AMRI-2000-P000

Mobile Navigation Interface IC
for Slider Mechanical Module

Data Sheet

Description

The AMRI-2000 is a low power multi mode navigation sense and interface IC designed for use with the AMRS and AMRT series of navigation pad modules to provide a high-accuracy analog pointing solution for mobile applications.

In combination with the AMRS/AMRT navigation pads the AMRI-2000 can provide a mouse-like cursor control interface, analog joystick cursor control, four-way or eight-way switch functionality, as well as scroll-wheel emulation. This combination of analog and digital cursor control provides improved web browsing and graphical user interface for next generation mobile phones as well as backward compatible rocker and scroll-wheel emulation for existing user interfaces.

The operating mode can be dynamically reconfigured to provide the best user navigation experience for any active application. For example, the operating system may select joystick mode for web browsing and gaming, scroll wheel mode for phone book scrolling, while menu navigation is done with the backward compatible 4-way switch mode– always optimized and user configurable for any application.

Compared to competing solutions, the AMRI-2000 combined with Avago's AMRS/AMRT series navigation pads is unique in its ability to provide superior tactile feedback as well as multiple intuitive operating modes in a compact form factor.

Component Image

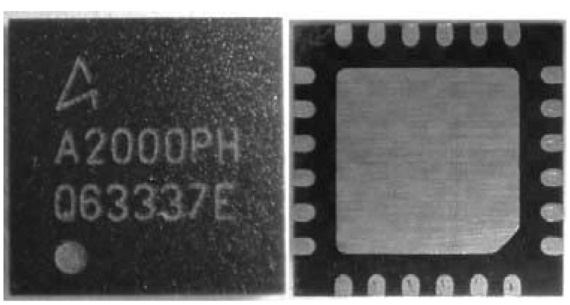


Figure 1. AMRI-2000 in 4 mm x 4 mm TQFN package

Features

- 360 degree navigation
- Dynamically Reconfigurable Multimode operation:
- Analog Joystick mode
- Mouse mode
- 4-way / 8-way rocker switch emulation modes
- Scroll wheel mode
- Up to 250Hz update rate
- Over 2000 dpi resolution with AMRS/AMRT puck module
- Internal clock
- Automatic calibration
- Automatic gain adjustment
- Automatic power saving sleep function
- 1.4 mW operating power1 (footnote: with 25% run rate while navigating)
- 0.2 mW standby power with wake on motion2 (footnote: with 1 Hz sampling rate)
- 60 µW power in shutdown mode
- 1.8V and 2.8V Supply Voltage
- 1.8V I/O Voltage
- Compact form factor in standard 4 mm x 4 mm TQFN package
- Two-wire serial interface or four-wire SPI interface (selectable)

Applications

- Mobile Phones and Smart Phones
- Computer Peripherals
- PDAs, Sub-Notebook and Laptop PCs
- Remote Controls
- Mobile Multi Media Players
- Video Game Controllers

Theory of Operation

The AMRI-2000 includes a single drive channel and four capacitive sense electrodes. The AMRS/AMRT modules include a conductive sliding disk which couples signal from the drive to the sense electrodes, allowing the AMRI-2000 to accurately determine puck position, as well as measured the user-applied vertical forces. Algorithms within the AMRI-2000 process the force and displacement information to generate cursor control data. The cursor control output is available over SPI or TWI bus.

The sliding disk of the AMRS/AMRT module may be moved in any direction with excellent tactile feel, and is returned to center by the proprietary spring re-centering system. A selection or clicking operation can be performed anywhere in the field of motion by fully depressing the sliding disk. Positive tactile feedback is provided from a dome switch contained within the sliding disk. Although the measurement is capacitive-based, it does not depend on finger capacitance, so the device can be used while wearing gloves.

Autogain and Autocalibration

The AMRI-2000 has internal routines for autocalibration and autogain. When used with AMRS/AMRT puck assemblies with properly designed PCB layouts (see Application Note xxx) the IC will automatically find appropriate threshold levels to recognize user touch and clicks. In rare circumstances these can be manually configured if necessary.

The AMRI-2000 also has built-in automatic gain adjustment, so it can seamlessly operate with a range of capacitive pucks. The AMRI-2000 will automatically select the optimal gain for best sensing performance. Although not recommended, the gain setting can be manually overridden if desired.

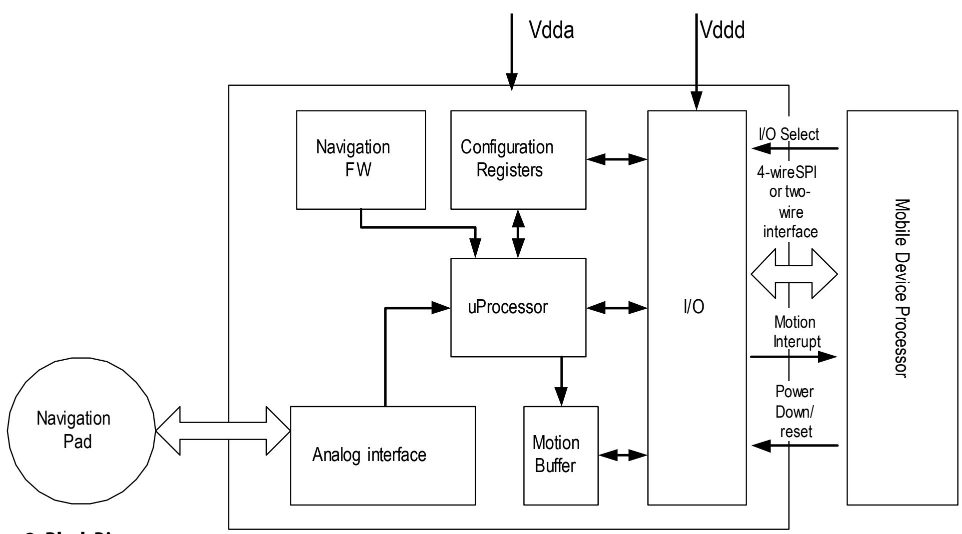


Figure 2. Block Diagram

Navigation Modes

The AMRI-2000 provides four primary navigation modes: joystick, mouse, rocker emulation and scroll wheel emulation. Joystick mode and mouse mode are for analog cursor, such as a Windows PC environment. Rocker mode and scroll-wheel mode are for use in icon-based systems, conventionally controlled with D-pads or 5-way digital joysticks.

Joystick Mode

In joystick mode the position of the puck controls the velocity and direction of the cursor motion. In general, the further the puck is moved from the origin, the faster the cursor will move. The finger sensing capability of the system is used to detect when the puck is being touched, so that no drifting of the cursor occurs when the puck is not being touched. Because of this finger sense feature, almost no deadzone is required around the puck origin, enabling highly responsive navigation. Since the button can be clicked anywhere in the field of motion, joystick mode also supports one-handed drag and drop functionality.

Mouse Mode

In mouse mode the puck position directly corresponds to the cursor position, as it does with a traditional desktop computer mouse. This enables a highly responsive navigation experience if the puck has sufficient travel. When the puck is released the finger sensor suppresses further cursor motion. Even though the spring system returns the puck to the origin, the cursor remains where it was when the puck was last touched. This allows for "skating", as with a desktop mouse.

The difference between joystick and mouse modes can be understood with the following example. Suppose the user moves the puck with constant velocity from the center position to the uppermost position, holds it there for a moment, and then releases the puck. In joystick mode the cursor will move upwards with increasing velocity (as the puck radius increases), and then continue to move at the final velocity while the puck is held stationary at the perimeter. When the puck is released, the cursor stops moving. In mouse mode, the cursor will move upwards with the puck at constant velocity. As soon as the puck stops moving the cursor will also stop moving. When the puck is released, the springs will cause it to re-center, but the cursor will remain stationary.

Rocker Mode

In rocker mode digital signals for up, down, left and right are generated when the puck moves from the center position beyond a pre-determined radius. The next signal is generated when the puck has returned inside this radius and crosses it again moving outward. A series of upward gestures with the puck will generate a series of steps up through a list or icons, the same as repeatedly pressing the up key on a 5-way pad. Rocker mode supports a fully configurable auto-repeat feature if the puck is held at the perimeter. Rocker mode can also be configured for 8-way motion.

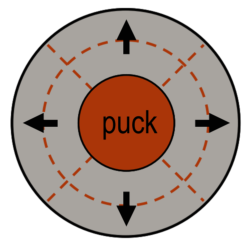


Figure 3. Illustration of 4-way rocker mode algorithm.

Scroll Mode

In scroll mode if the puck is translated in a circular motion (outside a predetermined radius) the AMRI-2000 will output a series of signals to step up or down through a list. This gives a user the ability to rapidly navigate long menus, such as e-mail or song indexes. The number of steps per revolution is user-configurable, as is the scroll direction and the initial angular change to start scrolling.

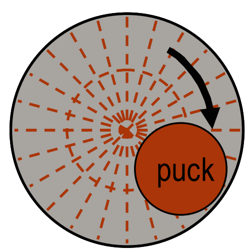


Figure 4. Illustration of 2-D scroll mode algorithm.

A variation on scroll mode is 2D scroll mode, in which the AMRI-2000 can be used to scroll either vertically or horizontally through a 2-D matrix of icons. The initial radial gestures sets whether the scrolling will be horizontal or vertical.

Scroll mode and rocker mode can both be active simultaneously. Radial gestures will cause 4-way or 8-way stepping as normal, but if the user begins moving in a circular motion, scrolling will automatically begin.

Table 1. Pinout

Pin	Pin Name	SPI	Two-Wire interface (TWI)	I/O	Description
1	IO_CLK	SCLK(I)	SCL (I)	I	Serial clock signal
2	IO_MISO_SDA	MISO(O)	SDA (IO)	I/O	TWI mode: SDA (Serial data) signal SPI mode: MISO (Master in Slave out) signal
3	IO_MOSI_A0	MOSI(I)	A0 (I)	I/O	Address select when used as TWI, addr[0], 3 states SPI mode: MOSI (Master out Slave in) signal
4	IO_NCS_A1	NCS (I)	A1 (I)	I	Address select when used as TWI, addr[1], 3 states SPI mode: nCS (Chip select) signal
5	Reserved			I	Connect to VDDD
6	Reserved			I	Connect to Ground
7	Reserved			O	No Connection
8	Reserved			I	Connect to Ground
9	Reserved			O	No Connection
10	MOTION			O	Motion interrupt pin
11	VDDD			P	Supply voltage for logic interface
12	Drive			O	Analog Drive to center electrode
13	GND			P	Connect to Ground
14	Reserved			A	No connection
15	SLIDER_SENSE1			A	Analog Sense
16	SLIDER_SENSE2			A	Analog Sense
17	SLIDER_SENSE3			A	Analog Sense
18	SLIDER_SENSE4			A	Analog Sense
19	VDDA			P	VDDA
20	GND			P	Connect to ground
21	NRST_NSHD			I	Reset and shutdown
22	RESERVED			P	Connect to ground
23	RESERVED			P	Connect to ground
24	IO_SELECT			I/O	SPI/TWI Select High = SPI

Note: I/O = digital input/output A = analog P = power

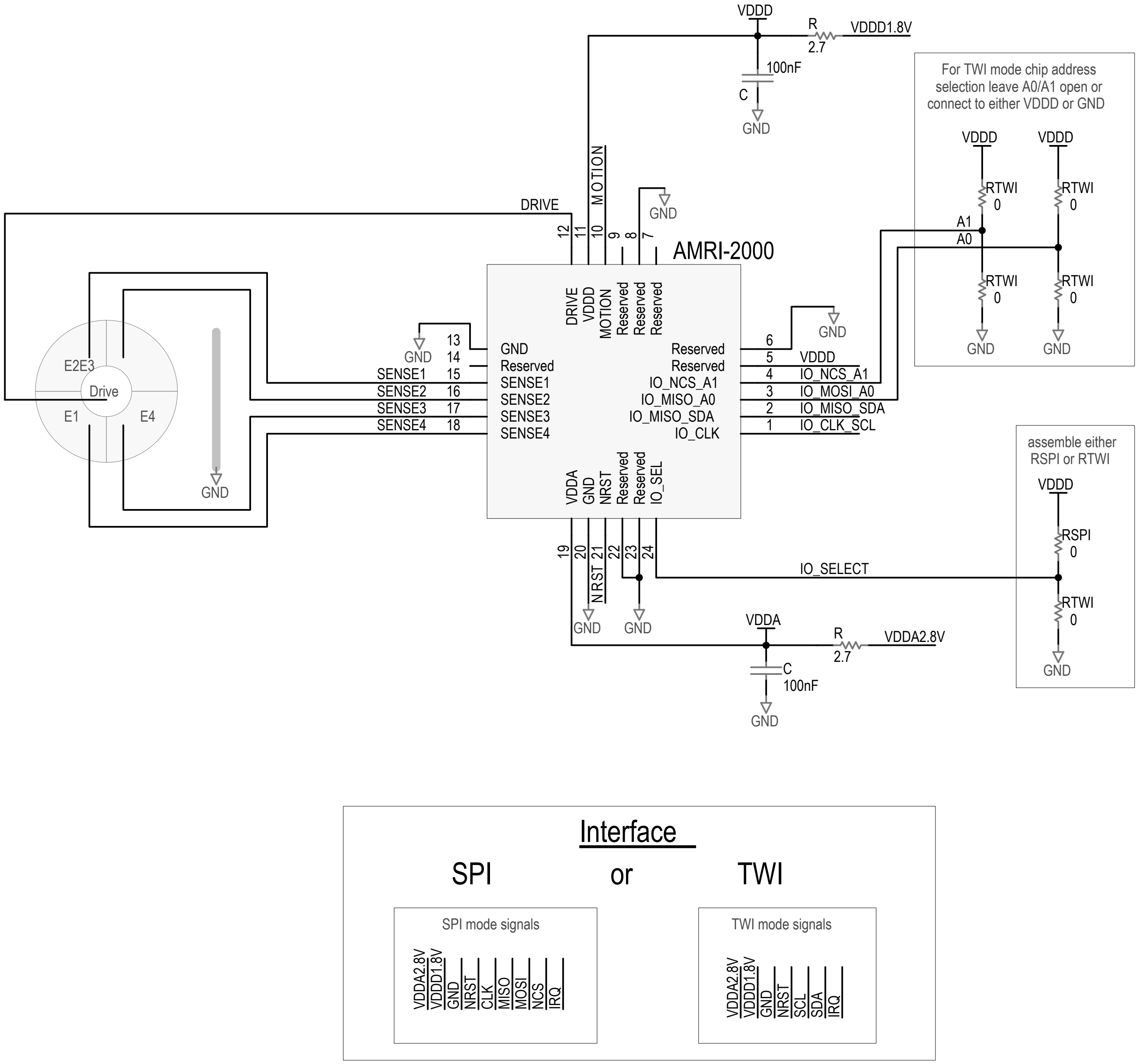
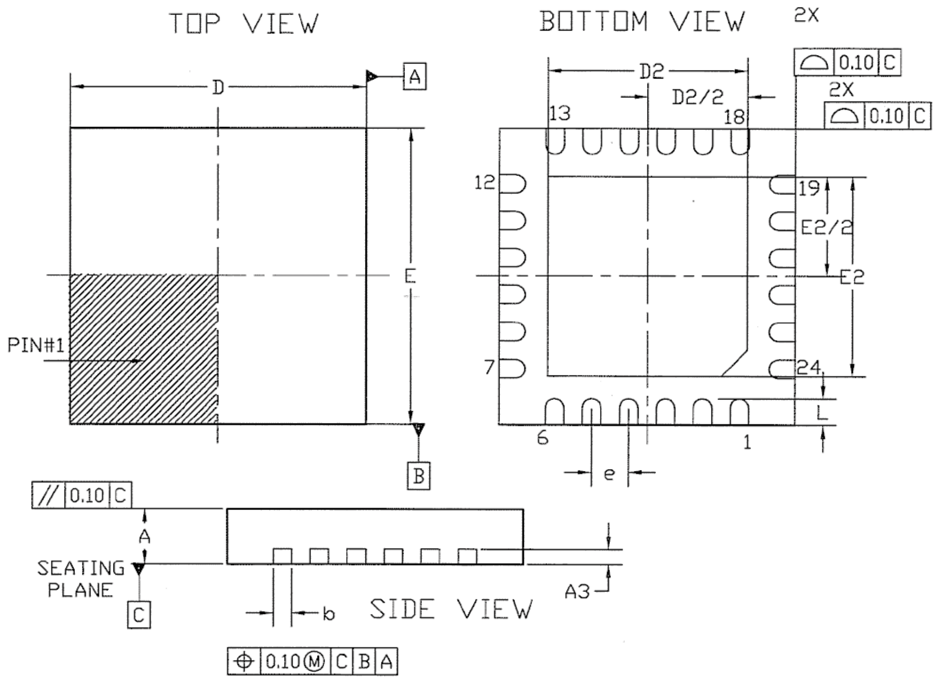


Figure 5. AMRI-2000 recommended schematic

IC Package (TQFN) and connections to navigation pad



SYMBOL	COMMON					
	DIMENSIONS MILIMETER			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.700	0.750	0.800	0.027	0.029	0.031
A3	0.1950	0.2030	0.2110	0.0077	0.0080	0.0083
b	0.1800	0.2300	0.3000	0.0070	0.0090	0.0120
D	3.9250	4.0000	4.0750	0.1540	0.1570	0.1600
E	3.9250	4.0000	4.0750	0.1540	0.1570	0.1600
e	0.500 BSC			0.020 BSC		
L	0.3000	0.3500	0.4000	0.1200	0.1400	0.1600

Figure 6. IC Dimensions (bottom and side view)

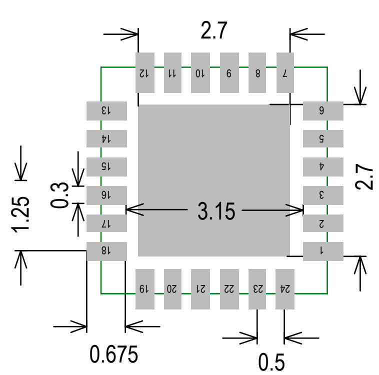


Figure 7. Recommended solder pad pitch and dimensions

Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Units	Notes
Storage Temperature	T_S	-40	85	°C	
Operating Temperature	T_A	-25	70	°C	
Supply Voltage	V_{DDA}	-0.5	3.6	V	
ESD			2000	V	All pins, human body model MIL 883 Method 3015
Input Voltage Transients	V_{TR}		+/- 0.3V	V	
I/O voltage	V_{IO}		V_{DDD} +0.3V	V	
Lead Solder Temp			260	°C	

Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Operating Temperature	T_A	-25		70	°C	
Power supply voltage	V_{DDA}	2.5	2.8	3.6	Volts	
I/O supply voltage	V_{DDD}	1.62	1.8	1.98	Volts	I/Os must be below V_{DDD}
Supply noise	V_N			50	mV	Peak to peak within 0-1 MHz bandwidth

DC Electrical Specifications

Electrical Characteristics over recommended operating conditions. (Typical values at 25 °C, V_{DDA} = 2.8 V, V_{DDD} = 1.8V Default register values)

Parameter		Symbol	Minimum	Typical	Maximum	Units	Notes
System Current, run mode		I_{DD5}		2.3	5.3	mA	NAVG = 0x20
System current, rest modes		I_{REST}				mA	See 'Rest mode' section
	Rest1			1.5	3.4	mA	Wakeup time ~20ms, Register 0x26 set to 0x05
	Rest2			0.3	0.6	mA	Wakeup time ~100ms, Register 0x2A default value 0x1D
	Rest3			0.07	0.17	mA	Wakeup time ~1s, Register 0x2E default value 0xFF
System Current, shutdown		I_{DD5N}		25	170	µA	
Resolution		RES	TBD	TBD		counts	
Input/Output Levels	Input High Voltage	V_{IH}	-0.6		0.3	V	Voltage is relative to V_{DDD} (0.65 V_{DDD} per Jedec87)
	Input Low Voltage	V_{IL}	-0.3		0.6	V	Voltage is relative to ground (0.35 GND per Jedec87)
	Output High Voltage	V_{OH}	-0.2		0	V	Voltage is relative to V_{DDD} (per Jedec87)
	Output Low Voltage	V_{OL}	0		0.2	V	Voltage is relative to ground (per Jedec87)
	Output Low Current	I_{OL}	-1.2			mA	at V_{OL}
	Output High Current	I_{OH}	0.6			mA	at V_{OH}
Input Leakage Current				1.9	9.4	µA	
Input Offstate Leakage Current				0.02	0.04	µA	

AC Electrical Specifications

Electrical Characteristics over recommended operating conditions. Typical values at 25 °C, V_{DDA}=2.8 V

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Power up delay	T_{PUP}			25	ms	From the time VDDA reaches 2.8V until normal operation
Motion refresh rate	$F_{REFRESH}$			250	Hz	
Two-Wire Interface Speed				400	kHz	
4-wire SPI Interface speed				2	MHz	

SPI Interface Specifications

Parameter	Symbol	Min.	Typical	Max.	Unit	Comment
SPI port clock frequency	S_{CLK}			2	MHz	50% duty cycle
MISO rise time	$t_{r\text{-}MISO}$		150		ns	CL = 100pF
MISO fall time	$t_{f\text{-}MISO}$		150		ns	CL = 100pF
MISO delay after SCLK	$t_{DLY\text{-}MISO}$			120	ns	From SCLK falling edge to MISO data valid, no load conditions
MISO hold time	$t_{hold\text{-}MISO}$	0.25		1/fSCLK	µs	Data held until next falling SCLK edge
MOSI hold time	$t_{hold\text{-}MOSI}$	200			ns	Amount of time data is valid after SCLK rising edge
MOSI setup time	$t_{setup\text{-}MOSI}$	120			ns	From data valid to SCLK rising edge
SPI read address-data delay	$t_{s\text{-}RAD}$	4			µs	From rising SCLK for last bit of the address byte, to falling SCLK for first bit of data being read.
NCS to SCLK active	$t_{NCS\text{-}SCLK}$	200			ns	From NCS falling edge to first SCLK rising edge
SCLK to NCS inactive (for read operation)	$t_{SCLK\text{-}NCS}$	120			ns	From last SCLK rising edge to NCS rising edge, for valid MISO data transfer
SCLK to NCS inactive (for write operation)	$t_{SCLK\text{-}NCS}$	20			µs	From last SCLK rising edge to NCS rising edge, for valid MOSI data transfer
NCS to MISO high-Z	$t_{NCS\text{-}MISO}$			500	ns	From NCS rising edge to MISO high-Z state

TWI Interface Specifications

Parameter	Symbol	Min.	Max.	Unit
SCL clock frequency	f_{SCL}		400	kHz
Hold time (repeated) START condition. After this period the first clock pulse is generated.	$t_{HD:STA}$	0.6	—	—
LOW period of the SCL clock	t_{LOW}	1.3	—	µs
HIGH period of the SCL clock	t_{HIGH}	0.6	—	µs
Set-up time for a repeated START condition	$t_{SU:STA}$	0.6	—	µs
Data hold time for CBUS compatible masters (see NOTE, section 10.1.3 for I2C compatible devices)	$t_{HD:DAT}$	— 0(2)	— 0.9(3)	µs µs
Data set-up time	$t_{SU:DAT}$	100		ns
Rise time of both SDA and SCL signals	t_r	20+0.1Cb(5)	300	ns
Fall time of both SDA and SCL signals	t_f	20+0.1Cb(5)	300	ns
Set-up time for STOP condition	$t_{SU:STO}$	0.6	—	µs
Bus free time between a STOP and START condition	t_{BUF}	1.3	—	µs
Capacitive load for each bus line	C_b	—	400	pF
Noise margin at the LOW level for each connected device (including hysteresis)	V_{nL}	0.1VDDD	—	V
Noise margin at the HIGH level for each connected device (including hysteresis)	V_{nH}	0.2VDDD	—	V

Notes:
1. All values referred to V_{IHmin} and V_{ILmax} levels (see Table 4)
2. A device must internally provide a hold time of at least 300 ns for the SDA signal (referred to the V_{IHmin} of the SCL signal) to bridge the undefined region of the falling edge of SCL.
3. The maximum $t_{HD:DAT}$ has only to be met if the device does not stretch the LOW period (t_{LOW}) of the SCL signal.
4. A fast-mode I^2C-bus device can be used in a standard-mode I^2C-bus system, but the requirement $t_{SU:DAT} \geq 250$ ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line $t_{rMAX} + t_{SU:DAT} = 1000 + 250 = 1250$ ns (according to the standard-mode I^2C-bus specification) before the SCL line is released.

***WARNING**: These devices are Electrostatic Discharge (ESD) sensitive. The following precautions are strongly recommended. Ensure that an ESD approved carrier is used when units are transported from one destination to another. Personal grounding is to be worn at all times handling these devices. Failure to observe proper ESD handling precautions will void warranties. Refer to Avago Application Note A004R: Electrostatic Discharge Damage and Control.*

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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