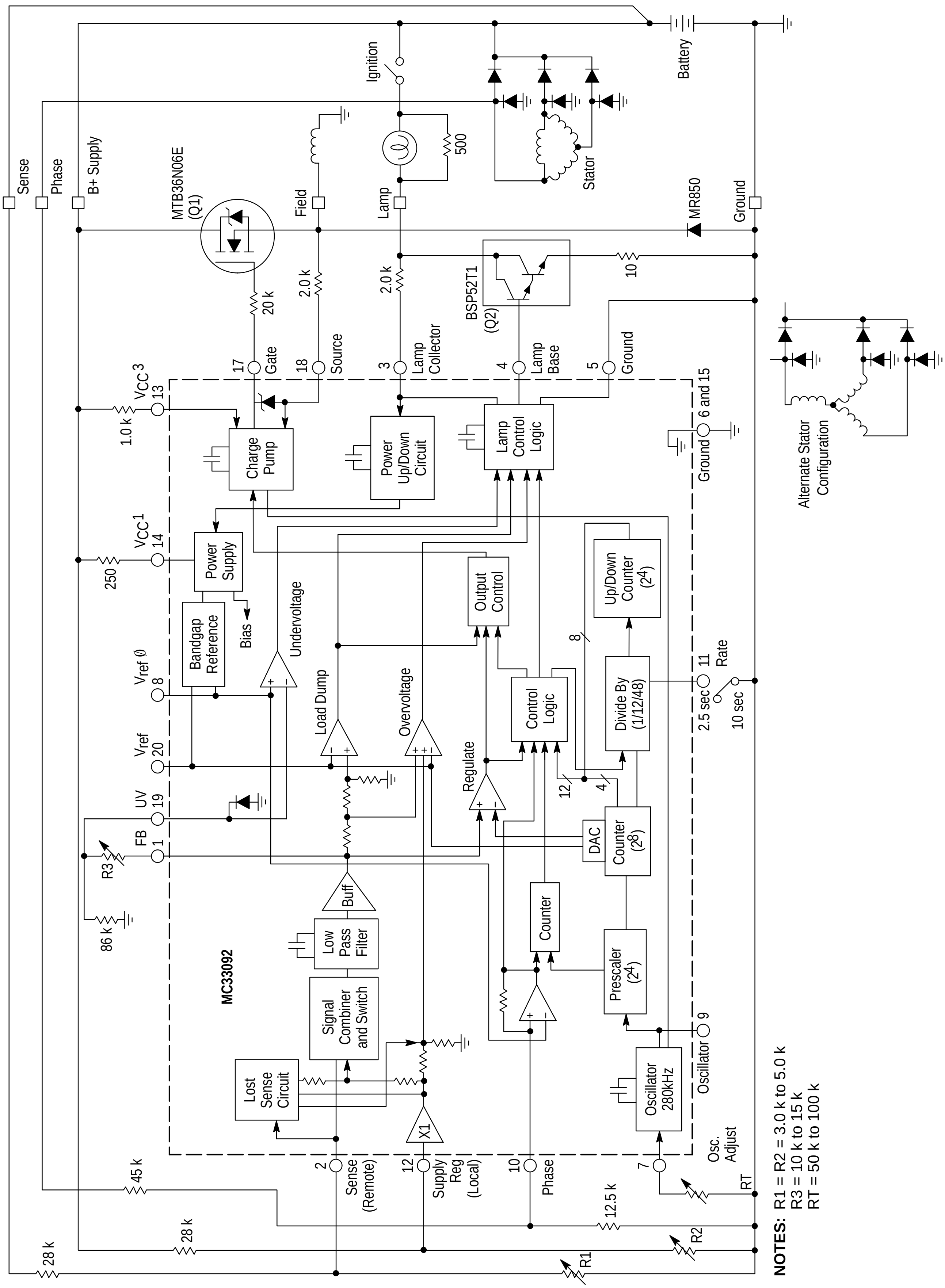


Figure 2. Standby Current versus Temperature

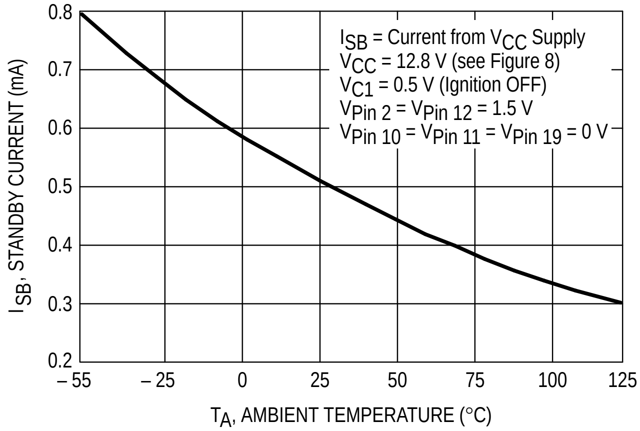


Figure 3. Turn–On Voltage versus Temperature

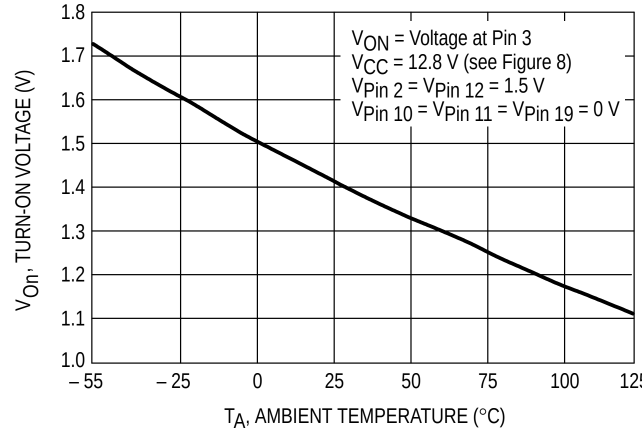


Figure 4. Reference Voltage versus Temperature

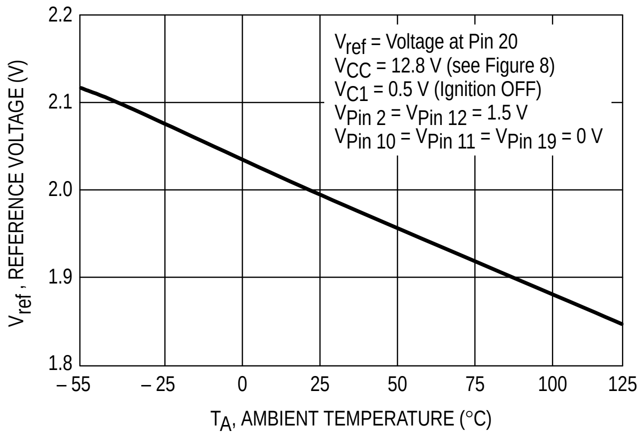


Figure 5. 0TC Reference Voltage versus Temperature

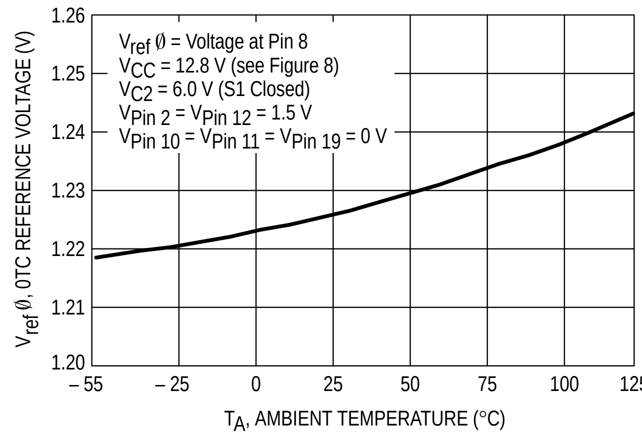


Figure 6. Oscillator Frequency versus Timing Resistor

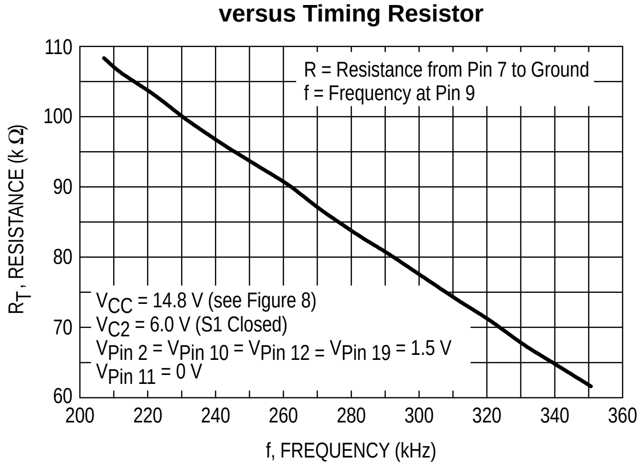
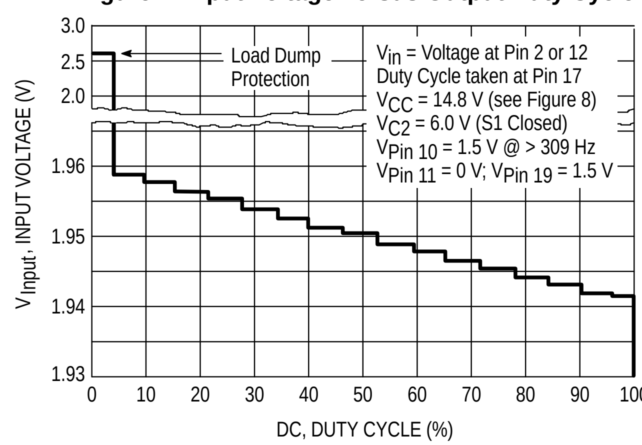


Figure 7. Input Voltage versus Output Duty Cycle



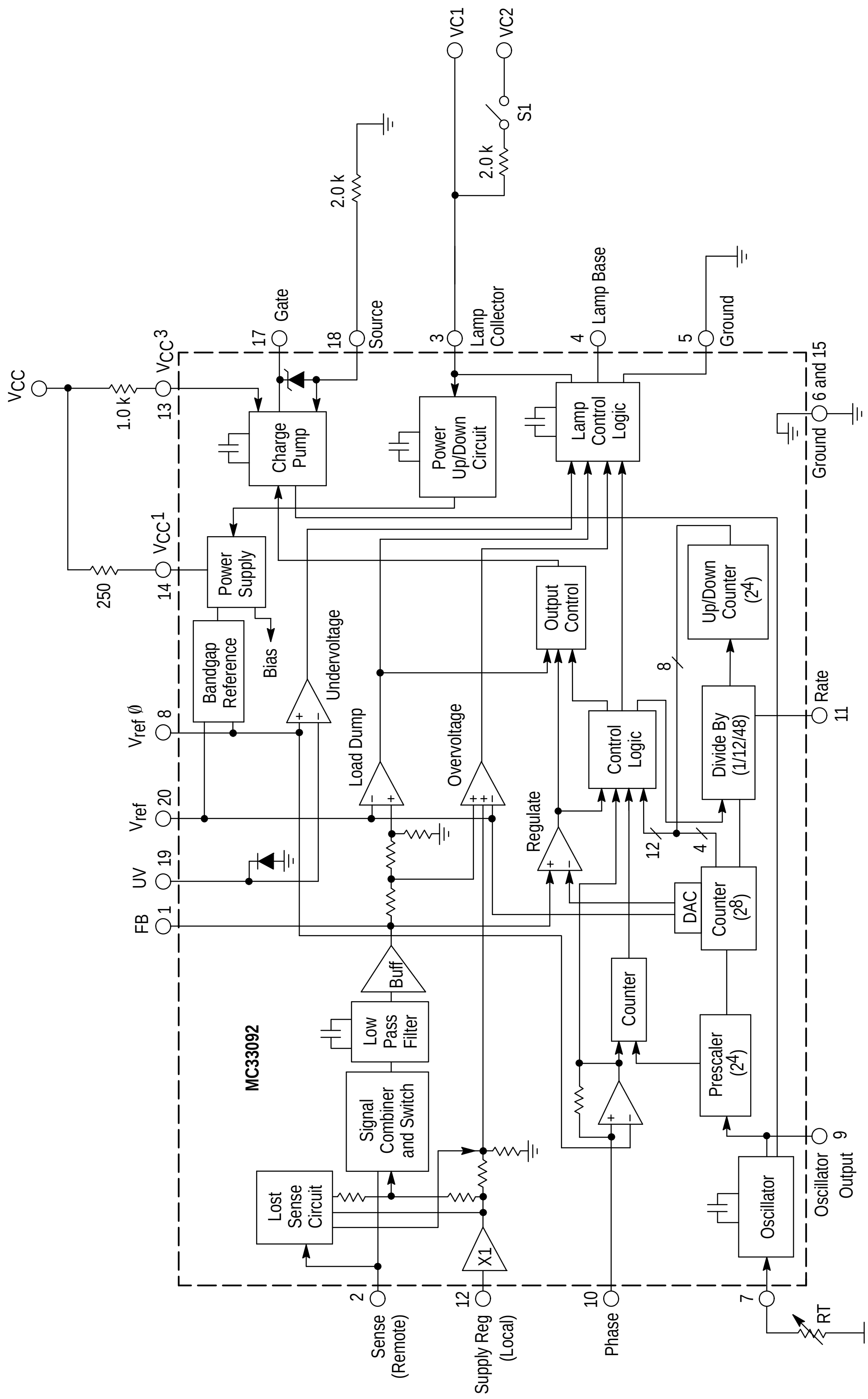


Figure 8. Typical Test Circuit

PIN FUNCTION DESCRIPTION

Pin No.	Function	Description
1	FB	This pin provides a filtered result of the Sense input (if the Sense input is used) or the Supply Regulation input (if the Sense input is not used).
2	Sense	The Sense input is a remote (Kelvin), low current battery voltage reference input used to give an accurate representation of the true battery voltage. This input is also used to monitor overvoltage or load dump conditions.
3	Lamp Collector and Power–Up/Down	This pin connects to the collector of the transistor (Q2) used to drive the fault lamp. It is also used to sense a closed ignition switch (voltage sense) which then turns power on to the IC.
4	Lamp Base	The Lamp Base pin provides base current to the fault lamp drive transistor (Q2).
5	Ground	Grounded to provide a ground return for the fault lamp control logic circuit.
6, 15	Ground	IC ground reference pins.
7	Oscillator Adjust	A resistor to ground on this pin adjusts the internal oscillator frequency (see Figure 6).
8	* $V_{ref\phi}$	This is a test point for the 1.1 V to 1.4 V reference voltage. It has a zero temperature coefficient. The reference is used internally for phase signal and undervoltage detection.
9	* Oscillator	Test point for checking the operation of the internal oscillator.
10	Phase	The Phase input detects the existence of a magnetic field rotating within the alternator.
11	Rate	The Rate pin is used to select a slow mode (floating) or fast mode (ground) Load Response Control recovery rate.
12	Supply Regulation	The voltage on the Supply Regulation pin is used as a representation of the alternator output voltage. This input also used to monitor overvoltage or load dump conditions.
13	$V_{CC}3$	Positive supply for the internal Charge Pump.
14	$V_{CC}1$	Positive supply for the entire IC except for the Charge Pump.
15, 6	Ground	Ground reference for the IC.
16	N/C	No connection.
17	Gate	Controls the Gate of the MOSFET used to energize the field winding.
18	Source	Field winding control MOSFET source reference.
19	Undervoltage	If the voltage at this pin goes below 1.0 V, the fault lamp is guaranteed to turn on. The IC will continue to function, but with limited performance.
20	* V_{ref}	Test point for the 1.7 V to 2.3 V Bandgap reference voltage. This voltage has a negative temperature coefficient of approximately –11 mV/°C.

***NOTE:** Pins 8, 9 and 20 are test points only.

APPLICATION CIRCUIT DESCRIPTION

Introduction

The MC33092A, designed to operate in a 12 V system, is intended to control the voltage in an automotive system that uses a 3 phase alternator with a rotating field winding. The system shown in Figure 1 includes an alternator with its associated field coil, stator coils and rectifiers, a battery, a lamp and an ignition switch. A tap is connected to one corner of the stator windings and provides an ac signal for rotation (phase) detection.

A unique feature of the MC33092A is the Load Response Control (LRC) circuitry. The LRC circuitry is active when the stator winding ac signal frequency (phase buffer input signal, Pin 10) is lower than the Low/High RPM transition frequency. When active, the LRC circuitry dominates the basic analog control circuitry and slows the alternator response time to sudden increases in load current. This prevents the alternator from placing a sudden, high torque load on the automobile engine when a high current accessory is switched on.

The LRC circuitry is inactive when the stator winding ac signal frequency is higher than the Low/High RPM transition frequency. When the LRC circuitry is inactive, the basic analog control circuitry controls the alternator so it will supply a constant voltage that is independent of the load current.

Both the LRC and analog control circuits control the system voltage by switching ON and OFF the alternator field current using Pulse Width Modulation (PWM). The PWM approach controls the duty cycle and therefore the average field current. The field current is switched ON and OFF at a fixed frequency by a MOSFET (Q1) which is driven directly by the IC. The MC33092A uses a charge pump to drive the MOSFET in a high side configuration for alternators having a grounded field winding.

A fault detector is featured which detects overvoltage, undervoltage, slow rotation or non–rotation (broken alternator belt) conditions and indicates them through a fault lamp drive output (Pin 4).

A Load Dump protection circuit is included. During a load dump condition, the MOSFET gate drive (Pin 17) and the fault lamp drive output are disabled to protect the MOSFET, field winding and lamp.

Power–Up/Down

Power is continuously applied to the MC33092A through $V_{CC}1$ and $V_{CC}3$. A power–up/down condition is determined by the voltage on the Lamp Collector pin (Pin 3). When this voltage is below 0.5 V the IC is guaranteed to be in a low current standby mode. When the voltage at Pin 3 is above 2.0 V, the IC is guaranteed to be fully operational. The power–up voltage is applied to Pin 3 via the ignition switch and fault lamp. In case the fault lamp opens, a 500 Ω bypass resistor should be used to ensure regulator IC power–up.

A power–up reset circuit provides a reset or set condition for all digital counter circuitry. There is also a built–in power–up delay circuit that protects against erratic power–up signals.

Battery and Alternator Output Voltage Sensing

The battery and the alternator output voltage are sensed by the remote (Sense, Pin 2), and the local (Supply Regulator, Pin 12) input buffer pins, respectively, by way of external voltage dividers. The regulated system voltage is determined by the voltage divider resistor values.

Normally the remote pin voltage determines the value at which the battery voltage is regulated. In some cases the remote pin is not used. When this condition ($V_{Pin\ 2}$ < 0.6 V typically) exists, a sense loss function allows the local pin voltage to determine the regulated battery voltage with no attenuation of signal. If, however, when the remote pin is used, and the voltage at this pin is approximately 25% less than the voltage at the local sense pin (but greater than 0.6 V, typically), the value at which the battery voltage is regulated is switched to the local sense pin voltage (minus the 25%). The signal combiner/switch controls this transfer function.

Low Pass Filter, DAC & Regulator Comparator

The output of the combiner/switch buffer feeds a low pass filter block to remove high frequency system noise. The filter output is buffered and compared by the regulator comparator to a descending ramp waveform generated by an internal DAC. When the two voltages are approximately equal, the output of the regulator comparator changes state and the gate of the MOSFET is pulled low (turned OFF) by the output control logic for the duration of the output frequency clock cycle. At the beginning of the next output clock cycle, the DAC begins its descending ramp waveform and the MOSFET is turned ON until the regulator comparator output again changes state. This ongoing cycle constitutes the PWM technique used to control the system voltage.

Oscillator

The oscillator block provides the clock pulses for the prescaler–counter chain and the charge control for the charge pump circuit. The oscillator frequency is set by an external resistor from Pin 7 to ground as presented in Figure 6.

The prescaler–counter divides the oscillator frequency by 2^{12} (4096) and feeds it to the output control logic and divider–up/down counter chain. The output control logic uses it as the fundamental regulation output frequency (Pin 17).

Load Response Control

The Load Response Control (LRC) circuit generates a digital control of the regulation function and is active when the stator output ac signal (Pin 10) frequency is lower than the Low/High RPM transition frequency. The LRC circuit takes the output signal of the prescaler–counter chain and with a subsequent divider and up/down counter to provide delay, controls the alternator response time to load increases on the system. The response time is pin programmable to two rates. Pin 11 programs the divider to divide by 12 or divide by 48. If Pin 11 is grounded, the signal fed to the up/down counter is divided by 12 and the response time is 12 times slower than the basic analog response time. If Pin 11 is left floating, the signal to the up/down counter is divided by 48 and the response time is 48 times slower.

The basic analog (LRC not active) and digital duty cycle control (LRC active) are OR'd such that either function will terminate drive to the gate of the MOSFET device with the shortest ON–time, i.e., lower duty cycle dominating.

The digital ON–time is determined by comparing the output of the up/down counter to a continuous counter and decoding when they are equal. This event will terminate drive to the MOSFET. A count direction shift register requires three consecutive clock pulses with a state change on the data input of the register to result in an up/down count direction change. The count will increase for increasing system load up to 100% duty cycle and count down for decreased loading to a minimum of 29% duty cycle. The analog control can provide a minimum duty cycle of 4 to 5%. The initial power–up duty cycle is 29% until the phase comparator input exceeds its input threshold voltage. Also, the IC powers up with the LRC circuit active, i.e., when the Lamp Collector pin exceeds the power–up threshold voltage.

Fault Lamp Indicator

Pins 3 and 4 control the external Darlington transistor (Q2) that drives the fault indicator lamp. A 10 Ω resistor should be placed in series with the transistor's emitter for current limiting purposes. The fault lamp is energized during any of the following fault conditions: 1) No Phase buffer (Pin 10) input due to slow or no alternator rotation, shorted phase winding, etc.; 2) Phase buffer input ac voltage less than the phase detect threshold; 3) Overvoltage on Pin 2, or Pin 12 if Pin 2 is not used, or 4) Undervoltage on Pin 19 with the phase buffer input signal higher than the Low/High RPM transition frequency.

Phase Buffer Input

A tap is normally connected to one corner of the alternator's stator winding to provide an ac voltage for rotation detection. This ac signal is fed into the phase buffer input (Pin 10) through a voltage divider. If the frequency of this signal is less than the phase rotation detect frequency (36 Hz, typically), the fault lamp is lit indicating an insufficient alternator rotation and the MOSFET drive (Pin 17) output duty cycle is restricted to approximately 29% maximum. Also, if the peak voltage of the ac signal is less than the phase detect threshold, the fault lamp is lit indicating an insufficient amount of field current and again the MOSFET drive (Pin 17) output duty cycle is restricted to approximately 29% maximum.

Undervoltage, Overvoltage and Load Dump

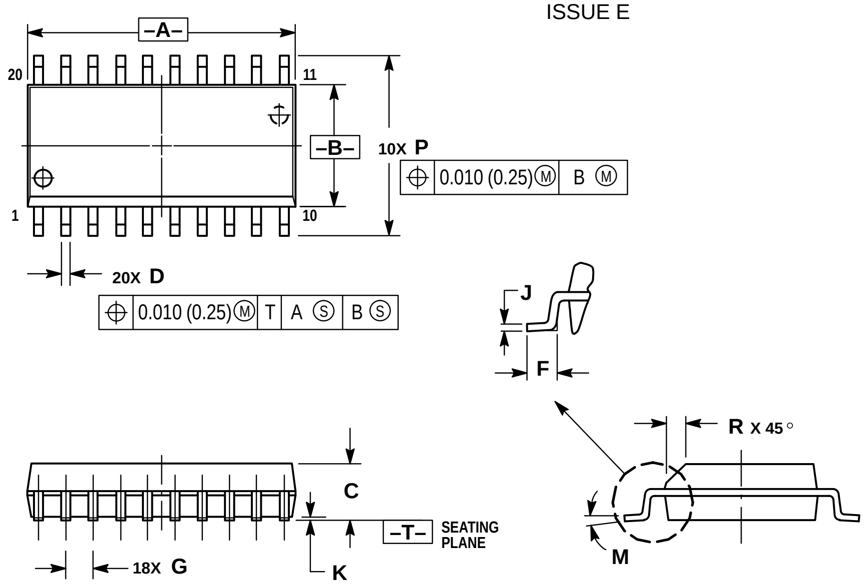
The low pass filter output feeds an undervoltage comparator through an external voltage divider. The voltage divider can be used to adjust the undervoltage detection level. During an undervoltage condition, the fault lamp will light only if the phase buffer input signal frequency is higher than the Low/High RPM transition frequency. This is to ensure that the undervoltage condition is caused by a true fault and not just by low alternator rotation. To help maintain system voltage regulation during an undervoltage condition, the output duty cycle is automatically increased to 100%. Even though the fault lamp may be energized for an undervoltage condition, the MC33092A will continue to operate but with limited performance.

Through an internal voltage divider, the low pass filter feeds an overvoltage comparator which monitors this output for an overvoltage condition. If the overvoltage threshold is exceeded, the fault lamp is lit and the MOSFET drive (Pin 17) output duty cycle is restricted to approximately 4% maximum.

The internal voltage divider on the input to the load dump comparator has a different ratio than the divider used on the overvoltage comparator. This allows the load dump detect threshold to be higher than the overvoltage threshold even though both comparators are monitoring the same low pass filter output. If the load dump detect threshold is exceeded, the fault lamp and MOSFET drive outputs are disabled to protect the MOSFET, field winding and lamp.

OUTLINE DIMENSIONS

DW SUFFIX
PLASTIC PACKAGE
CASE 751D–04
(SO–20L)
ISSUE E



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.150 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	12.65	12.95	0.499	0.510
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

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