



bq4016/bq4016Y

1024Kx8 Nonvolatile SRAM

Features

- Data retention in the absence of power
- Automatic write-protection during power-up/power-down cycles
- Conventional SRAM operation; unlimited write cycles
- 10-year minimum data retention in absence of power
- Battery internally isolated until power is applied

General Description

The CMOS bq4016 is a nonvolatile 8,388,608-bit static RAM organized as 1,048,576 words by 8 bits. The integral control circuitry and lithium energy source provide reliable non-volatility coupled with the unlimited write cycles of standard SRAM.

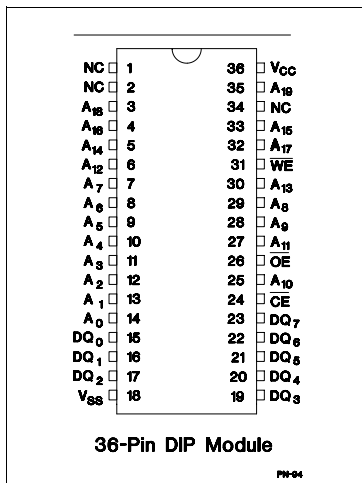
The control circuitry constantly monitors the single 5V supply for an out-of-tolerance condition. When VCC falls out of tolerance, the SRAM is unconditionally write-protected to prevent an inadvertent write operation.

At this time the integral energy source is switched on to sustain the memory until after VCC returns valid.

The bq4016 uses extremely low standby current CMOS SRAMs, coupled with a small lithium coin cell to provide nonvolatility without long write-cycle times and the write-cycle limitations associated with EEPROM.

The bq4016 has the same interface as industry-standard SRAMs and requires no external circuitry.

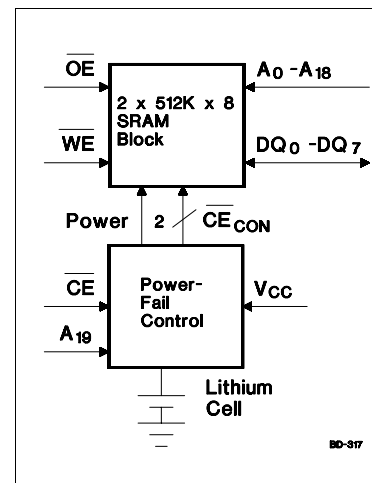
Pin Connections



Pin Names

- A₀-A₁₉ Address inputs
- DQ₀-DQ₇ Data input/output
- $\overline{\text{CE}}$ Chip enable input
- $\overline{\text{OE}}$ Output enable input
- $\overline{\text{WE}}$ Write enable input
- VCC +5 volt supply input
- VSS Ground
- NC No connect

Block Diagram



Selection Guide

Part Number	Maximum Access Time (ns)	Negative Supply Tolerance	Part Number	Maximum Access Time (ns)	Negative Supply Tolerance
bq4016MC -70	70	-5%	bq4016YMC -70	70	-10%

bq4016/bq4016Y

Functional Description

When power is valid, the bq4016 operates as a standard CMOS SRAM. During power-down and power-up cycles, the bq4016 acts as a nonvolatile memory, automatically protecting and preserving the memory contents.

Power-down/power-up control circuitry constantly monitors the V_{CC} supply for a power-fail-detect threshold V_{PFD} . The bq4016 monitors for $V_{PFD} = 4.62V$ typical for use in systems with 5% supply tolerance. The bq4016Y monitors for $V_{PFD} = 4.37V$ typical for use in systems with 10% supply tolerance.

When V_{CC} falls below the V_{PFD} threshold, the SRAM automatically write-protects the data. All outputs become high impedance, and all inputs are treated as "don't care." If a valid access is in process at the time of power-fail detection, the memory cycle continues to completion. If the memory cycle fails to terminate within time t_{WPT} , write-protection takes place.

As V_{CC} falls past V_{PFD} and approaches 3V, the control circuitry switches to the internal lithium backup supply, which provides data retention until valid V_{CC} is applied.

When V_{CC} returns to a level above the internal backup cell voltage, the supply is switched back to V_{CC} . After V_{CC} ramps above the V_{PFD} threshold, write-protection continues for a time t_{CER} (120ms maximum) to allow for processor stabilization. Normal memory operation may resume after this time.

The internal coin cells used by the bq4016 have an extremely long shelf life. The bq4016 provides data retention for more than 10 years in the absence of system power.

As shipped from Benchmarq, the integral lithium cells are electrically isolated from the memory. (Self-discharge in this condition is approximately 0.5% per year.) Following the first application of V_{CC} , this isolation is broken, and the lithium backup provides data retention on subsequent power-downs.

Truth Table

Mode	\overline{CE}	\overline{WE}	\overline{OE}	I/O Operation	Power
Not selected	H	X	X	High Z	Standby
Output disable	L	H	H	High Z	Active
Read	L	H	L	DOUT	Active
Write	L	L	X	DIN	Active

Absolute Maximum Ratings

Symbol	Parameter	Value	Unit	Conditions
V_{CC}	DC voltage applied on V_{CC} relative to V_{SS}	-0.3 to 7.0	V	
V_T	DC voltage applied on any pin excluding V_{CC} relative to V_{SS}	-0.3 to 7.0	V	$V_T \leq V_{CC} + 0.3$
T_{OPR}	Operating temperature	0 to +70	°C	
T_{STG}	Storage temperature	-40 to +70	°C	
T_{BIAS}	Temperature under bias	-10 to +70	°C	
T_{SOLDER}	Soldering temperature	+260	°C	For 10 seconds

Note: Permanent device damage may occur if **Absolute Maximum Ratings** are exceeded. Functional operation should be limited to the Recommended DC Operating Conditions detailed in this data sheet. Exposure to conditions beyond the operational limits for extended periods of time may affect device reliability.

bq4016/bq4016Y

Recommended DC Operating Conditions (T_A = 0 to 70°C)

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Notes
V _{CC}	Supply voltage	4.5	5.0	5.5	V	bq4016Y
		4.75	5.0	5.5	V	bq4016
V _{SS}	Supply voltage	0	0	0	V	
V _{IL}	Input low voltage	-0.3	-	0.8	V	
V _{IH}	Input high voltage	2.2	-	V _{CC} + 0.3	V	

Note: Typical values indicate operation at T_A = 25°C.

DC Electrical Characteristics (T_A = 0 to 70°C, V_{CCmin} ≤ V_{CC} ≤ V_{CCmax})

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Conditions/Notes
I _{LI}	Input leakage current	-	-	± 2	μA	V _{IN} = V _{SS} to V _{CC}
I _{LO}	Output leakage current	-	-	± 2	μA	$\overline{CE} = V_{IH}$ or $\overline{OE} = V_{IH}$ or $\overline{WE} = V_{IL}$
V _{OH}	Output high voltage	2.4	-	-	V	I _{OH} = -1.0 mA
V _{OL}	Output low voltage	-	-	0.4	V	I _{OL} = 2.1 mA
I _{SB1}	Standby supply current	-	5	12	mA	$\overline{CE} = V_{IH}$
I _{SB2}	Standby supply current	-	2.5	5	mA	0V ≤ V _{IN} ≤ 0.2V, $\overline{CE} \geq V_{CC} - 0.2V$, or V _{IN} ≥ V _{CC} - 0.2
I _{CC}	Operating supply current	-	75	115	mA	Min. cycle, duty = 100%, $\overline{CE} = V_{IL}$, I _{I/O} = 0mA, A19 < V _{IL} or A19 > V _{IH} ,
V _{PF_D}	Power-fail-detect voltage	4.55	4.62	4.75	V	bq4016
		4.30	4.37	4.50	V	bq4016Y
V _{SO}	Supply switch-over voltage	-	3	-	V	

Note: Typical values indicate operation at T_A = 25°C, V_{CC} = 5V.

bq4016/bq4016Y

Capacitance (T_A = 25°C, F = 1MHz, V_{CC} = 5.0V)

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Conditions
C _{I/O}	Input/output capacitance	-	-	20	pF	Output voltage = 0V
C _{IN}	Input capacitance	-	-	20	pF	Input voltage = 0V

Note: These parameters are sampled and not 100% tested.

AC Test Conditions

Parameter	Test Conditions
Input pulse levels	0V to 3.0V
Input rise and fall times	5 ns
Input and output timing reference levels	1.5 V (unless otherwise specified)

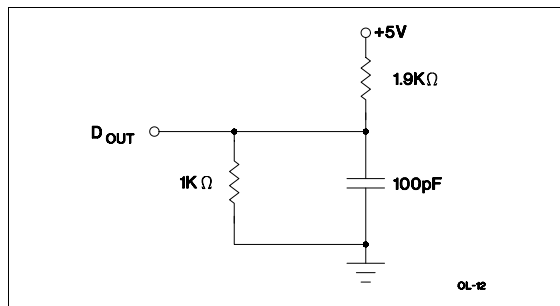


Figure 1. Output Load A

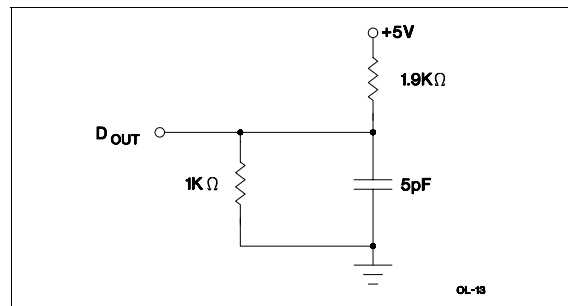


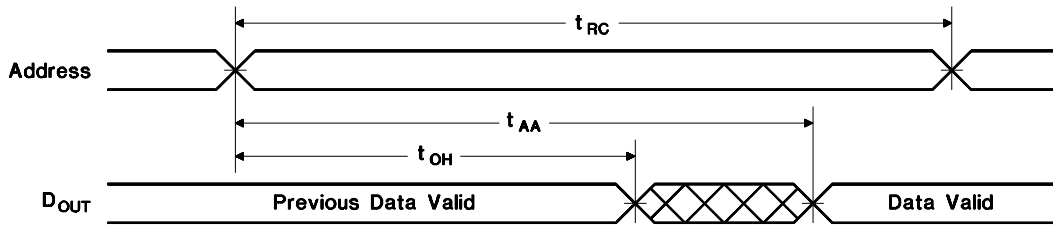
Figure 2. Output Load B

Read Cycle (T_A = 0 to 70°C, V_{CCmin} ≤ V_{CC} ≤ V_{CCmax})

Symbol	Parameter	-70		Unit	Conditions
		Min.	Max.		
t _{RC}	Read cycle time	70	-	ns	
t _{AA}	Address access time	-	70	ns	Output load A
t _{ACE}	Chip enable access time	-	70	ns	Output load A
t _{OE}	Output enable to output valid	-	35	ns	Output load A
t _{CLZ}	Chip enable to output in low Z	5	-	ns	Output load B
t _{OLZ}	Output enable to output in low Z	5	-	ns	Output load B
t _{CHZ}	Chip disable to output in high Z	0	25	ns	Output load B
t _{OHZ}	Output disable to output in high Z	0	25	ns	Output load B
t _{OH}	Output hold from address change	10	-	ns	Output load A

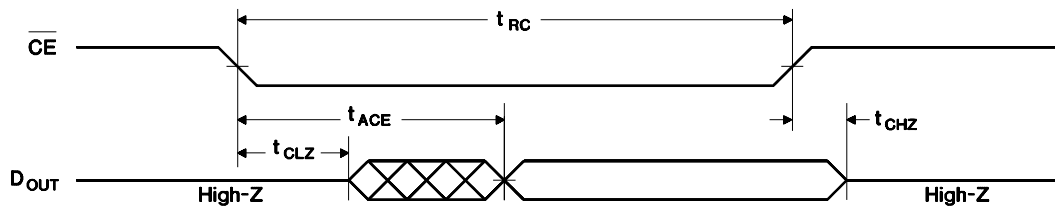
Sept. 1996 B

Read Cycle No. 1 (Address Access) ^{1,2}



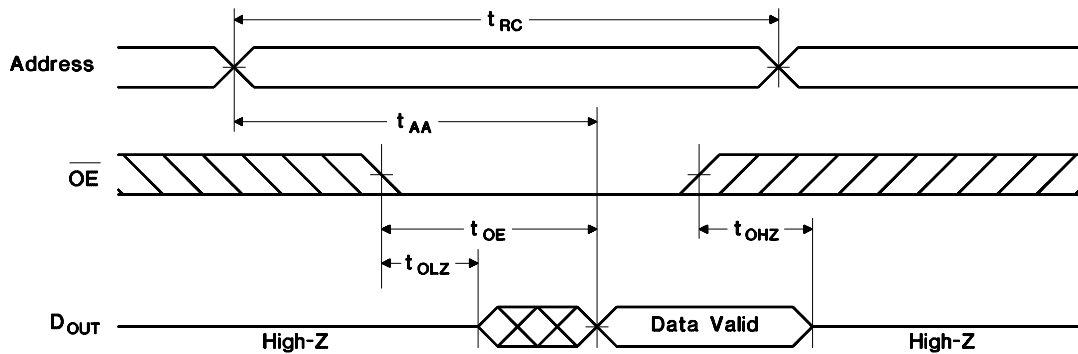
RC-1

Read Cycle No. 2 ($\overline{\text{CE}}$ Access) ^{1,3,4}



RC-2

Read Cycle No. 3 ($\overline{\text{OE}}$ Access) ^{1,5}



RC-3

- Notes:**
1. $\overline{\text{WE}}$ is held high for a read cycle.
 2. Device is continuously selected: $\overline{\text{CE}} = \overline{\text{OE}} = V_{\text{IL}}$.
 3. Address is valid prior to or coincident with $\overline{\text{CE}}$ transition low.
 4. $\overline{\text{OE}} = V_{\text{IL}}$.
 5. Device is continuously selected: $\overline{\text{CE}} = V_{\text{IL}}$.

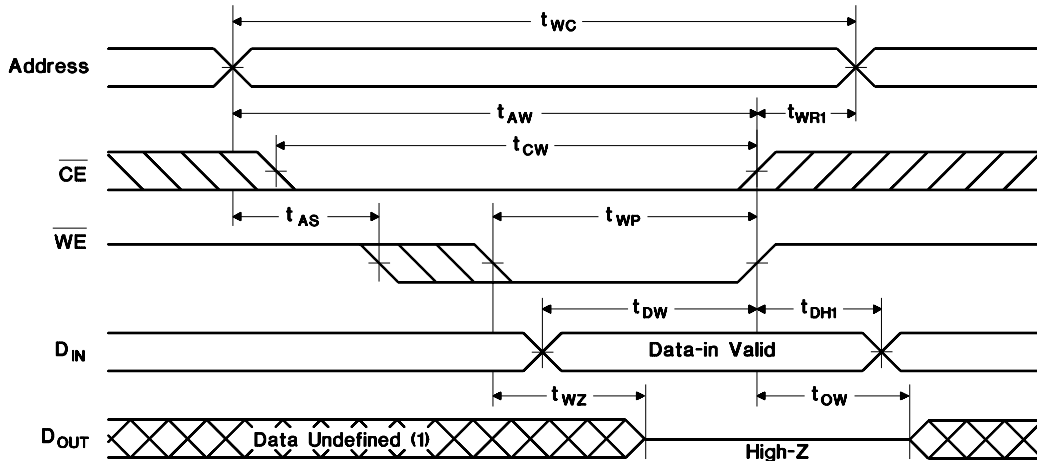
bq4016/bq4016Y

Write Cycle (TA = 0 to 70°C, VCCmin ≤ VCC ≤ VCCmax)

Symbol	Parameter	-70		Units	Conditions/Notes
		Min.	Max.		
tWC	Write cycle time	70	-	ns	
tCW	Chip enable to end of write	65	-	ns	(1)
tAW	Address valid to end of write	65	-	ns	(1)
tAS	Address setup time	0	-	ns	Measured from address valid to beginning of write. (2)
tWP	Write pulse width	55	-	ns	Measured from beginning of write to end of write. (1)
tWR1	Write recovery time (write cycle 1)	5	-	ns	Measured from \overline{WE} going high to end of write cycle. (3)
tWR2	Write recovery time (write cycle 2)	15	-	ns	Measured from \overline{CE} going high to end of write cycle. (3)
tDW	Data valid to end of write	30	-	ns	Measured to first low-to-high transition of either CE or WE.
tDH1	Data hold time (write cycle 1)	0	-	ns	Measured from \overline{WE} going high to end of write cycle. (4)
tDH2	Data hold time (write cycle 2)	10	-	ns	Measured from \overline{CE} going high to end of write cycle. (4)
tWZ	Write enabled to output in high Z	0	25	ns	I/O pins are in output state. (5)
tOW	Output active from end of write	5	-	ns	I/O pins are in output state. (5)

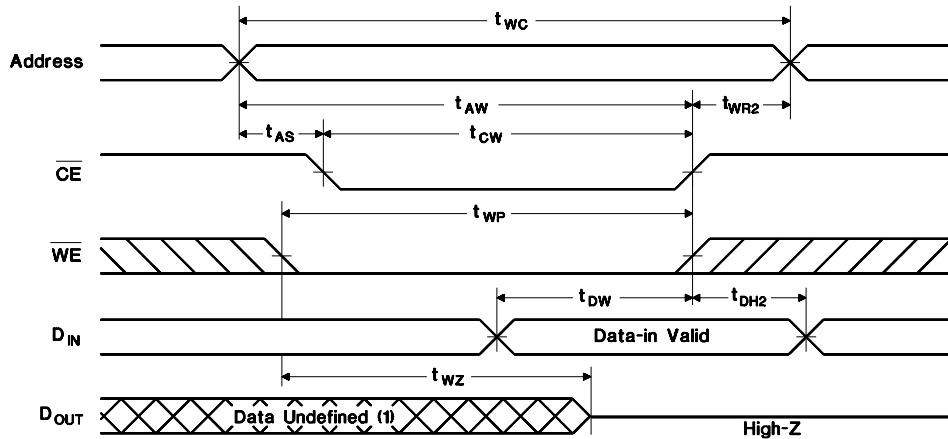
- Notes:**
1. A write ends at the earlier transition of \overline{CE} going high and \overline{WE} going high.
 2. A write occurs during the overlap of a low \overline{CE} and a low \overline{WE} . A write begins at the later transition of \overline{CE} going low and \overline{WE} going low.
 3. Either tWR1 or tWR2 must be met.
 4. Either tDH1 or tDH2 must be met.
 5. If \overline{CE} goes low simultaneously with \overline{WE} going low or after \overline{WE} going low, the outputs remain in high-impedance state.

Write Cycle No. 1 (\overline{WE} -Controlled) ^{1,2,3}



WC-3

Write Cycle No. 2 (\overline{CE} -Controlled) ^{1,2,3,4,5}



WC-4

- Notes:**
1. \overline{CE} or \overline{WE} must be high during address transition.
 2. Because I/O may be active (\overline{OE} low) during this period, data input signals of opposite polarity to the outputs must not be applied.
 3. If \overline{OE} is high, the I/O pins remain in a state of high impedance.
 4. Either t_{WR1} or t_{WR2} must be met.
 5. Either t_{DH1} or t_{DH2} must be met.

bq4016/bq4016Y

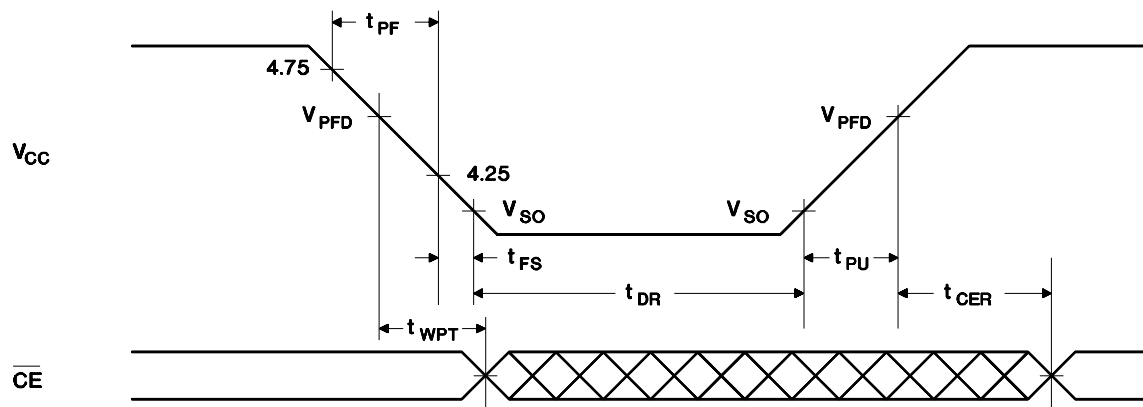
Power-Down/Power-Up Cycle ($T_A = 0$ to 70°C)

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Conditions
t_{PF}	V_{CC} slew, 4.75 to 4.25 V	300	-	-	μs	
t_{FS}	V_{CC} slew, 4.25 to V_{SO}	10	-	-	μs	
t_{PU}	V_{CC} slew, V_{SO} to V_{PFD} (max.)	0	-	-	μs	
t_{CER}	Chip enable recovery time	40	80	120	ms	Time during which SRAM is write-protected after V_{CC} passes V_{PFD} on power-up.
t_{DR}	Data-retention time in absence of V_{CC}	10	-	-	years	$T_A = 25^\circ\text{C}$. (2)
t_{WPT}	Write-protect time	40	100	150	μs	Delay after V_{CC} slews down past V_{PFD} before SRAM is write-protected.

- Notes:**
1. Typical values indicate operation at $T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{V}$.
 2. Batteries are disconnected from circuit until after V_{CC} is applied for the first time. t_{DR} is the accumulated time in absence of power beginning when power is first applied to the device.

Caution: Negative undershoots below the absolute maximum rating of -0.3V in battery-backup mode may affect data integrity.

Power-Down/Power-Up Timing



PD-B

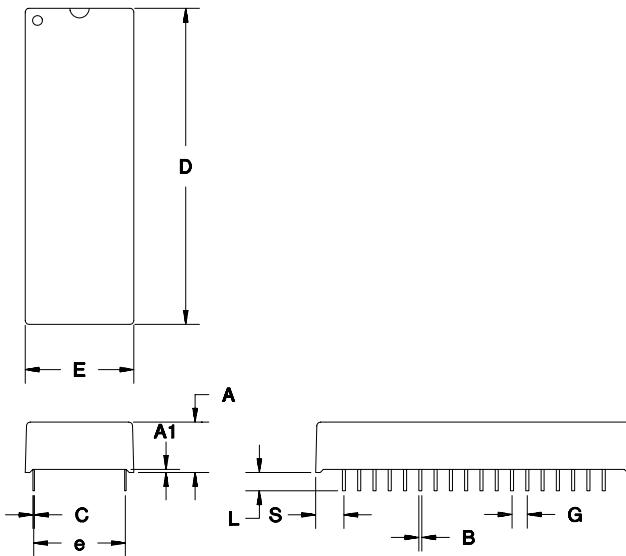
Sept. 1996 B

Data Sheet Revision History

Change No.	Page No.	Description
1	All	Changed from "Preliminary" to "Final" data sheet

Notes: Change 1 = Sept 1996 B changes from June 1995.

MC: 36-Pin C-Type Module



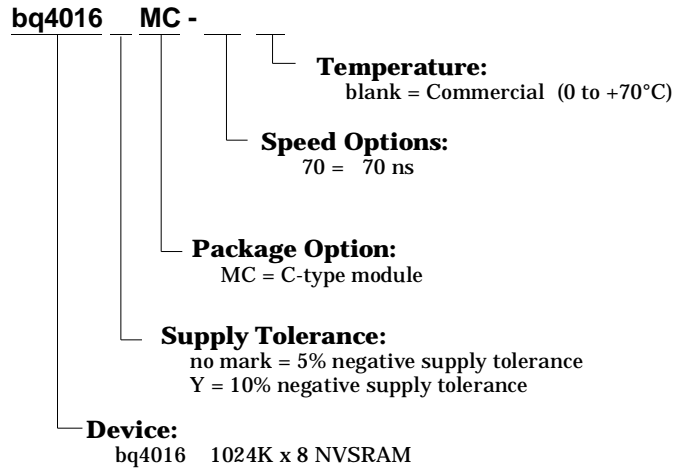
36-Pin MC (C-Type Module)

Dimension	Minimum	Maximum
A	0.365	0.375
A1	0.015	-
B	0.017	0.023
C	0.008	0.013
D	2.070	2.100
E	0.710	0.740
e	0.590	0.630
G	0.090	0.110
L	0.120	0.150
S	0.175	0.210

All dimensions are in inches.

bq4016/bq4016Y

Ordering Information



PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
BQ4016MC-70	NRND	DIP MOD ULE	MC	36	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
BQ4016YMC-70	NRND	DIP MOD ULE	MC	36	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

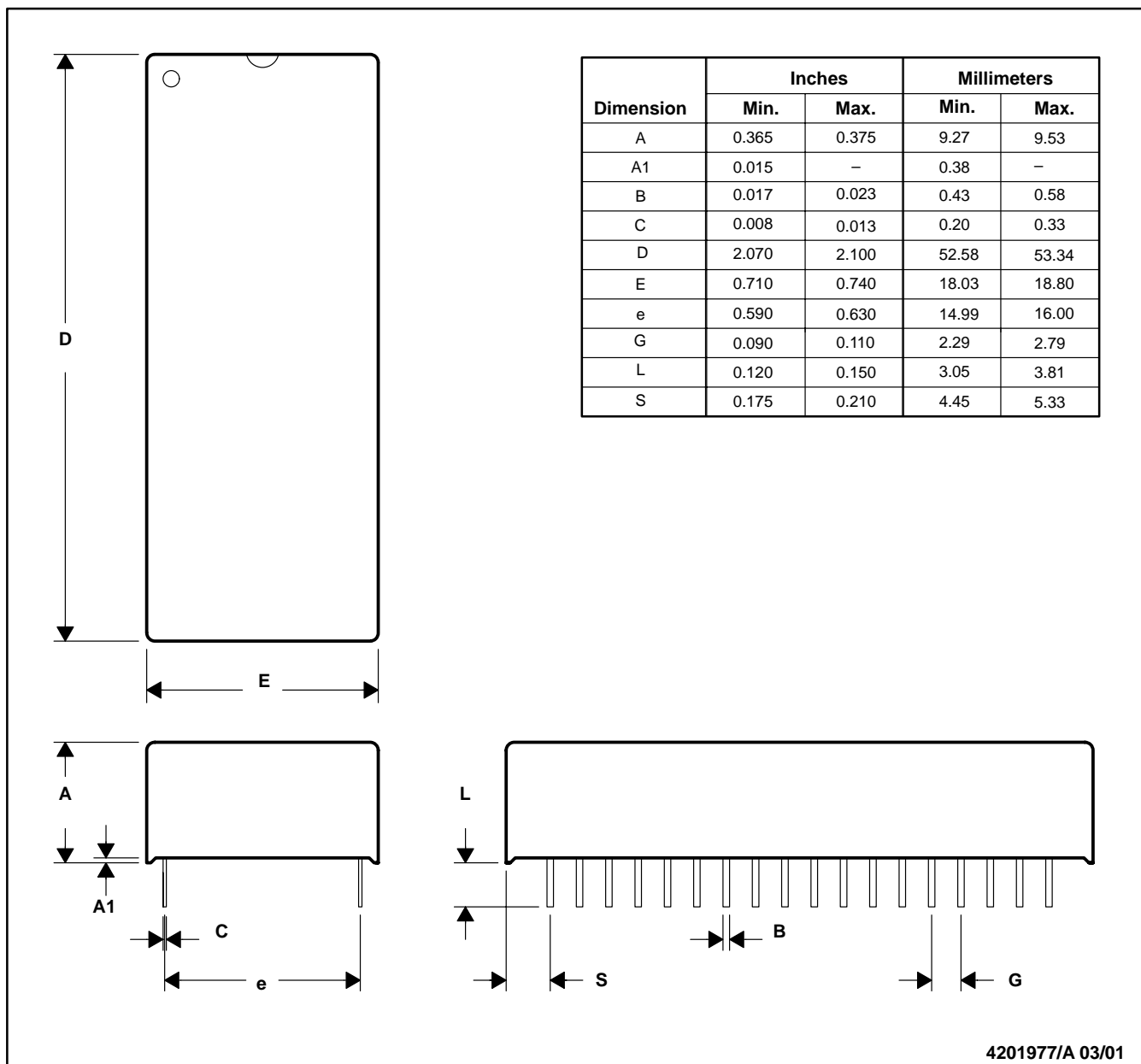
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

MC (R-PDIP-T36)

PLASTIC DUAL-IN-LINE



4201977/A 03/01

NOTES: A. All linear dimensions are in inches (mm).
 B. This drawing is subject to change without notice.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2009, Texas Instruments Incorporated