SSI 32M590-Series
5-1/4 Inch Motor Speed Control

July, 1990

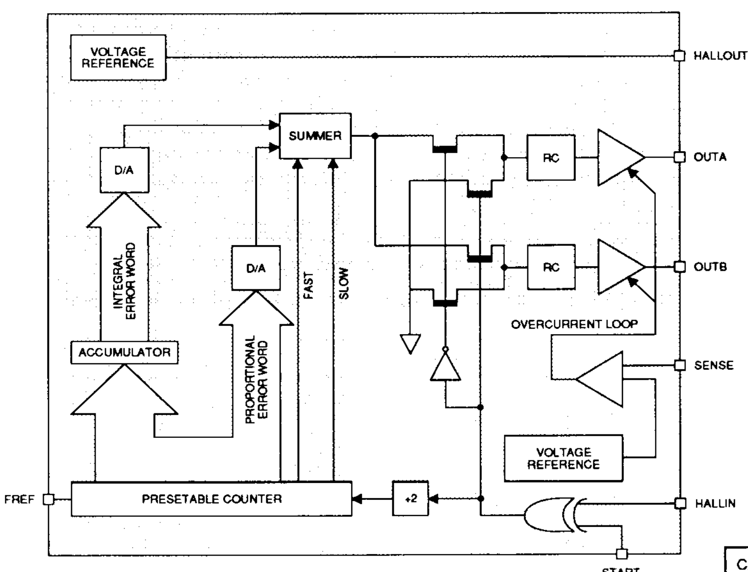
DESCRIPTION

The SSI 32M590-Series consisting of SSI 32M5901 and SSI 32M5902 are motor controller ICs designed to provide all timing and control functions necessary to start, drive and brake a two-phase, four-pole, brushless DC spindle motor. The IC requires two external power transistors (such as Darlington power transistors), three external resistors, and an external frequency reference. The motor HALL sensor is directly driven and decoded by the device. The controller is optimized for a 3600 rpm disc drive motor using a 2 MHz clock. Motor protection features include stuck rotor shutdown, coil over-current detection and control, and supply fault detection. The device's linear control loop controls the power drivers using Pulse Amplitude Modulation.

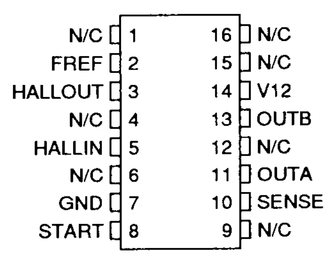
FEATURES

- **Available in 8-pin DIP (SSI 32M5901), 14-pin DIP (SSI 32M5902) or 16-pin SOL (SSI 32M5902)**
- **CMOS with single +12 volt power supply**
- **All motor START, DRIVE and STOP timing and control**
- **Includes HALL-Effect sensor drive and input pins**
- **Highly Accurate speed regulation of ±0.035%**
- **On-chip digital filtering requires no external compensation or adjustments**
- **Provides protection against stuck rotor, coil over-current, and supply fault**
- **Regenerative braking with shutdown**

BLOCK DIAGRAM



PIN DIAGRAM



SSI 32M5902

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

The device incorporates both analog and digital circuit techniques to utilize the advantages of each. The analog portion of the loop uses switched capacitor filter technology to eliminate external components. The control loop uses a Pulse Amplitude Modulation (PAM) control scheme to avoid the switching transients and torque ripple inherent in Pulse Width Modulation (PWM) schemes.

A binary counter is preset once per motor revolution by an index signal generated by the HALL position sensor. On the next index pulse, the remaining least significant bits are loaded into the proportional D/A and accumulated by a saturation accumulator. The most significant bits are loaded into the integral D/A. The size of the accumulator and the bit locations determine the major scaling (within a factor of two) for the gain and zero location of the filter. To prevent overflow in the proportional D/A the counter is decoded to detect overflow, and the proportional D/A is saturated as needed. The overflow also generates a boost signal used in the summer. The range of the accumulator is larger than the linear range of the proportional channel to help filter small load disturbances that tend to saturate the proportional channel. The entire counter is also used to provide a time-out feature to protect the motor and external circuitry.

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
FREF	I	Frequency Reference Input. A TTL compatible input used by the device to set and maintain the desired motor speed and operate circuit blocks.
HALLOUT	O	Provides a regulated bias voltage for the HALL effect sensor inside the motor.
HALLIN	I	HALL Sensor Input. The TTL open-collector type output of the motor's Hall switch feeds this input which has a resistor pullup to the HALLOUT bias voltage. Refer to Figure 1 for input timing.
OUTA, OUTB	O	Driver Outputs. These two driver outputs drive the external power transistors, such as TIP120 NPN Darlington power transistors as shown in the typical application. The power transistors control the motor current through the current setting resistor Re. The motor current is V (sense)/Re. During normal operation, the drive voltages are adjusted as necessary to maintain the proper motor speed and drive current. Regenerative braking is accomplished with self biasing of the power transistors thru resistors Rb with power shutdown. Refer to Figure 1 for output timing.
SENSE	I	Coil Current Sense Line. Senses the coil current and limits the sense voltage to the threshold by limiting the drive to the external power transistors.
N/C	-	No Connection, 14-pin package only. These pins must remain unconnected and floating.
START	I	

PROTECTION FEATURES

LOW VOLTAGE DETECTION

If the supply drops below the detect threshold the device will turn off all of the external power transistors to prevent damage to the motor and the power devices.

STUCK ROTOR SHUTDOWN

If the delay from power onset to a positive Index transition or the time interval between successive Index transitions is greater than the prescribed time, the device interprets this delay as a stuck rotor and reduces the motor current to zero until such time as one positive HALLIN transition is detected or until power is removed and reapplied.

MOTOR COIL OVER-CURRENT

Refer to SENSE input description. Sense voltage is generated by current through Re shown in the typical application. The SENSE input threshold limits the maximum coil current.

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Positive Supply Voltage, VDD	14	V
Storage Temperature	-65 to +125	°C
Ambient Operating Temperature	0 to 70	°C
HALLIN, FREF, and SENSE Input Voltages	-0.3 to VDD +0.3	V
HALLOUT Current	10	mA
Lead Temperature (soldering, 10 sec.)	260	°C
Power Dissipation	400	mW

RECOMMENDED OPERATING CONDITIONS

Unless otherwise specified, $10.8V \le V12 \le 13.2V$; $0\ °C \le Ta \le 70\ °C$; FREF = 2.00 MHz; Re = 0.4Ω ± 10% (2 watt); Rb = 4.7 kΩ ± 10% (1/4 watt); $0.8 \le$ Darlington Vbe ≤ 1.8

Motor Parameters: (1 to 3 platters)

KT	Torque constant	= 0.015 Nt-m/amp ±10%
J	Inertia	= 0.000489 Nt-m/s/s ±33%
KD	Damping factor	= 0.0000318 Nt-m/rad/s ± 33%

where: $$\frac{\text{Motor Frequency}(s)}{\text{Motor Current}(s)} = \frac{KT}{J \times s + KD}$$

DC ELECTRICAL CHARACTERISTICS

PARAMETERS	CONDITIONS	MIN	NOM	MAX	UNIT
POWER SUPPLY CURRENT					
ICC (Includes Drive Outputs)		(17 typ)		30	mA
FREF AND START INPUTS					
Input Low Voltage	Iil = 500 μA			0.8	V
Input High Voltage	Iih = 100 μA	2.0			V

DC ELECTRICAL CHARACTERISTICS (Continued)

PARAMETERS	CONDITIONS	MIN	NOM	MAX	UNIT
HALL SENSOR INTERFACE					
HALLOUT Bias voltage	I = 5 mA	5.0		6.8	V
HALLOUT Pullup Resistance	To HALLOUT Pin	5		20	kΩ
Input Low Voltage				1.0	V
Input High Voltage		4.0			V
DRIVER OUTPUTS					
Sink Capability	VOUTA or VOUTB = 0.5 Volts	5.0			mA
Source Capability	VOUTA or VOUTB = 3.0 Volts	-5.0			mA
Capacity Load Drive Capability				50.0	pF
SENSE INPUT					
Threshold Voltage		0.9		1.1	V
Input Current		-100		100	µA
Input Capacitance				25.0	pF
STUCK ROTOR DETECTION					
Shutdown Time	Power On To Driver	0.815		0.935	sec
LOW VOLTAGE DETECTION					
Detect Threshold		6.0		9.0	V
CONTROL LOOP - DESCRIPTION*					
Divider Ratio	FREF/Avg. Motor Frequency	16664		16672	
Index to Index Jitter	Total Jitter			8.0	µs
Loop Gain H (2 X π X f)	f = 2 Hz		0 Typical		dB
Loop Zero	Kp/Ki	0.97		1.03	Hz
CONTROL LOOP Vs SUPPLY VARIATION					
$\frac{Kp(V12 = 13.2V)}{Kp(V12 = 10.8V)}$		0.96		1.04	
$\frac{Ki(V12 = 13.2V)}{Ki(V12 = 10.8V)}$		0.96		1.04	
START/STOP VELOCITY PROFILES					
Power on Delay to FHALL Greater than FREF/16668	1 Platter	7.0		11.0	sec
	2 Platters	9.0		13.0	sec
	3 Platters	11.0		15.0	sec
Speed Overshoot $\frac{FHALL - (FREF/16668)}{(FREF/16668)}$	1 Platter	0.5		2.0	%
	2 Platters	0.5		2.0	%
	3 Platters	0.5		2.0	%

START/STOP VELOCITY PROFILES (Continued)

PARAMETERS	CONDITIONS	MIN	NOM	MAX	UNIT
Setting Time: Motor Frequency Settles to 0.05%	1 Platter	9.0		13.0	sec
	2 Platters	11.0		15.0	sec
	3 Platters	13.0		17.0	sec
Stop Time (Regenerative): Motor Frequency Slows to 30% after Power is Removed	1 Platter	7.0		13.0	sec
	2 Platters	8.0		15.0	sec
	3 Platters	9.0		17.0	sec
Stop Time (Active):		4.0			sec

*The continuous Time Transfer Function of the on-chip control can be modeled as follows:

$$H(s) = \frac{Vc(s)}{F(s)} = Ki \times \frac{(1 + s/(2 \times \pi \times (Kp/Ki)))}{s}$$

Ki = Integral gain
Kp = Proportional gain

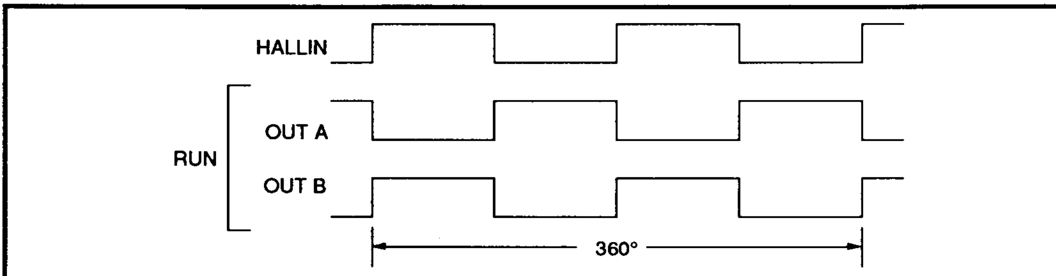
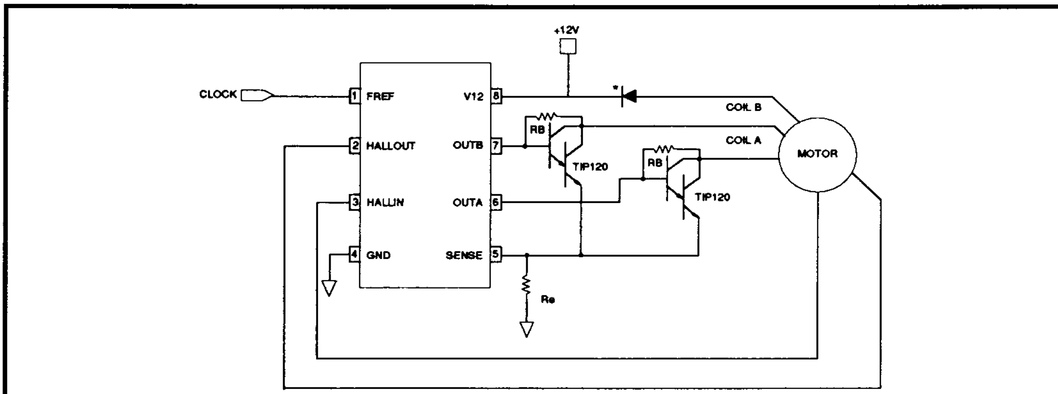


FIGURE 1: Firing Order



*NOTE: Diode required for regenerative braking, (three amp minimum rating)

FIGURE 2: Typical Application

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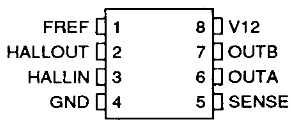
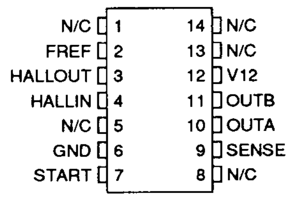
PACKAGE PIN DESIGNATIONS

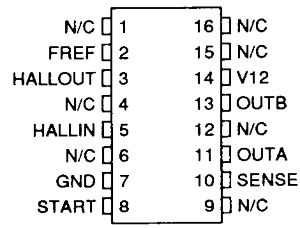
(TOP VIEW)



SSI 32M5901
8-Pin PDIP



SSI 32M5902
14-Pin PDIP



SSI 32M5902
16-Pin SOL

ORDERING INFORMATION

PART DESCRIPTION	ORDERING NUMBER	PACKAGE MARK
SSI 32M590-Series		
8-Pin PDIP	SSI 32M5901-CP	32M5901-CP
14-Pin PDIP	SSI 32M5902-CP	32M5902-CP
16-Pin SOL	SSI 32M5902-CL	32M5902-CL

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