StepIC SC188804 Stepper Motor Controller

Data Sheet

Contents

1 Introduction

The StepIC SC188804 stepper motor controller, when used in conjunction with compatible drivers, provides flexible control of two stepper motors with minimum processor overhead. It is designed to interface directly with full-step, half-step or microstepping drivers and operates from a 5 Volt or 3.3 Volt power supply.

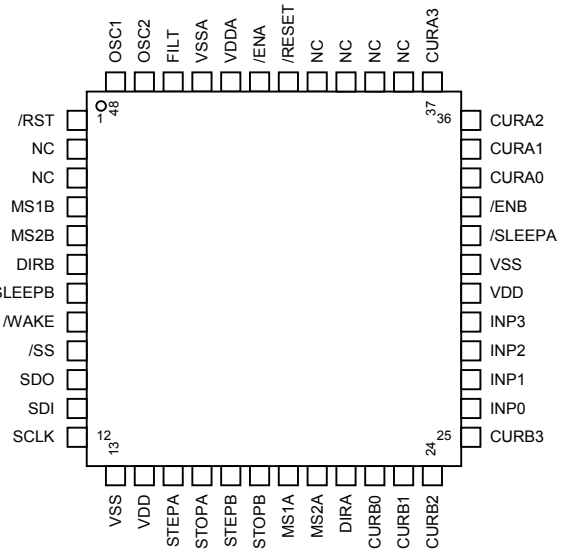
The SC188804 is able to generate step pulse trains at up to 20kHz and is controlled by means of an SPI serial interface. As well as standard acceleration and deceleration modes, the SC188804 command set allows for the programming of arbitrary speed profiles.

2 Features

- Drives two independent stepper motors.
- Step rates to 20kHz.
- Suitable for full step, half-step and microstepping applications.
- 5 Volt or 3.3 Volt operation (15kHz max step rate at 3.3V).
- SPI interface.
- User-definable acceleration and deceleration rates.
- User-definable arbitrary speed profiles.
- Direct interfacing to Allegro A3977 and similar stepper motor drivers.
- 4-bit user-programmable current register.
- 16-bit step-period resolution.
- Programmable step base period (1, 2, 4 or 8μs).
- 32-bit position register.
- On-chip clock generator runs from 32.768kHz crystal.
- Ability to share clocks for synchronised operation.
- 48 pin LQFP package.

3 Pinout

The SC188804 is supplied in a 0.5mm pitch 48 pin LQFP package.



4 Pin Description

Pin Number	Name	Direction	Description
1	/RST	Input/Output	Active-low open-drain reset. Initialises controller.
2	NC	-	No connection.
3	NC	-	No connection.
4	MS1B	Output	Microstep select signal to stepper motor driver B. Under user control.
5	MS2B	Output	Microstep select signal to stepper motor driver B. Under user control.
6	DIRB	Output	Direction signal to stepper motor controller B.
7	/SLEEPB	Output	Active-low sleep signal to stepper motor driver B. Under user control.
8	/WAKE	Input	Bring SC188804 out of low power sleep mode.
9	/SS	Input	Slave select. Active low signal to SPI interface, indicating that the device is selected.
10	SDO	Output	Data out from SPI interface.
11	SDI	Input	Data in to SPI interface.
12	SCLK	Input	SPI clock input.
13	VSS	-	Power supply pin (0V).
14	VDD	-	Power supply pin (3.3V/5V).
15	STEPA	Output	Active-high step signal to stepper motor driver A.
16	STOPA	Input	Programmable active-low or active-high signal. Immediately stop any running step sequence on motor A.
17	STEPB	Output	Active-high step signal to stepper motor driver B.
18	STOPB	Input	Programmable active-low or active-high signal. Immediately stop any running step sequence on motor B.
19	MS1A	Output	Microstep select signal to stepper motor driver A. Under user control.
20	MS2A	Output	Microstep select signal to stepper motor driver A. Under user control.
21	DIRA	Output	Direction signal to stepper motor controller A.
22	CURB0	Output	Stepper driver current control output, motor controller B (LSB).
23	CURB1	Output	Stepper driver current control output, motor controller B.
24	CURB2	Output	Stepper driver current control output, motor controller B.
25	CURB3	Output	Stepper driver current control output, motor controller B (MSB).
26	INP0	Input	Uncommitted input 0.
27	INP1	Input	Uncommitted input 1.
28	INP2	Input	Uncommitted input 2.
29	INP3	Input	Uncommitted input 3.
30	VDD	-	Power supply pin (3.3V/5V).
31	VSS	-	Power supply pin (0V).
32	/SLEEPA	Output	Active-low sleep signal to stepper motor driver A. Under user control.
33	/ENB	Output	Active-low enable signal to stepper motor driver B. Under user control.
34	CURA0	Output	Stepper driver current control output, motor controller A (LSB).
35	CURA1	Output	Stepper driver current control output, motor controller A.
36	CURA2	Output	Stepper driver current control output, motor controller A.
37	CURA3	Output	Stepper driver current control output, motor controller A (MSB).
38	NC	-	No connection.
39	NC	-	No connection.
40	NC	-	No connection.
41	NC	-	No connection.
42	/RESET	Output	Active-low reset signal to stepper motor drivers. Generated on power-up and on a controller reset.
43	/ENA	Output	Active-low enable signal to stepper motor driver A. Under user control.
44	VDDA	-	Power supply to internal PLL (3.3V/5V).
45	VSSA	-	Power supply to internal PLL (0V).
46	FILT	-	PLL filter.
47	OSC2	Output	Crystal oscillator output pin.
48	OSC1	Input	Crystal oscillator input pin.

5 Device Connections

5.1 Clock Circuit

The SC188804 derives its internal clock from a 32.768kHz crystal oscillator circuit, which consists of an inverting amplifier and external crystal. OSC1 is the input to the amplifier and OSC2 is the amplifier output. Fig 1 shows the recommended crystal oscillator circuit (see section 7.6 for suitable component values).

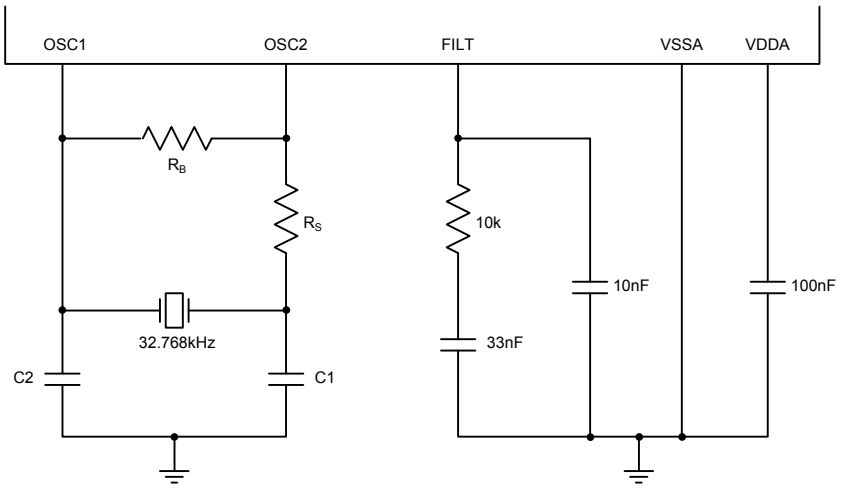


Fig 1

The crystal clock frequency is multiplied up by an internal phase-locked loop (PLL). The internal clock frequency is 8MHz at 5 Volts, or 4MHz at 3.3 Volts. The supply voltage is sampled at reset and used to determine the clock frequency. The FILT pin must be connected to a filter network as shown in Fig 1. The VDDA and VSSA pins are local power supply pins for the PLL and should be decoupled with a 100nF ceramic capacitor close to the device.

5.2 Resets

5.2.1 External Reset

A logic 0 applied to the bidirectional /RST pin resets the controller. Refer to section 7 for timing requirements. The /RST pin includes an internal pull-up resistor, allowing this line to be left unconnected if not required.

5.2.2 Power-On Reset

The device contains power-on reset circuitry. A power-on reset is an internal reset caused by a positive transition on the V_{DD} pin. V_{DD} must go below V_{POR} (see section 7) to reset the controller.

A power-on reset drives the open-drain /RST pin low for 0.125 seconds and then commences the internal initialisation of the device. Initialisation time is determined by the oscillator start-up time, in addition to the PLL lock time T_{lock} (see section 7.6).

5.3 Serial Peripheral Interface

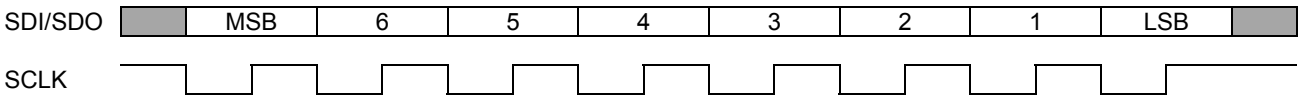
The controller acts as a Serial Peripheral Interface (SPI) slave device, which allows full-duplex synchronous communications with an SPI master. The SPI module has four interface signals:

/SS	Input	Slave select. Active low signal to SPI interface, indicating that the device is selected.
SDO	Output	Data out from SPI interface.
SDI	Input	Data in to SPI interface.
SCLK	Input	SPI clock input.

The SPI accepts synchronous data on the SDI line, and simultaneously presents output data on the SDO line. Data is transferred in both directions by a clock signal on the SCLK line.

5.3.1 Transmission Format

Data is transferred as 8-bit bytes, MSB first:



Data is clocked on the rising edge of SCLK. The SPI runs at a standard clock frequency of up to 100kHz (80μs per byte). Higher clock frequencies may be used (see sections 7.7 and 7.8), but the inter-byte time must not fall below 80μs.

The SC188804 supports a command set that allows full programming of the device. An inherent feature of the SPI communications interface is that data is clocked into the master from the SC188804 simultaneously to data being clocked out of the master and into the SC188804.

5.3.2 Slave Select (/SS)

The /SS signal must be low to enable an SC188804 device. In systems in which a single SC188804 is present, this line may be tied low. Where two or more SC188804 devices share a single SPI, the /SS signal selects the active device. When /SS is high, transitions on the SCLK line are ignored. The SC188804 drives its SDO output only when its /SS input is low. Thus multiple SC188804 devices may share a single SPI by ensuring that only one SC188804 /SS is low at any time. The SDI, SDO and SCLK signals from each device are connected together. Care should be taken to ensure that only one /SS signal is low at any given time, to avoid bus contention on the SDO lines.

The /SS signal must go low a minimum of T_{Lead} before the first falling edge of SPCLK and must remain low for T_{Lag} after the last rising edge of SPSCK (see sections 7.7 and 7.8).

5.4 Stepper Motor Driver Interface

The SC188804 can control two stepper motor drivers completely independently. Specific reference is made in this section to the Allegro A3977, which is typical of such devices. The following signals provide for the driver interface:

Name	Direction	Description
STEPA STEPB	Output	Active-high step signal to stepper motor driver.
DIRA DIRB	Output	Direction signal to stepper motor controller.
/SLEEPA /SLEEPB	Output	Active-low sleep signal to stepper motor driver. Under user control.
/ENA /ENB	Output	Active-low enable signal to stepper motor driver. Under user control.
/RESET	Output	Active-low reset signal to stepper motor drivers. Generated on power-up and on a controller reset.
MS1A MS1B	Output	Microstep select signal to stepper motor driver. Under user control.
MS2A MS2B	Output	Microstep select signal to stepper motor driver. Under user control.
VDD	-	Power supply pin (3.3V/5V).
VSS	-	Power supply pin (0V).
CURA0 CURB0	Output	Stepper driver current control output (LSB).
CURA1 CURB1	Output	Stepper driver current control output.
CURA2 CURB2	Output	Stepper driver current control output.
CURA3 CURB3	Output	Stepper driver current control output (MSB).

5.4.1 STEPA, STEPB

The STEPA (STEPB) output produces positive-going step pulses at a rate determined by the programmed mode of the SC188804. The pulse width is 1, 2, 4 or 8μs, as determined by the PERIOD command.

5.4.2 DIRA, DIRB

The DIRA (DIRB) signal is an output to the stepper motor controller, which indicates the direction of motor travel. A low level indicates movement in the forward direction, and a high level indicates reverse travel. As far as the SC188804 is concerned, these directions are arbitrary, the only significance being that the internal position register increases with forward motion and decreases with reverse motion.

5.4.3 /SLEEPA, /SLEEPB

The /SLEEPA (/SLEEPB) output is driven low on receipt of a SLEEP command, and is driven high on receipt of a WAKE command. It may be connected to an active-low sleep input on the stepper motor driver if required, or used as a general-purpose output. The /SLEEPA (/SLEEPB) output is set low on a device reset.

5.4.4 /ENA, /ENB

The /EN output is driven low on receipt of an ENABLE command, and is driven high on receipt of a DISABLE command. It may be connected to an active-low enable input on the stepper motor driver if required, or used as a general-purpose output. The /EN output is set high on a device reset.

5.4.5 /RESET

The /RESET output produces a 1μs active-low reset signal to the stepper motor drivers when the SC188804 is reset. A reset pulse can be produced at any subsequent time by issuing a RESET command.

5.4.6 MS1A, MS2A, MS1B, MS2B

The MS1A (MS1B) and MS2A (MS2B) outputs are intended for connection to microstep select inputs on a stepper motor driver. The MS1 (MS1B) and MS2A (MS2B) outputs are at a low logic level on reset, and may be programmed by the MICROSTEPS command. The number of microsteps per full step is determined only by the stepper motor driver, and is immaterial to the SC188804.

5.4.7 CURA0-CURA3, CURB0-CURB3

The CURA (CURB) outputs set the phase current to the stepper motor driver. They may be connected directly to current-control inputs on the driver, or may drive a DAC if the stepper motor driver has an analog current control input. A simple resistor network may be used as a four-bit DAC for this purpose, providing that the output current capability of the SC188804 and the input current requirements of the stepper motor driver input are taken into consideration. The CURA (CURB) outputs are fully programmable during stepper motion commands and at rest.

Fig 2 shows a resistor network suitable for interfacing the SC188804 CURA (CURB) outputs to an Allegro A3977. With the resistor values shown, the voltage at the A3977 REF pin can be varied from 0 to 4 Volts when the SC188804 is running from a 5 Volt supply.

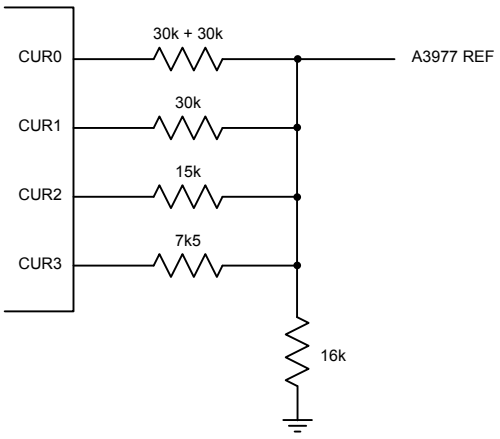


Fig 2

5.5 Stop and INP Signals

5.5.1 STOPA, STOPB

The STOPA (STOPB) input immediately stops any active step sequence on the appropriate motor and takes that channel of the SC188804 out of the RUNNING state. No deceleration profile is applied. The STOPA (STOPB) signal can be enabled or disabled, and its polarity set, by the STOPMODE command, thus allowing full flexibility for use as an index signal.

5.5.2 INP0-3

The INP0-3 pins provide four general-purpose inputs. They are provided with internal pull-ups, allowing these lines to be left unconnected if not required. The logic levels at INP0-3 may be read with the INP command (see section 6.4.24).

6 Serial Interface

6.1 SPI Protocol

The SC188804 communicates with a microcontroller over a Serial Peripheral Interface. The data transmission format is described in section 5.3.1. The SC188804 acts as a slave – thus it relies on the master device to clock data across the SPI interface. All commands conform to the following data format:

Command	(Data)	(Data)	(Data)	…

Commands and data are 8 bits wide, MSB first. The SC188804 interprets the command and if additional data is required, waits until all data is received before executing the command. The SC188804 buffers commands in a 64-byte FIFO buffer, so that it is possible for the master device to send several commands while previous ones are still being executed. The SC188804 also includes a 64-byte data output buffer for command responses.

The SC188804 acknowledges each command received by returning an ACK (5Ah) byte to the master, or in the event of a command error, a NAK (A5h) byte. If the SC188804 has additional data to send (when a command expecting return data has been issued by the master), the ACK is replaced by a byte count that specifies the number of bytes that will follow.

For example, the INTPOSREAD command results in the SC188804 returning the current position of stepper motor A as a two-byte (16-bit) integer. The SC188804 therefore returns the following byte sequence:

02h	Position (MSB)	Position (LSB)

Note that the SC188804 uses a big-endian (most significant byte first) format for all parameters.

It is important to remember that the full-duplex synchronous nature of the SPI means that the data can only be returned by the SC188801 when the master device clocks it out. ACK or response packets can always be retrieved from the SC188801 by issuing subsequent commands, or by issuing NULL (0) bytes until all response bytes are returned. Note that commands that generate acceleration profiles (SMARTMOVE and STEPTABLEACCEL) require up to 40ms (in the case of SMARTMOVE, which generates an acceleration and a deceleration profile) before returning an ACK. Therefore the rate at which NULL bytes are issued while waiting for ACK should be limited, in order to avoid overrunning the 64 byte receive buffer. A maximum rate of one NULL every millisecond will ensure this.

Another aspect of this is that typically the SC188804 will have fewer bytes to transmit than receive, and so it pads inter-response gaps with NULL (0) bytes.

6.2 Functional Overview

The SC188804 command set provides considerable flexibility for a broad range of applications. At the simplest level, the device may be programmed to generate a specified number of step pulses at a given frequency. The SC188804 is however capable of producing arbitrary patterns of steps, based on the concept of a “Step Table”. Two completely independent Step Tables are provided, one for each motor. A Step Table consists of a list of step counts and step rates, which the SC188804 can run. The Step Table can be programmed and then executed, allowing complex movement profiles to be defined. The built-in commands to define acceleration and deceleration profiles generate these profiles in the Step Table, but commands that allow direct read and write access into the Step Table permit any other user-defined profile to be generated.

The Step Table can be modified “on-the-fly”. A single step entry may be defined as continuous (never-ending); changing the step frequency of this entry while running allows the SC188804 to be used in applications requiring dynamic speed control (e.g. closed-loop feedback systems).

The SC188804 Step Tables can accommodate up to 60 elements.

6.3 Command Set

The following table lists the complete command set, with parameters and the SC188804 response (ACK and NAK responses are omitted).

Opcode (Hex) Motor Channel A	Opcode (Hex) Motor Channel B	Command	Parameters	Response
01	81	DISABLE	-	-
02	82	ENABLE	-	-
03	83	SLEEP	-	-
04	84	WAKE	-	-
05	85	MICROSTEPS	Microsteps (0-3)	-
06	86	PERIOD	Period (0-3)	-
07	-	RESET	-	-
08	88	IWRITE	Current (0-15)	-
09	89	IREAD	-	Current (0-15)
0A	8A	POSWRITE	Position3 (MSB) Position2 Position1 Position0 (LSB)	-
0B	8B	INTPOSREAD	-	Position1 (MSB) Position0 (LSB)
0C	8C	POSREAD	-	Position3 (MSB) Position2 Position1 Position0 (LSB)
0D	8D	SINGLESTEPFWD	-	-
0E	8E	SINGLESTEPREV	-	-
0F	8F	STEP	Period (MSB) Period (LSB) NSteps (MSB) NSteps (LSB) Ctl	-
10	90	STEPTABLEWRITE	Index Period (MSB) Period (LSB) NSteps (MSB) NSteps (LSB) Ctl	-
11	91	STEPPERIODWRITE	Index Period (MSB) Period (LSB) Div	-
12	92	STEPTABLEREAD	Index	Period (MSB) Period (LSB) NSteps (MSB) NSteps (LSB) Ctl
13	93	STEPTABLEACCEL	Index StartPeriod (MSB) StartPeriod (LSB) EndPeriod (MSB) EndPeriod (LSB) NSteps (MSB) NSteps (LSB) Coarseness Ctl	-
14	94	RUN	Index	-
15	95	STOP	-	-
16	96	STOPMODE	StopCtl	-
17	97	STATUS	-	Status
18	-	INP	-	Inp

Opcode (Hex) Motor Channel A	Opcode (Hex) Motor Channel B	Command	Parameters	Response
19	99	SMARTMOVE	NSteps3 (MSB) NSteps2 NSteps1 NSteps0 (LSB)	-
1A	-	SMARTPARAMWRITE	StartPeriod (MSB) StartPeriod (LSB) RapidPeriod (MSB) RapidPeriod (LSB) AccelSteps (MSB) AccelSteps (LSB) AccelCurrent RapidCurrent HoldingCurrent	-
1B	-	SMARTPARAMREAD	-	StartPeriod (MSB) StartPeriod (LSB) RapidPeriod (MSB) RapidPeriod (LSB) AccelSteps (MSB) AccelSteps (LSB) AccelCurrent RapidCurrent HoldingCurrent
1F	9F	TABLEPOS	-	Index NSteps (MSB) NSteps (LSB)
20	-	VERSION	-	Version

6.3.1 Motor Driver Selection

Where appropriate, the motor driver channel (A or B) is selected by means of bit 7 of the opcode. The table in section 6.3 lists the commands for both motor channels.

6.4 Detailed Command Description

In the following command descriptions, motor channel-specific commands are covered in terms of Motor A (Motor B), where appropriate.

6.4.1 DISABLE

Set the /ENA (/ENB) output to logic 1. The /ENA (/ENB) output may be connected to an active-low enable input on the stepper motor driver or used as a general-purpose output.

Command Format

DISABLE (01h/81h)

Response Format

ACK (5Ah)

6.4.2 ENABLE

Set the /ENA (/ENB) output to logic 0. The /ENA (ENB) output may be connected to an active-low enable input on the stepper motor driver or used as a general-purpose output.

Command Format

ENABLE (02h/82h)

Response Format

ACK (5Ah)

6.4.3 SLEEP

Set the /SLEEPA (/SLEEPB) output to logic 0. The /SLEEPA (/SLEEPB) output may be connected to an active-low sleep input on the stepper motor driver or used as a general-purpose output.

Command Format

SLEEP (03h/83h)

Response Format

ACK (5Ah)

6.4.4 WAKE

Set the /SLEEPA (/SLEEPB) output to logic 1. The /SLEEPA (/SLEEPB) output may be connected to an active-low sleep input on the stepper motor driver or used as a general-purpose output.

Command Format

WAKE (04h/84h)

Response Format

ACK (5Ah)

6.4.5 MICROSTEPS

Set the MS1A (MS1B), MS2A (MS2B) outputs. The MS1A (MS1B) and MS2A (MS2B) outputs may be connected to microstep select inputs on a stepper motor driver stepper motor driver or used as general-purpose outputs.

Command Format

MICROSTEPS (05h/85h)	Microsteps (0-3)

Bit 0 is presented on MS1A (MS1B) and bit 1 on MS2A (MS2B).

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Microsteps > 3)

6.4.6 PERIOD

Set the base step base period for all step commands for this motor. The step base period can be in the range 0 (1μs) to 3 (8μs):

Period Argument	Base Period (μs)
0	1
1	2
2	4
3	8

If running, the stepper motor is stopped on receipt of this command.

Command Format

PERIOD (06h/86h)	Period (0-3)

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Period > 3)

6.4.7 RESET

Reset the stepper motor drivers (see section 5.4.5).

Command Format

RESET (07h)

Response Format

ACK (5Ah)

6.4.8 IWRITE

Set the stepper motor driver phase current (see section 5.4.7). Note that this command usually only makes sense if issued while the motor is stationary or during a long step move. If issued while running, the phase current is reloaded on the next step pulse. The specified phase current appears at the CURA0-3 (CURB0-3) outputs.

Command Format

IWRITE (08h/88h)	Current (0-15)

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Current > 15)

6.4.9 IREAD

Read the stepper motor driver phase current (see section 5.4.7).

Command Format

IREAD (09h/89h)

Response Format

RspLen (1)	Current (0-15)

6.4.10 POSWRITE

Set the current stepper motor step position to the specified 32-bit value. This command may be issued after indexing to a known position or at any other time.

Command Format

POSWRITE (0Ah/8Ah)	Position3 (MSB)	Position2	Position1	Position0 (LSB)

Response Format

ACK (5Ah)

6.4.11 INTPOSREAD

Read the current stepper motor step position as a 16-bit integer. The step position is returned as a modulo 10000h counter that increases with step movement in the forward direction and decreases in the reverse direction. This command is provided so that the position can be read without the communications overhead of returning a 32-bit value; this may be a consideration where continuous monitoring of position is required. The full 32-bit position value (if required) can be re-created in software by looking for 16-bit wraparound conditions or by using the POSREAD command.

Command Format

INTPOSREAD (0Bh/8Bh)

Response Format

RspLen (2)	Position1 (MSB)	Position0 (LSB)

6.4.12 POSREAD

Read the current stepper motor step position. The step position is a modulo 100000000h counter that increases with step movement in the forward direction and decreases in the reverse direction.

Command Format

POSREAD (0Ch/8Ch)

Response Format

RspLen (4)	Position3 (MSB)	Position2	Position1	Position0 (LSB)

6.4.13 SINGLESTEPFWD

Single-step the stepper motor in the forward direction. This command issues one step pulse at the SC188804 STEPA (STEPB) output, with the DIRA (DIRB) output in the low state. The IWRITE command should be used to set the phase current prior to issuing this command. The phase current remains at this level, unless the STOPMODE command (section 6.4.22) has been issued with the Hold bit true, in which case the current on completing the step is set to the value specified by the STOPMODE command.

Command Format

SINGLESTEPFWD (0Dh/8Dh)

Response Format

ACK (5Ah)

6.4.14 SINGLESTEPREV

Single-step the stepper motor in the reverse direction. This command issues one step pulse at the SC188804 STEPA (STEPB) output, with the DIRA (DIRB) output in the high state. The IWRITE command should be used to set the phase

current prior to issuing this command. The phase current remains at this level, unless the STOPMODE command (section 6.4.22) has been issued with the Hold bit true, in which case the current on completing the step is set to the value specified by the STOPMODE command.

Command Format

SINGLESTEPREV (0Eh/8Eh)

Response Format

ACK (5Ah)

6.4.15 STEP

Set the stepper motor running at a constant rate for the specified number of steps in a specified direction. This is the fundamental command for simple movement control. The specified phase current appears at the CURA0-3 (CURB0-3) outputs.

Command Format

STEP (0Fh/8Fh)	Period (MSB)	Period (LSB)	NSteps (MSB)	NSteps (LSB)	Ctl

Period
The period between each step. Period is in units of the base step period (section 6.4.6), which can be 1μs, 2μs, 4μs or 8μs. The maximum period between steps is therefore 65535 x 8μs = 524,280μs. Do not specify a period that results in the period falling below the minimum (32μs at 5 Volts or 64μs at 3.3 Volts):

	Min Value of Period	
Step Period (μs)	5 Volts	3.3 Volts
1	32	64
2	16	32
4	8	16
8	4	8

≤ Period ≤ 65535

NSteps
The number of steps to move.

0 ≤ NSteps ≤ 65535

A value of 0 sets the motor running continuously.

Ctl
The following bits are defined in the Ctl byte:

MSB							LSB
7	6	5	4	3	2	1	0
			Dir	Current			

Dir	
0	Forward (DIRA/DIRB output = 0)
1	Reverse (DIRA/DIRB output = 1)

The Current value is presented at the motor current outputs CURA0-3 (CURB0-3). These outputs remain at the specified current on completion of the movement (but see the STOPMODE command in section 6.4.22).

Bits 5, 6 and 7 are not used.

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Period out-of-range)

The ACK response is sent immediately and further commands may be issued while the STEP command is running. Thus commands such as POSREAD, STATUS or STOP may be issued while the stepper motor is running.

6.4.16 STEPTABLEWRITE

Low-level command to write directly to the Step Table.

Command Format

STEPTABLEWRITE (10h/90h)	Index	Period (MSB)	Period (LSB)	NSteps (MSB)

NSteps (LSB)	Ctl

Index
Index is the array index in the Step Table.

$0 \leq \text{Index} \leq 59$

Period
The period between each step. Period is in units of the base step period (section 6.4.6), which can be 1μs, 2μs, 4μs or 8μs. The maximum period between steps is therefore 65535 x 8μs = 524,280μs. Do not specify a period that results in the period falling below the minimum (50μs at 5 Volts or 100μs at 3.3 Volts):

	Min Value of Period	
Step Period (μs)	5 Volts	3.3 Volts
1	50	100
2	25	50
4	13	25
8	7	13

$0 \leq \text{Period} \leq 65535$

NSteps
The number of steps in this Step Table entry.

$0 \leq \text{NSteps} \leq 65535$

A value of 0 is interpreted as continuous movement.

Ctl
The following bits are defined in the Ctl byte:

MSB							LSB
7	6	5	4	3	2	1	0
		Cmd		Current			

Cmd		
0	0	Forward (DIRA/DIRB output = 0)
0	1	Reverse (DIRA/DIRB output = 1)
1	0	Stop
1	1	TableEnd

The Stop command terminates step pulses and halts execution of the step table. The motor current outputs CURA0-3 (CURB0-3) remain at the current specified by the Current bits (but see the STOPMODE command in section 6.4.22).

The TableEnd command switches execution to the start of the table. It is not necessary to follow a Stop command with a TableEnd command. The TableEnd command may be used to continuously cycle through a Step Table (for example, a stepwise sinusoidal Step Table could be programmed).

For Forward or Reverse step sequences, the Current bits are presented at CURA0-3 (CURB0-3).

When a Stop or TableEnd command is issued, the Period and NSteps parameters are ignored.

Bits 6 and 7 are not used.

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Parameter out-of-range)

6.4.17 STEPPERIODWRITE

Low-level command to write directly to the Step Table. Only the period and clock prescale divisor is specified. The number of steps (NSteps) and the control byte (Ctl) remain unchanged (see STEPTABLEWRITE command, section 6.4.16). This command is useful for modifying a Step Table on the fly – i.e. when it is running. The rate of a complex profile may be changed by just changing the period of the Step Table entries without the need to re-write the number of steps and control byte.

Command Format

STEPPERIODWRITE (11h/91h)	Index	Period (MSB)	Period (LSB)

Index
Index is the array index in the Step Table.

$0 \leq \text{Index} \leq 59$

Period
The period between each step. Period is in units of the base step period (section 6.4.6), which can be 1μs, 2μs, 4μs or 8μs. The maximum period between steps is therefore 65535 x 8μs = 524,280μs. Do not specify a period that results in the period falling below the minimum (50μs at 5 Volts or 100μs at 3.3 Volts):

	Min Value of Period	
Step Period (μs)	5 Volts	3.3 Volts
1	50	100
2	25	50
4	13	25
8	7	13

$7 \leq \text{Period} \leq 65535$

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Parameter out-of-range)

6.4.18 STEPTABLEREAD

Low-level command to read a Step Table entry.

Command Format

STEPTABLEREAD (12h/92h)	Index

Index
Index is the array index in the step table.

0 ≤ Index ≤ 59

Response Format

RspLen (5)	Period (MSB)	Period (LSB)	NSteps (MSB)	NSteps (LSB)	Ctl

Or

NAK (A5h)

(Index out-of-range)

Period
The period between each step. Period is in units of the base step period (section 6.4.6), which can be 1μs, 2μs, 4μs or 8μs.

0 ≤ Period ≤ 65535

NSteps
The number of steps in this Step Table entry.

0 ≤ NSteps ≤ 65535

Ctl
The following bits are defined in the Ctl byte:

MSB							LSB
7	6	5	4	3	2	1	0
		Cmd		Current			

Cmd		
0	0	Forward (DIRA/DIRB output = 0)
0	1	Reverse (DIRA/DIRB output = 1)
1	0	Stop
1	1	TableEnd

Refer to section 6.4.16 for a full description of the Ctl byte.

6.4.19 STEPTABLEACCEL

Low-level command to generate an acceleration or deceleration profile directly in the Step Table. The command synthesizes linear acceleration or deceleration profiles in the Step Table, and may be used in conjunction with STEPTABLEWRITE to build complex velocity profiles.

Command Format

STEPTABLEACCEL(13h/93h)	Index	StartPeriod (MSB)	StartPeriod (LSB)	EndPeriod (MSB)

EndPeriod (LSB)	NSteps (MSB)	NSteps (LSB)	Coarseness	Ctl

Index
Index is the array index in the step table where the acceleration/deceleration profile will start.

0 ≤ Index ≤ (59 – Coarseness)

StartPeriod
The period between each step at the start of the acceleration/deceleration profile. StartPeriod is in units of the base step period (section 6.4.6), which can be 1μs, 2μs, 4μs or 8μs. Do not specify a period that results in the period falling below the minimum (50μs at 5 Volts or 100μs at 3.3 Volts). See section 6.4.15 for further details.

16 ≤ StartPeriod ≤ 10000

Note that the acceleration/deceleration profile built with STEPTABLEWRITE does not include entries at StartPeriod or EndPeriod. It is therefore usual to surround the acceleration profile defined by a STEPTABLEWRITE command with entries with period StartPeriod and EndPeriod.

EndPeriod
The period between each step at the end of the acceleration/deceleration profile. EndPeriod is in units of the base step period. Do not specify a period that results in the period falling below the minimum (50μs at 5 Volts or 100μs at 3.3 Volts).

16 ≤ EndPeriod ≤ 10000

For an acceleration profile, specify StartPeriod > EndPeriod. For a deceleration profile, specify StartPeriod < EndPeriod.

NSteps
The total number of steps to be used in this acceleration/deceleration profile.

16 ≤ NSteps ≤ 1000

Coarseness
The acceleration/deceleration profile is built as a staircase with a number of discrete speed steps. The Coarseness parameter specifies the number of steps in this staircase. A higher value results in a smoother acceleration/deceleration, but takes longer to build in the Step Table.

4 ≤ Coarseness ≤ 16

Ctl
The following bits are defined in the Ctl byte:

MSB							LSB
7	6	5	4	3	2	1	0
			Dir	Current			

Note that although the Div bit is supported by the STEPTABLEACCEL command, in practice the very slow rate changes implied by setting this bit are of limited application.

Dir	
0	Forward (DIRA/DIRB output = 0)
1	Reverse (DIRA/DIRB output = 1)

The Current value is used for the duration of the programmed acceleration or deceleration.

Bits 5, 6 and 7 are not used.

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Parameter out-of-range)

6.4.20 RUN

Run the Step Table, starting at the specified index. Although this will usually be 0 (the start of the table), this need not necessarily be the case: the SC188804 can start executing a Step Table at any entry. On encountering a TableEnd command, the SC188804 returns to the start of the Step Table. Thus a Step Table can be built comprising a repeating sequence at the beginning of the table (terminated with a TableEnd command), followed by a start-up sequence (for instance an acceleration profile), again terminated by a TableEnd command. By starting execution at the beginning of the start-up sequence, the controller will accelerate up to the repetitive section.

Specifying an index of 255 will cause the controller to resume running within a Step Table from the point at which it stopped. This form of the RUN command may be used where a movement sequence is halted by an active STOP input or a STOP command.

Command Format

RUN (14h/94h)	Index

Index
Index is the array index in the Step Table at which to start executing.

$0 \leq$ Index ≤ 59

or Index = 255 to resume.

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Index out-of-range)

6.4.21 STOP

Immediately stop the stepper motor. If not already running, this command may change the holding current if the Hold bit in the StopCtl byte has been set (see STOPMODE command, section 6.4.22).

Command Format

STOP (15h/95h)

Response Format

ACK (5Ah)

6.4.22 STOPMODE

This command configures the STOP input and also determines the holding current that will be applied via the CURA0-3 (CURB0-3) outputs when the controller is stopped.

Command Format

STOPMODE (16h/96h)	StopCtl

StopCtl
The following bits are defined in the StopCtl byte:

MSB							LSB
7	6	5	4	3	2	1	0
	Pol	En	Hold	HoldCurrent			

HoldCurrent
Holding current to apply (via the CURA0-3 or CURB0-3 outputs) when the motor is stopped, if Hold is true.

Hold
Holding current enable bit:

Hold Bit

0 The motor holding current (as applied via the CURA0-3 or CURB0-3 outputs) is defined by the Step Table entry active at the instant at which the motor stopped. A step movement may be stopped in one of three ways:

By encountering a Stop Step Table command. This may be programmed explicitly by the low level STEPTABLEWRITE command, or at the end of a STEP (6.4.15) or SMARTMOVE (6.4.25) command. In the case of the STEPTABLEWRITE command, the applied holding current is defined by the Stop Step Table command. In the case of the STEP command, it is defined by the Ctl parameter, and for the SMARTMOVE command, by the HoldingCurrent parameter.

By issuing the STOP command. In this case, the holding current will be the applied current at the instant that the command was issued.

By asserting the STOP input, if enabled. The holding current will be the applied current at the instant that the signal was asserted.

1 The motor holding current is set to HoldCurrent whenever the motor is stopped, whether as a result of completing a STEP or SMARTMOVE command, or by reaching a programmed Stop Step Table command, by a STOP command being issued or the STOP input being asserted. This has the advantage that the holding current is independent of the cause of the motor stopping. However in some situations, it may not be appropriate to switch to a generic current on stopping.

Note that with the Hold bit set, issuing a STOP command will cause the holding current to change to HoldCurrent, even if the motor was not currently moving.

En
If true, enable the STOP input.

Pol
Set the active polarity of the STOP input:

Pol Bit
0 Stop motor on low level on STOP input.
1 Stop motor on high level on STOP input.

Bit 7 of the StopCtl byte is not used.

Response Format

ACK (5Ah)

6.4.23 STATUS

Return the current status of the specified SC188804 motor channel.

Command Format

STATUS (17h/97h)

Response Format

RspLen (1)	Status

The following bits are defined in the Status byte:

MSB							LSB
7	6	5	4	3	2	1	0
		Stop	Dir	/Sleep	/En		Running

Running	0 if stopped, 1 if currently running.
/En	0 if /ENA (/ENB) output = 0, 1 if /ENA (/ENB) output = 1.
/Sleep	0 if /SLEEPA (/SLEEPB) output = 0, 1 if /SLEEPA (/SLEEPB) output = 1.
Dir	Forward (DIRA/DIRB output = 0), Reverse (DIRA/DIRB output = 1).
Stop	State of STOPA (STOPB) input.

Bits 1, 6 and 7 are always 0.

6.4.24 INP

Return the current state of the INP0-3 inputs. These are uncommitted general-purpose inputs.

Command Format

INP (18h)

Response Format

RspLen (1)	Inp

The following bits are defined in the Inp byte:

MSB							LSB
7	6	5	4	3	2	1	0
				INP3	INP2	INP1	INP0

Bits 4-7 are always 0.

6.4.25 SMARTMOVE

High-level command to move the specified number of steps, with acceleration and deceleration. The start step period, minimum step period (maximum speed) and acceleration/deceleration profile are specified by the SMARTPARAMWRITE command. The SMARTMOVE command provides a convenient means for generic stepper motor movement control with acceleration and deceleration. SMARTMOVE commands with a small number of specified steps (less than twice the number of acceleration steps specified by the SMARTPARAMWRITE command) will accelerate at the defined rate and then start decelerating at the appropriate point so as to return to the start/stop speed in NSteps steps.

The SC188804 uses the Step Table of the specified motor channel (starting at location 0) to build the SMARTMOVE profile.

Command Format

SMARTMOVE (19h/99h)	NSteps3 (MSB)	NSteps2	NSteps1	NSteps0 (LSB)

NSteps
The signed total number of steps to be moved.

Positive = Forward (DIRA/DIRB output = 0).
Negative = Reverse (DIRA/DIRB output = 1).

$-1048576 \leq NSteps \leq 1048576$

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Parameter out-of-range)

6.4.26 SMARTPARAMWRITE

Set parameters for the SMARTMOVE command. Default parameters are defined for SMARTMOVE commands after resetting the controller prior to issuing any SMARTPARAMWRITE commands.

Command Format

SMARTPARAMWRITE (1Ah/9Ah)	StartPeriod (MSB)	StartPeriod (LSB)	RapidPeriod (MSB)	RapidPeriod (LSB)

AccelSteps (MSB)	AccelSteps (LSB)	AccelCurrent	RapidCurrent	HoldingCurrent

StartPeriod
The period between each step at the start of the acceleration profile, and end of the deceleration profile. StartPeriod is in units of the base step period (section 6.4.6), which can be 1μs, 2μs, 4μs or 8μs. Do not specify a period that results in the period falling below the minimum (50μs at 5 Volts or 100μs at 3.3 Volts).

16 ≤ StartPeriod ≤ 10000

Default: 800

RapidPeriod
The period between each step at maximum speed. RapidPeriod is in units of the base step period (section 6.4.6), which can be 1μs, 2μs, 4μs or 8μs. Do not specify a period that results in the period falling below the minimum (50μs at 5 Volts or 100μs at 3.3 Volts).

16 ≤ RapidPeriod ≤ 10000

Default: 500

RapidPeriod must be less than StartPeriod.

AccelSteps
The number of steps to be used in the acceleration phase and deceleration phase of the smart move.

16 ≤ AccelSteps ≤ 1000

Default: 200

AccelCurrent
The current (presented at the CURA0-3 or CURB0-3 outputs) during the acceleration and deceleration phases of the smart move.

0 ≤ AccelCurrent ≤ 15

Default: 8

RapidCurrent
The current (presented at the CURA0-3 or CURB0-3 outputs) during the rapid phase of the smart move.

0 ≤ RapidCurrent ≤ 15

Default: 8

HoldingCurrent
The holding current applied at the end of the smart move. The Current value is presented at the motor current outputs CURA0-3 (CURB0-3). These outputs remain at the specified current on completion of the movement (but see the STOPMODE command in section 6.4.22 – if the Hold bit is true, then the current specified by the STOPMODE command takes precedence over HoldingCurrent).

0 ≤ HoldingCurrent ≤ 15

Default: 4

Response Format

ACK (5Ah)

Or

NAK (A5h)

(Parameter out-of-range)

6.4.27 SMARTPARAMREAD

Read the SMARTMOVE parameters.

Command Format

SMARTPARAMREAD (1Bh/9Bh)

Response Format

RspLen (9)	StartPeriod (MSB)	StartPeriod (LSB)	RapidPeriod (LSB)	RapidPeriod (MSB)

AccelSteps (MSB)	AccelSteps (LSB)	AccelCurrent	RapidCurrent	HoldingCurrent

See the SMARTPARAMWRITE command (section 6.4.26) for a description of the response fields.

6.4.28 TABLEPOS

When running, return the index of the step table entry currently running, and the number of steps remaining to run on this entry.

Command Format

TABLEPOS (1Fh/9Fh)

Response Format

RspLen (3)	Index	NSteps (MSB)	NSteps (LSB)

Index
Index is the currently running array index in the Step Table.

NSteps
The number of steps remaining to run on this Step Table entry.

6.4.29 VERSION

Return the SC188804 firmware version.

Command Format

VERSION (20h)

Response Format

RspLen (1)	Version

Version

The version is returned in BCD format. The MS nibble is the major version number, and the LS nibble is the minor version number:

MSB							LSB
7	6	5	4	3	2	1	0
Version.Major				Version.Minor			

7 Electrical Specifications

7.1 Absolute Maximum Ratings

Absolute maximum ratings are the limits to which the SC188804 can be exposed without sustaining permanent damage. Note that correct operation is not guaranteed at the absolute maximum ratings.

Characteristic	Symbol	Value	Unit
Supply voltage	V_{DD}	-0.3 to +6.0	V
Input voltage	V_{in}	V_{ss} - 0.3 to V_{DD} + 0.3	V
Maximum current per pin		±15	mA
Maximum current into V_{DD}		150	mA
Maximum current out of V_{SS}		150	mA
Storage temperature		-55 to +150	°C

7.2 Functional Operating Range

Characteristic	Symbol	Value	Unit
Operating voltage range	V_{DD}	5.0 ±10% 3.3 ±10%	V
Operating temperature range		-40 to +125	°C

7.3 Thermal Characteristics

Characteristic	Symbol	Value	Unit
Thermal resistance		95	°C/W
I/O pin power dissipation	$P_{I/O}$	User determined	W
Power dissipation	P_D	$(I_{DD} \times V_{DD}) + P_{I/O}$	W

7.4 5.0Vdc Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Unit
Output high voltage (I_{LOAD} = -2.0mA) all I/O pins (I_{LOAD} = -10.0mA) all I/O pins Maximum combined I_{OH} all I/O pins	 V_{OH} V_{OH} I_{OH}	 V_{DD} – 0.8 V_{DD} – 1.5 –	 – – –	 – – 50	 V V mA
Output low voltage (I_{LOAD} = 1.6mA) all I/O pins (I_{LOAD} = 10.0mA) all I/O pins Maximum combined I_{OL} all I/O pins	 V_{OL} V_{OL} I_{OL}	 – – –	 – – –	 0.4 1.5 50	 V V mA
Input high voltage	V_{IH}	0.7 x V_{DD}	–	V_{DD}	V
Input low voltage	V_{IL}	V_{SS}	–	0.2 x V_{DD}	V
V_{DD} supply current	I_{DD}	–	14	30	mA
Input current	I_{in}	-1	–	+1	µA
Pullup resistors on INP0-1	R_{pu}	20	45	65	kΩ
Capacitance Output pins Input pins	 C_{out} C_{in}	 – –	 – –	 12 8	pF
Supply voltage sample threshold (see section 5.1)	V_{thresh}	3.9	4.25	4.5	V
Power-on rearm voltage	V_{POR}	0	–	100	mV
Power-on reset voltage	V_{PORRST}	0	700	800	mV
Power-on reset rise time	R_{POR}	0.035	–	–	V/ms
RESET input pulse width low	t_{RL}	50	–	–	ns

7.5 3.3Vdc Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Unit
Output high voltage (I_{LOAD} = -2.0mA) all I/O pins (I_{LOAD} = -10.0mA) all I/O pins Maximum combined I_{OH} all I/O pins	 V_{OH} V_{OH} I_{OH}	 V_{DD} – 0.3 V_{DD} – 1.0 –	 – – –	 – – 30	 V V mA
Output low voltage (I_{LOAD} = 1.6mA) all I/O pins (I_{LOAD} = 10.0mA) all I/O pins Maximum combined I_{OL} all I/O pins	 V_{OL} V_{OL} I_{OL}	 – – –	 – – –	 0.3 1.0 30	 V V mA
Input high voltage	V_{IH}	0.7 x V_{DD}	–	V_{DD}	V
Input low voltage	V_{IL}	V_{SS}	–	0.3 x V_{DD}	V
V_{DD} supply current	I_{DD}	–	4	12	mA
Input current	I_{in}	-1	–	+1	µA
Pullup resistors on INP0-1	R_{pu}	20	45	65	kΩ
Capacitance Output pins Input pins	 C_{out} C_{in}	 – –	 – –	 12 8	 PF
Power-on rearm voltage	V_{POR}	0	–	100	mV
Power-on reset voltage	V_{PORRST}	0	700	800	mV
Power-on reset rise time	R_{POR}	0.02	–	–	V/ms
RESET input pulse width low	t_{RL}	125	–	–	ns

7.6 Crystal Clock Generator Characteristics

Characteristic	Symbol	Min	Typ	Max	Unit
Crystal load capacitance[1]	C_L	–	–	–	pF
Crystal fixed capacitance	C_1	6	2 x C_L	40	pF
Crystal tuning capacitance	C_2	6	2 x C_L	40	pF
Feedback bias resistor	R_B	10	10	22	MΩ
Series resistor	R_S	330	330	470	kΩ
PLL lock time	T_{lock}	–	–	50	ms

[1]Refer to manufacturer's data.

7.7 5.0V SPI Characteristics

Characteristic	Symbol	Min	Typ	Max	Unit
Operating frequency	F_{SPI}	–	–	8	MHz
Cycle Time	T_{SPI}	125	–	–	ns
/SS Lead Time	T_{Lead}	125	–	–	ns
/SS Lag Time	T_{Lag}	125	–	–	ns
Clock (SPSCK) high time	T_{SPIh}	40	–	–	ns
Clock (SPSCK) low time	T_{SPIl}	40	–	–	ns
Data setup time (SDI)	t_s	30	–	–	ns
Data hold time (SDI)	t_h	30	–	–	ns
Access time[1]	t_a	0	–	40	ns
Disable time[2]	t_d	–	–	40	ns
Data valid time (SDO)	t_v	–	–	50	ns
Data hold time (SDO)	t_{ho}	0	–	–	ns
Data rate	T_{Dspi}	80	–	–	µs/byte

[1]Time to data active from high impedance state.
[2]Hold time to high impedance state.

7.8 3.3V SPI Characteristics

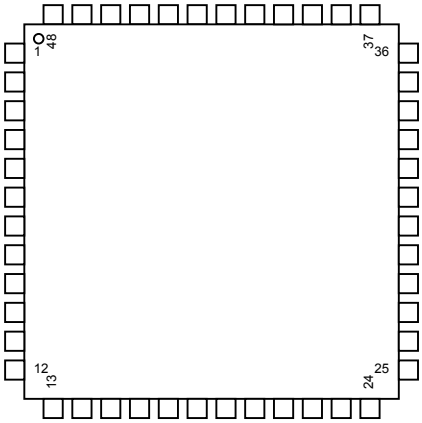
Characteristic	Symbol	Min	Typ	Max	Unit
Operating frequency	F_{SPI}	–	–	4	MHz
Cycle Time	T_{SPI}	250	–	–	ns
/SS Lead Time	T_{Lead}	250	–	–	ns
/SS Lag Time	T_{Lag}	250	–	–	ns
Clock (SPSCK) high time	T_{SPIh}	90	–	–	ns
Clock (SPSCK) low time	T_{SPIl}	90	–	–	ns
Data setup time (SDI)	t_s	40	–	–	ns
Data hold time (SDI)	t_h	40	–	–	ns
Access time[1]	t_a	0	–	50	ns
Disable time[2]	t_d	–	–	50	ns
Data valid time (SDO)	t_v	–	–	60	ns
Data hold time (SDO)	t_{ho}	0	–	–	ns
Data rate	T_{Dspi}	80	–	–	µs/byte

[1]Time to data active from high impedance state.
[2]Hold time to high impedance state.

8 Ordering Information and Mechanical Specifications

8.1 Pin Numbering

The SC188804 is available in a 0.5mm pitch 48 pin low-profile quad flat pack (LQFP).



8.2 Order Numbers and Operating Temperature Ranges

Order Number	Operating Temperature Range
SC188804CFA	-40°C to +85°C
SC188804VFA	-40°C to +105°C
SC188804MFA	-40°C to +125°C

9 Further Information

The data contained in this document is preliminary information and is liable to change without notice. For further details of the product described herein, please contact the factory.

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