RoHS

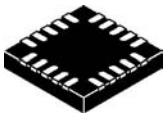
Advanced Information

Proximity Capacitive Touch Sensor Controller

MPR121

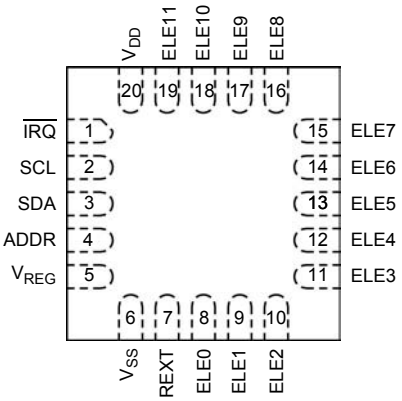
Capacitive Touch Sensor Controller

Bottom View



20-PIN QFN
CASE 2059-01

Top View



Pin Connections

MPR121 OVERVIEW

The MPR121 is the second generation sensor controller after the initial release of the MPR03x series devices. The MPR121 will feature increased internal intelligence in addition to Freescale's second generation capacitance detection engine. Some of the major additions include an increased electrode count, a hardware configurable I^2C address, an expanded filtering system with debounce, and completely independent electrodes with auto-configuration built in. The device also features a 13^{th} simulated electrode that represents the simultaneous charging of all the electrodes connected together to allow for increased proximity detection in a touch panel or touch screen array.

Features

- 1.71 V to 3.6 V operation
- 29 μA supply current at 16 ms sample period
- 3 μA shutdown current
- 12 electrodes
- Continuous independent auto-calibration for each electrode input
- Separate touch and release trip thresholds for each electrode, providing hysteresis and electrode independence
- I^2C interface, with $\overline{IRQ}$ output to advise electrode status changes
- 3 mm x 3 mm x 0.65 mm 20 lead QFN package
- LED driver functionality with 8 shared LEDs
- -40°C to +85°C operating temperature range

Implementations

- Switch Replacements
- Touch Pads

Typical Applications

- PC Peripherals
- MP3 Players
- Remote Controls
- Mobile Phones
- Lighting Controls

ORDERING INFORMATION					
Device Name	**Temperature Range**	**Case Number**	**Touch Pads**	**IRC Address**	**Shipping**
MPR121QR2	-40°C to +85°C	2059 (20-Pin QFN)	12-pads	0x4C - 0x4F	Tape & Reel

SCHEMATIC DRAWINGS AND IMPLEMENTATION

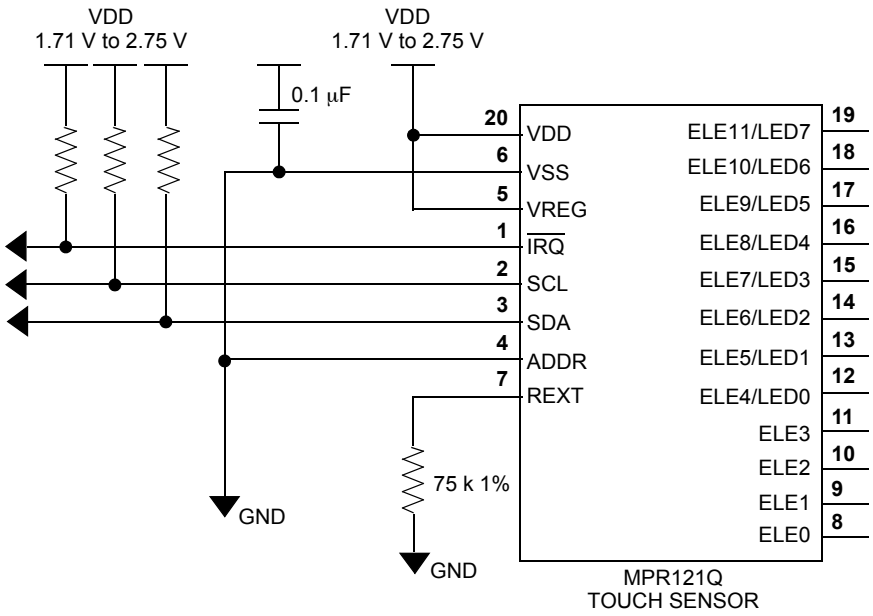


Figure 1. Configuration 1: MPR121 runs from a 1.71 V to 2.75 V supply.

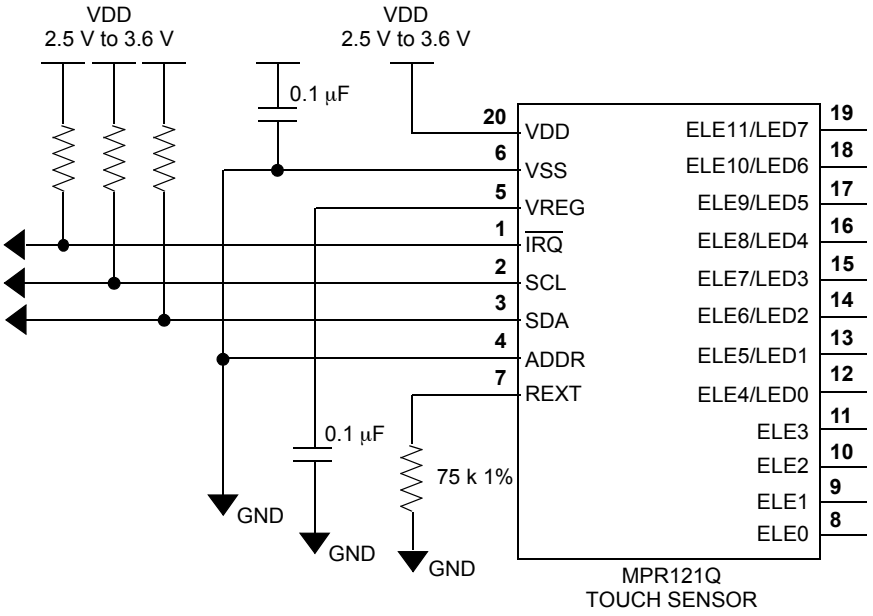


Figure 2. Configuration 2: MPR121 runs from a 2.5 V to 3.6 V supply.

Capacitance Sensing

The MPR121 uses a constant current touch sensor system with two primary types of control. It can measure capacitances ranging from 10 pF to 2000 pF by varying the current and the amount of time supplied to each electrode. The electrodes are controlled independently allowing for a great deal of flexibility in electrode pattern design. To make setup of the device easier, an automatic configuration system can be used to set the ideal capacitance of each electrode. For information on how to set up this system refer to application note AN3889.

Once capacitance is calculated, it runs through a couple of levels of digital filtering allowing for good noise immunity in different environments without sacrificing response time or power consumption. The MPR121 can be configured for sample rates between 1 ms and 128 ms. For information on how to set up this system refer to application note AN3890.

Touch Sensing

Once the capacitance is determined at any given moment, this information must then be translated into intelligent touch recognition. The MPR121 has a couple of systems that have improved over the previous generation in the MPR03x series devices. A baseline tracking system allows the system to track the untouched capacitance in the system. For information on how to set up the baseline capacitance system refer to application note AN3891. The baseline value is then compared with the current value to determine if a touch has occurred. A designer has the ability to set both the rising and falling thresholds in addition to a debounce to eliminate jitter and false touches due to noise. These elements are described in application note AN3892.

Proximity Sensing

A new feature of the MPR121 is the use of a proximity sensing system whereby all of a system's electrodes can be shorted together internally and create a single large electrode. The capacitance of this electrode is larger and projected capacitance can be measured. When enabled, this "13^{th}" electrode will be included at the end of a normal detection cycle and will have its own independent set of configuration registers. This system is described in application note AN3893.

LED Driver

The MPR121 includes eight shared LED driving pins. When these pins are not configured as electrodes, they may be used to drive LEDs. The system allows for both pull up and pull down LED configurations as well as general GPIO push/pull functionality. The configuration of the LED driver system is described in application note AN3894.

Serial Communication

The MPR121 is an Inter-Integrated Circuit (I^2C) compliant device with an additional interrupt that is triggered any time a touch or release of a button is detected. The device has a configurable I^2C address by connecting the ADDR pin to the VDD, VSS, SDA or SCL lines. The resulting I^2C addresses are 0x4C, 0x4D, 0x4E and 0x4F respectively. The specific details of this system are described in AN3895. For reference the register map of the MPR121 is included in **Table 1**.

Table 1. Register Map

REGISTER	Fields								Register Address	Initial Value	Auto Increment Address
ELE0 - ELE7 Touch Status	ELE7	ELE6	ELE5	ELE4	ELE3	ELE2	ELE1	ELE0	0x00	0x00	Register Address + 1
ELE8 - ELE11, ELEPROX Touch Status	OVCF	ELEPROX			ELE11	ELE10	ELE9	ELE8	0x01	0x00	
ELE0-7 OOR Status	ELE7	ELE6	ELE5	ELE4	ELE3	ELE2	ELE1	ELE0	0x02	0x00	
ELE8-11, ELEPROX OOR Status	ARFF	ACFF		ELEPROX	ELE11	ELE10	ELE9	ELE8	0x03	0x00	
ELE0 Electrode Filtered Data LSB	EFD0LB								0x04	0x00	
ELE0 Electrode Filtered Data MSB							EFD0HB		0x05	0x00	
ELE1 Electrode Filtered Data LSB	EFD1LB								0x06	0x00	
ELE1 Electrode Filtered Data MSB							EFD1HB		0x07	0x00	
ELE2 Electrode Filtered Data LSB	EFD2LB								0x08	0x00	
ELE2 Electrode Filtered Data MSB							EFD2HB		0x09	0x00	
ELE3 Electrode Filtered Data LSB	EFD3LB								0x0A	0x00	
ELE3 Electrode Filtered Data MSB							EFD3HB		0x0B	0x00	
ELE4 Electrode Filtered Data LSB	EFD4LB								0x0C	0x00	
ELE4 Electrode Filtered Data MSB							EFD4HB		0x0D	0x00	
ELE5 Electrode Filtered Data LSB	EFD5LB								0x0E	0x00	
ELE5 Electrode Filtered Data MSB							EFD5HB		0x0F	0x00	
ELE6 Electrode Filtered Data LSB	EFD6LB								0x10	0x00	
ELE6 Electrode Filtered Data MSB							EFD6HB		0x11	0x00	
ELE7 Electrode Filtered Data LSB	EFD7LB								0x12	0x00	
ELE7 Electrode Filtered Data MSB							EFD7HB		0x13	0x00	
ELE8 Electrode Filtered Data LSB	EFD8LB								0x14	0x00	
ELE8 Electrode Filtered Data MSB							EFD8HB		0x15	0x00	
ELE9 Electrode Filtered Data LSB	EFD9LB								0x16	0x00	
ELE9 Electrode Filtered Data MSB							EFD9HB		0x17	0x00	
ELE10 Electrode Filtered Data LSB	EFD10LB								0x18	0x00	
ELE10 Electrode Filtered Data MSB							EFD10HB		0x19	0x00	
ELE11 Electrode Filtered Data LSB	EFD11LB								0x1A	0x00	
ELE11 Electrode Filtered Data MSB							EFD11HB		0x1B	0x00	
ELEPROX Electrode Filtered Data LSB	EFDPROXLB								0x1C	0x00	
ELEPROX Electrode Filtered Data MSB							EFDPROXHB		0x1D	0x00	
ELE0 Baseline Value	E0BV								0x1E	0x00	
ELE1 Baseline Value	E1BV								0x1F	0x00	
ELE2 Baseline Value	E2BV								0x20	0x00	
ELE3 Baseline Value	E3BV								0x21	0x00	
ELE4 Baseline Value	E4BV								0x22	0x00	
ELE5 Baseline Value	E5BV								0x23	0x00	
ELE6 Baseline Value	E6BV								0x24	0x00	
ELE7 Baseline Value	E7BV								0x25	0x00	
ELE8 Baseline Value	E8BV								0x26	0x00	
ELE9 Baseline Value	E9BV								0x27	0x00	
ELE10 Baseline Value	E10BV								0x28	0x00	
ELE11 Baseline Value	E11BV								0x29	0x00	
ELEPROX Baseline Value	EPROXBV								0x2A	0x00	
MHD Rising			MHDR						0x2B	0x00	
NHD Amount Rising			NHDR						0x2C	0x00	
NCL Rising	NCLR								0x2D	0x00	
FDL Rising	FDLR								0x2E	0x00	
MHD Falling			MHDF						0x2F	0x00	
NHD Amount Falling			NHDF						0x30	0x00	

Table 1. Register Map

REGISTER	Fields	Register Address	Initial Value	Auto Increment Address
NCL Falling	NCLF	0x31	0x00	Register Address + 1
FDL Falling	FDLF	0x32	0x00	
NHD Amount Touched	NHDT	0x33	0x00	
NCL Touched	NCLT	0x34	0x00	
FDL Touched	FDLT	0x35	0x00	
ELEPROX MHD Rising	MHDPROXR	0x36	0x00	
ELEPROX NHD Amount Rising	NHDPROXR	0x37	0x00	
ELEPROX NCL Rising	NCLPROXR	0x38	0x00	
ELEPROX FDL Rising	FDLPROXR	0x39	0x00	
ELEPROX MHD Falling	MHDPROXF	0x3A	0x00	
ELEPROX NHD Amount Falling	NHDPROXF	0x3B	0x00	
ELEPROX NCL Falling	NCLPROXF	0x3C	0x00	
ELEPROX FDL Falling	FDLPROXF	0x3D	0x00	
ELEPROX NHD Amount Touched	NHDPROXT	0x3E	0x00	
ELEPROX NCL Touched	NCLPROXT	0x3F	0x00	
ELEPROX FDL Touched	FDLPROXT	0x40	0x00	
ELE0 Touch Threshold	E0TTH	0x41	0x00	
ELE0 Release Threshold	E0RTH	0x42	0x00	
ELE1 Touch Threshold	E1TTH	0x43	0x00	
ELE1 Release Threshold	E1RTH	0x44	0x00	
ELE2 Touch Threshold	E2TTH	0x45	0x00	
ELE2 Release Threshold	E2RTH	0x46	0x00	
ELE3 Touch Threshold	E3TTH	0x47	0x00	
ELE3 Release Threshold	E3RTH	0x48	0x00	
ELE4 Touch Threshold	E4TTH	0x49	0x00	
ELE4 Release Threshold	E4RTH	0x4A	0x00	
ELE5 Touch Threshold	E5TTH	0x4B	0x00	
ELE5 Release Threshold	E5RTH	0x4C	0x00	
ELE6 Touch Threshold	E6TTH	0x4D	0x00	
ELE6 Release Threshold	E6RTH	0x4E	0x00	
ELE7 Touch Threshold	E7TTH	0x4F	0x00	
ELE7 Release Threshold	E7RTH	0x50	0x00	
ELE8 Touch Threshold	E8TTH	0x51	0x00	
ELE8 Release Threshold	E8RTH	0x52	0x00	
ELE9 Touch Threshold	E9TTH	0x53	0x00	
ELE9 Release Threshold	E9RTH	0x54	0x00	
ELE10 Touch Threshold	E10TTH	0x55	0x00	
ELE10 Release Threshold	E10RTH	0x56	0x00	
ELE11 Touch Threshold	E11TTH	0x57	0x00	
ELE11 Release Threshold	E11RTH	0x58	0x00	
ELEPROX Touch Threshold	EPROXTTH	0x59	0x00	
ELEPROX Release Threshold	EPROXRTH	0x5A	0x00	
Debounce Touch & Release	DR | DT	0x5B	0x00	
AFE Configuration	FFI | CDC	0x5C	0x10	
Filter Configuration	CDT | SFI | ESI	0x5D	0x04	
Electrode Configuration	CL | EL | EleEn	0x5E	0x00	
ELE0 Electrode Current	CDC0	0x5F	0x00	
ELE1 Electrode Current	CDC1	0x60	0x00	
ELE2 Electrode Current	CDC2	0x61	0x00	

Table 1. Register Map

REGISTER	Fields								Register Address	Initial Value	Auto Increment Address
ELE3 Electrode Current			CDC3						0x62	0x00	
ELE4 Electrode Current			CDC4						0x63	0x00	
ELE5 Electrode Current			CDC5						0x64	0x00	
ELE6 Electrode Current			CDC6						0x65	0x00	
ELE7 Electrode Current			CDC7						0x66	0x00	
ELE8 Electrode Current			CDC8						0x67	0x00	
ELE9 Electrode Current			CDC9						0x68	0x00	
ELE10 Electrode Current			CDC10						0x69	0x00	
ELE11 Electrode Current			CDC11						0x6A	0x00	
ELEPROX Electrode Current			CDCPROX						0x6B	0x00	
ELE0, ELE1 Charge Time		CDT1				CDT0			0x6C	0x00	
ELE2, ELE3 Charge Time		CDT3				CDT2			0x6D	0x00	
ELE4, ELE5 Charge Time		CDT5				CDT4			0x6E	0x00	
ELE6, ELE7 Charge Time		CDT7				CDT6			0x6F	0x00	
ELE8, ELE9 Charge Time		CDT9				CDT8			0x70	0x00	Register Address + 1
ELE10, ELE11 Charge Time		CDT11				CDT10			0x71	0x00	
ELEPROX Charge Time						CDTPROX			0x72	0x00	
GPIO Control Register 0	CTL011	CTL010	CTL09	CTL08	CTL07	CTL06	CTL05	CTL04	0x73	0x00	
GPIO Control Register 1	CTL111	CTL110	CTL19	CTL18	CTL17	CTL16	CTL15	CTL14	0x74	0x00	
GPIO Data Register	DAT11	DAT10	DAT9	DAT8	DAT7	DAT6	DAT5	DAT4	30x75	0x00	
GPIO Direction Register	DIR11	DIR10	DIR9	DIR8	DIR7	DIR6	DIR5	DIR4	0x76	0x00	
GPIO Enable Register	EN11	EN10	EN9	EN8	EN7	EN6	EN5	EN4	0x77	0x00	
GPIO Data Set Register	SET11	SET10	SET9	SET8	SET7	SET6	SET5	SET4	0x78	0x00	
GPIO Data Clear Register	CLR11	CLR10	CLR9	CLR8	7CLR7	CLR6	CLR5	CLR4	0x79	0x00	
GPIO Data Toggle Register	TOG11	TOG10	TOG9	TOG8	TOG7	TOG6	TOG5	TOG4	0x7A	0x00	
AUTO-CONFIG Control Register 0	AFES		RETRY		BVA		ARE	ACE	0x7B	0x00	
AUTO-CONFIG Control Register 1	SCTS					OORIE	ARFIE	ACFIE	0x7C	0x00	
AUTO-CONFIG USL Register	USL								0x7D	0x00	
AUTO-CONFIG LSL Register	LSL								0x7E	0x00	
AUTO-CONFIG Target Level Register	TL								0x7F	0x00	0x00

ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

Absolute maximum ratings are stress ratings only, and functional operation at the maxima is not guaranteed. Stress beyond the limits specified in Table 2 may affect device reliability or cause permanent damage to the device. For functional operating conditions, refer to the remaining tables in this section. This device contains circuitry protecting against damage due to high static voltage or electrical fields; however, it is advised that normal precautions be taken to avoid application of any voltages higher than maximum-rated voltages to this high-impedance circuit.

Table 2. Absolute Maximum Ratings - Voltage (with respect to V_{SS})

Rating	Symbol	Value	Unit
Supply Voltage	V_{DD}	-0.3 to +3.6	V
Supply Voltage	V_{REG}	-0.3 to +2.75	V
Input Voltage SCL, SDA, $\overline{IRQ}$	V_{IN}	V_{SS} - 0.3 to V_{DD} + 0.3	V
Operating Temperature Range	T_O	-40 to +85	°C
GPIO Source Current per Pin	i_{GPIO}	12	mA
GPIO Sink Current per Pin	i_{GPIO}	1.2	mA
Storage Temperature Range	T_S	-40 to +125	°C

ESD AND LATCH-UP PROTECTION CHARACTERISTICS

Normal handling precautions should be used to avoid exposure to static discharge.

Qualification tests are performed to ensure that these devices can withstand exposure to reasonable levels of static without suffering any permanent damage. During the device qualification ESD stresses were performed for the Human Body Model (HBM), the Machine Model (MM) and the Charge Device Model (CDM).

A device is defined as a failure if after exposure to ESD pulses the device no longer meets the device specification. Complete DC parametric and functional testing is performed per the applicable device specification at room temperature followed by hot temperature, unless specified otherwise in the device specification.

Table 3. ESD and Latch-up Test Conditions

Rating	Symbol	Value	Unit
Human Body Model (HBM)	V_{ESD}	±2000	V
Machine Model (MM)	V_{ESD}	±200	V
Charge Device Model (CDM)	V_{ESD}	±500	V
Latch-up current at T_A = 85°C	I_{LATCH}	±100	mA

DC CHARACTERISTICS

This section includes information about power supply requirements and I/O pin characteristics.

Table 4. DC Characteristics

(Typical Operating Circuit, V_{DD} and V_{REG} = 1.8 V, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
High Supply Voltage	V_{DD}		2.5	3.3	3.6	V
Low Supply Voltage	V_{REG}		1.71	1.8	2.75	V
Average Supply Current	I_{DD}	Run1 Mode @ 1 ms sample period		393		μA
Average Supply Current	I_{DD}	Run1 Mode @ 2 ms sample period		199		μA
Average Supply Current	I_{DD}	Run1 Mode @ 4 ms sample period		102		μA
Average Supply Current	I_{DD}	Run1 Mode @ 8 ms sample period		54		μA
Average Supply Current	I_{DD}	Run1 Mode @ 16 ms sample period		29		μA
Average Supply Current	I_{DD}	Run1 Mode @ 32 ms sample period		17		μA
Average Supply Current	I_{DD}	Run1 Mode @ 64 ms sample period		11		μA
Average Supply Current	I_{DD}	Run1 Mode @ 128 ms sample period		8		μA
Measurement Supply Current	I_{DD}	Peak of measurement duty cycle		1		mA
Idle Supply Current	I_{DD}	Stop Mode		3		μA
Input Leakage Current ELE_	I_{IH}, I_{IL}			0.025		μA
Input Capacitance ELE_					15	pF
Input High Voltage SDA, SCL	V_{IH}		0.7 x V_{DD}			V
Input Low Voltage SDA, SCL	V_{IL}				0.3 x V_{DD}	V
Input Leakage Current SDA, SCL	I_{IH}, I_{IL}			0.025	1	μA
Input Capacitance SDA, SCL					7	pF
Output Low Voltage SDA, $\overline{IRQ}$	V_{OL}	I_{OL} = 6mA			0.5V	V
Output High Voltage ELE4 - ELE11 (GPIO mode)	V_{OHGPIO}	V_{DD} = 2.7 V to 3.6 V: I_{OHGPIO} = -10 mA V_{DD} = 2.3 V to 2.7 V: I_{OHGPIO} = -6 mA V_{DD} = 1.8 V to 2.3 V: I_{OHGPIO} = -3 mA	V_{DD} - 0.5			V
Output Low Voltage ELE4 - ELE11 (GPIO mode)	V_{OLGPIO}	$I_{OLGPIOD}$ = 1 mA			0.5	V
Power On Reset	V_{TLH}	V_{DD} rising	1.08	1.35	1.62	V
	V_{THL}	V_{DD} falling	0.88	1.15	1.42	V

AC CHARACTERISTICS

Table 5. AC CHARACTERISTICS

(Typical Operating Circuit, V_{DD} and V_{REG} = 1.8 V, T_A = 25°C, unless otherwise noted.)

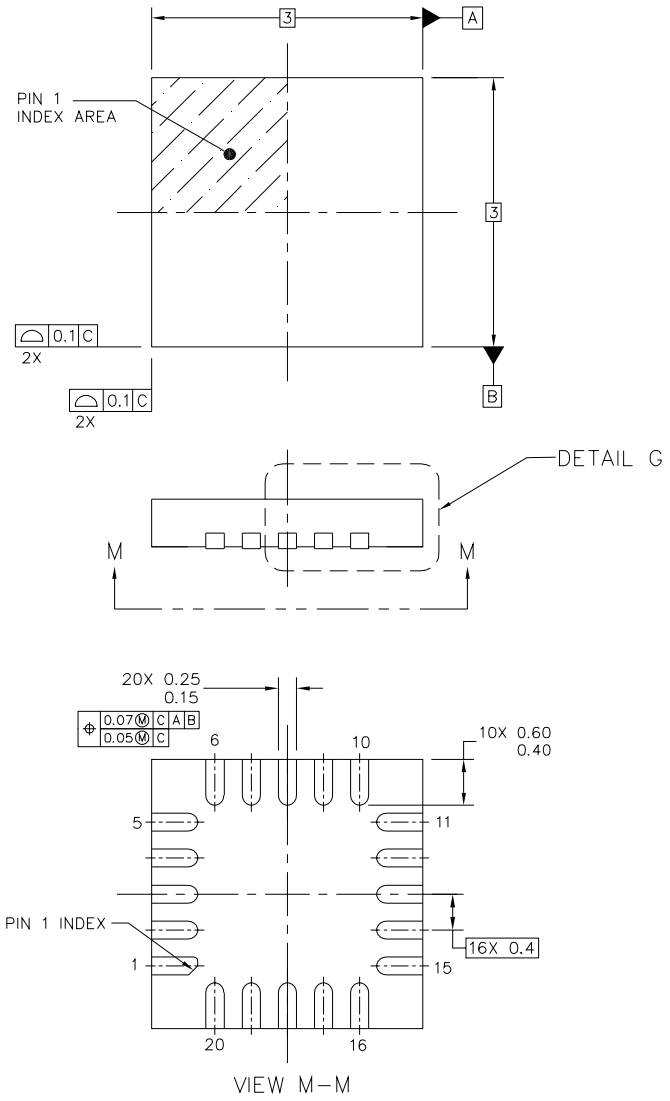
Parameter	Symbol	Conditions	Min	Typ	Max	Units
8 MHz Internal Oscillator	f_H		7.44	8	8.56	MHz
1 kHz Internal Oscillator	f_L		0.65	1	1.35	kHz

I^2C AC CHARACTERISTICS

Table 6. I^2C AC Characteristics
(Typical Operating Circuit, V_{DD} and V_{REG} = 1.8 V, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Serial Clock Frequency	f_{SCL}				400	kHz
Bus Free Time Between a STOP and a START Condition	t_{BUF}		1.3			μs
Hold Time, (Repeated) START Condition	$t_{HD, STA}$		0.6			μs
Repeated START Condition Setup Time	$t_{SU, STA}$		0.6			μs
STOP Condition Setup Time	$t_{SU, STO}$		0.6			μs
Data Hold Time	$t_{HD, DAT}$				0.9	μs
Data Setup Time	$t_{SU, DAT}$		100			ns
SCL Clock Low Period	t_{LOW}		1.3			μs
SCL Clock High Period	t_{HIGH}		0.7			μs
Rise Time of Both SDA and SCL Signals, Receiving	t_R			$20+0.1C_b$	300	ns
Fall Time of Both SDA and SCL Signals, Receiving	t_F			$20+0.1C_b$	300	ns
Fall Time of SDA Transmitting	$t_{F.TX}$			$20+0.1C_b$	250	ns
Pulse Width of Spike Suppressed	t_{SP}			25		ns
Capacitive Load for Each Bus Line	C_b				400	pF

PACKAGE DIMENSIONS



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	CASE NUMBER: 2059–01	19 FEB 2009
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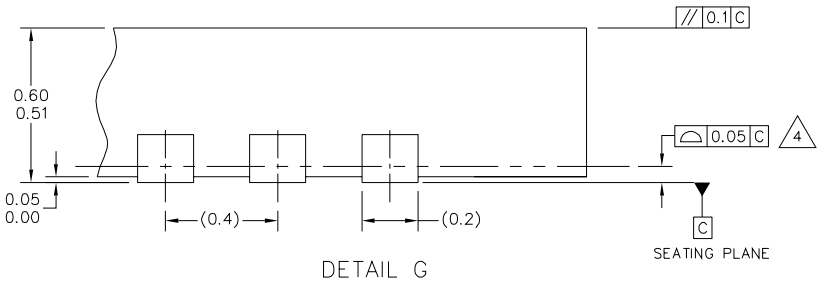
PAGE 1 OF 3



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	CASE NUMBER: 2059–01	19 FEB 2009	
	STANDARD: NON JEDEC		

PACKAGE DIMENSIONS

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. THIS IS NON JEDEC REGISTERED PACKAGE.
4. COPLANARITY APPLIES TO LEADS AND ALL OTHR BOTTOM SURFACE METALLIZATION.
5. MIN. METAL GAP SHOULD BE 0.2MM.

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