DOCUMENT NO. D-RBM256
REV. 1, FEBRUARY 1979

PART NUMBER
RBM256

Rockwell

BUBBLE MEMORY PRODUCTS DATA SHEET

256K-BIT BUBBLE MEMORY DEVICE

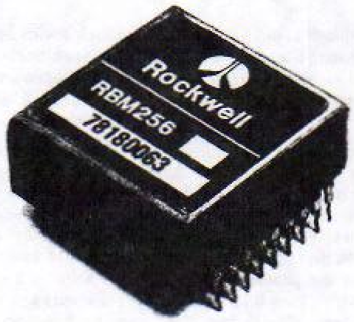
OVERVIEW

The Rockwell RBM256 bubble memory device stores 266,500 bits of data. It represents the latest advances in materials, architecture and packaging. Its reliability has been engineered on the basis of accelerated test data accumulated over a number of years.

The RBM256 is composed of 282 loops, each containing 1025 bubble positions. The device operates with a 260-bit data block, thus using only 260 of the available 282 loops. In a typical application binary data are stored in 256 loops and the remaining four loops are available to hold system "house-keeping" bits. Where eight RBM256 devices are used in parallel, the extra bits may be used to provide a 16-bit block address header and a 16-bit CRCC suffix.

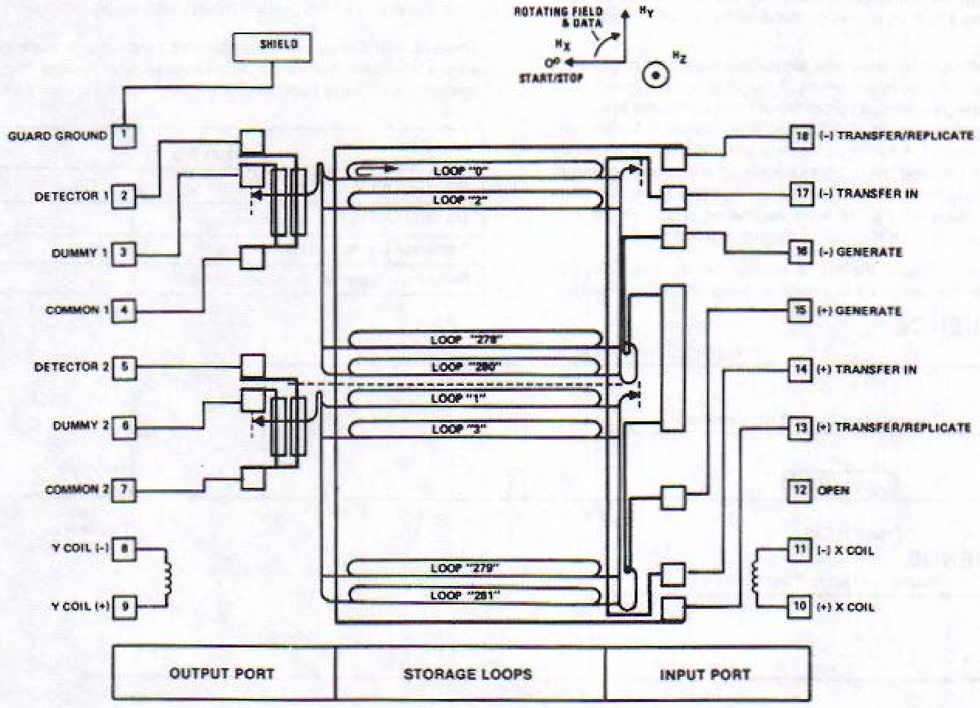
The RBM256 transfers data at 150 KHz, taking less than four milliseconds (average) to access the first bit of a block. Throughput is preserved during read operations with the device's replicate/read block architecture in which bubbles read at the detectors are actually duplicates of the loop-resident bubbles.

Packaged in an 18-pin, molded plastic DIP, the RBM256 occupies only 1.2 in. x 1.2 in. It consumes approximately one watt of power when operating; average power decreases dependent on duty cycle. The RBM256 offers −10°C to +70°C case temperature operation at 100 KHz and −10°C to +65°C case temperature operation at 150 KHz. Non-operating, non-volatile storage is −50°C to +100°C.



FEATURES

- Replicate/read block architecture
- 1025 blocks of 260 bits
- 150 KHz operation
- < 4 mS average access time
- 18-pin dual-in-line wide-track package; 0.1 inch pin centers
- Detector sensitivity:
  - > 2.2 mV/mA for a one
  - < 1.0 mV/mA for a zero
- −10°C to +65°C operation @ 150 KHz (case temp.)
- −10°C to +70°C operation @ 100 KHz (case temp.)
- −50°C to +100°C non-volatile, non-operating storage



256K-BIT BUBBLE MEMORY DEVICE

BUBBLE MEMORY PRODUCTS

FUNCTIONAL DESCRIPTION

The 256K-bit bubble device uses a block replicate access design, as shown in the architecture diagram. Data blocks are stored in the loops with the odd bits on one side of the die and the even bits on the other. A block is formed using the same relative bit position in each loop. Thus, there are as many blocks as bit/loops, and a block length equals the number of loops. Functionally the die is formed of three parts: a storage area composed of the loops, an output port composed of replicate/transfer switches and magnetoresistive detectors, and an input port composed of twin generators and a transfer-in switch. The loops are arranged as long, two bit wide recirculating registers. The ports are at half way points at either end of the loop. Surrounding the active area of the die is a guardrail composed so that bubbles can traverse only from the active area to the inactive area at the die edge.

Redundancy is utilized to increase yield and reduce device costs. 260 of the 282 minor loops are guaranteed to meet specifications. The host system must avoid writing bubbles into the bad loops and ignore any information read from them. Defective loops are identified during factory testing. A list of these is supplied with the device.

At the Output Port of the die, the loops are tangent to a series of replicate/transfer switches. When activated by the appropriate common current pulse, both the odd and even halves of a block of data are either replicated from or transferred out of the loops into a pair of read tracks. The valid information sites alternate with idle sites. The bubbles propagate along the read tracks to the detectors and then through the guardrail and out of the active die area. The number of steps from loop 0 to the detector (84 steps) and loop 1 to the detector (85 steps) differ by one. Thus, from the detectors continuous, interlaced data emerges.

Detection uses the magnetoresistive effect. The two sets of active and dummy detectors are connected in bridge configurations to give a high degree of noise cancellation. Each detector is composed of a 260 high stack of chevrons. In the detector, the "right circular cylindrical" domain is stretched into a "right elliptical cylindrical" domain that is the same width as a bubble, but as long as the 260 chevron stack. The flux from the stretched bubble interacts with the permalloy detector pattern and changes its resistance. The resistance change is translated into a difference signal by a current passing down the two identical detectors—the active detector containing the information (bubble or no bubble) and the dummy detector never containing a bubble. The dummy is placed in the adjacent chevron stack so that maximum matching occurs and any common mode noise is minimized. When a bubble moves to the dummy detector, that detector is not used.

A pair of generators, consisting of a single conductor path, generate serially blocks of data equal in length to the number of minor loops. The bubbles propagate along a pair of input tracks until the first bit in the block is opposite loop "0". On the odd side of the die, the second bit is opposite loop "1". A series of transfer switches are activated by a single current pulse and the bubbles are simultaneously transferred into the appropriate minor loops. The remaining bubbles — odd numbered bits from the even half or even numbered bits from the odd half — are subsequently shifted out through the guard rail.

Within the device package, the die is surrounded by two orthogonally wound coils that are used to create an electronically generated magnetic flux that forces all of the bubbles to advance one position for each 360° rotation.

Two orthogonal coils, X and Y, are driven 90° out of phase with X leading Y to provide a clockwise rotating magnetic field in the plane of the bubble device. This results in circulation of the magnetic domains around the device circuit loops and into proper orientation with the device operator circuit elements enabling read, write, transfer-in and transfer-replicate functions to be performed. The coils may be driven either continuously (within prescribed operating conditions) or in a stop-start intermittent mode without data loss.

Both X and Y coils can be driven from a common voltage supply with either sine, trapezoid or triangle current wave forms. A triangle drive is recommended as being most consistent with digital switching drivers.

Coil drive and electrical load data are listed in the data tables for triangle drive operation with field rates of 100 KHz and 150 KHz. Operation at other frequencies will result in appropriate proportional change in drive voltage requirements, AC resistance, and power dissipation.

Basic non-volatility is created by the use of permanent magnets arranged so that their flux is perpendicular to the surface of the die. This flux satisfies the stability criteria that permits right circular cylindrical domains (bubbles) to exist. The permanent magnets are chosen with a temperature coefficient that matches the bubble die so that the bubbles have nearly constant diameter over the temperature range.

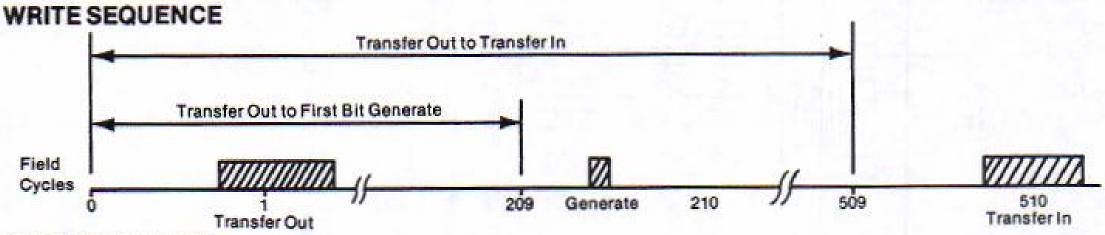
Non-volatility is guaranteed for data in the storage loops and the input port. Non-volatility of data in the output port is only assured during the uninterrupted completion of a block operation. Thus, an operation in the output port should not be interrupted. System timing should be arranged so that one complete rotational cycle is completed before a replication function is attempted.

The following shows the timing relationships between the different functions during the writing and reading of one block of data. The delays given are integral numbers of drive field cycles measured from the 0° drive field reference point just preceding the first function, to the 0° reference point just prior to the second function. Timing of a function within a field cycle is listed in the electrical characteristics.

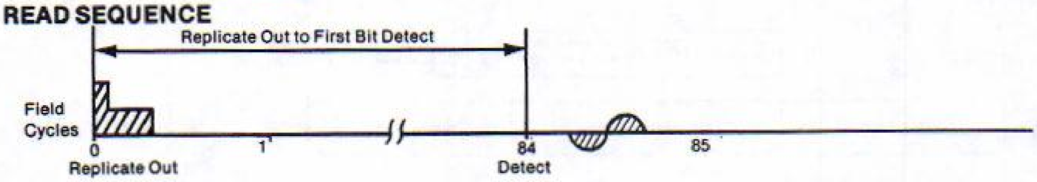
There is also a minimum delay between successive replicate-out and a transfer-out (or vice versa). This is necessary to insure that the major track is clear of any bubbles prior to the transfer or replicate function.

DELAYS	
Transfer Out to First Bit Generate	209
Transfer Out to Transfer In	509
Replicate Out to First Bit Detect	84
Repetitive Transfer/Replicate Operator	282

WRITE SEQUENCE



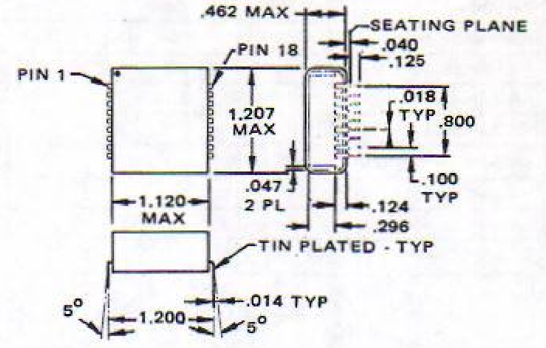
READ SEQUENCE



GENERAL PARAMETERS

Number of minor loops: 282
Useable minor loops: 260
Minor loop bits: 1,025
Useful chip bits: 266,500
Mounting footprint: (1.2 in)^2
Weight: 36 gm

RBM256 PACKAGE



ABSOLUTE MAXIMUM RATINGS

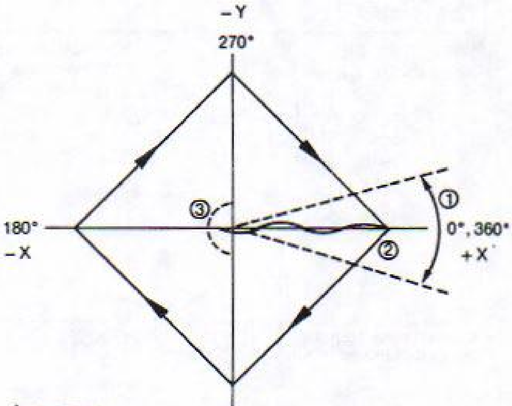
Parameter	Min.	Typical	Max.	Units
Storage Temperature	−55		+125	°C
Non-Volatile Storage Temperature	−50		+100	°C
Operating Temperature (Case) @ 100 KHz @ 150 KHz	 −10 −10		 +70 +65	 °C °C
Generator Dissipation		20*	60Δ	mW
Transfer-In Dissipation		0.75*	200Δ	mW
Replicate/Transfer Dissipation		1.7*	200Δ	mW
Detector Element Dissipation (4/Device)		35	150Δ	mW
Interelement Voltage			100	V
Relative Humidity			95	%
External Magnetic Fields			50	Oe

*Normal operation averaged over a block transaction.
ΔContinuous long-term dissipation without damage.

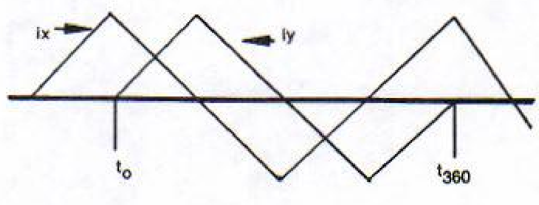
DRIVE INFORMATION

Parameter	Field Rate 100 KHz	Field Rate 150 KHz	Units
Start/Stop Direction ①	0 ± 20	0 ± 20	Deg.
Peak Drive Field②	55 ± 5	55 ± 5	Oe
Stop Undershoot (Max) ③	1.0	1.0	Oe
Coil Differential Voltage	11 ± 0.4	16 ± 0.4	V
Coil Power Loss	0.72	0.90	W
X-Coil			
Inductance	44 ± 2	44 ± 2	μH
DC Resistance	3.9	3.9	Ω
AC Resistance	3.5	4.5	Ω
Peak Current	0.54	0.54	A
Loss	0.40	0.46	W
Y-Coil			
Inductance	38 ± 2	38 ± 2	μH
DC Resistance	1.6	1.6	Ω
AC Resistance	2.2	3.0	Ω
Peak Current	0.65	0.65	A
Loss	0.32	0.44	W
Bias Field	155	155	Oe
Bias Margin (Min)	8	8	Oe

Note: All values nominal unless otherwise specified



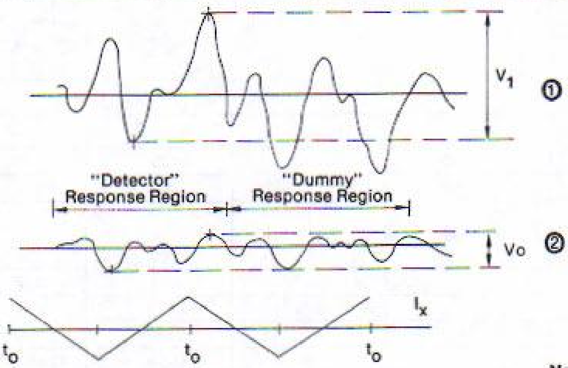
Drive Field Signal Definitions



BUBBLE MEMORY PRODUCTS

DETECTOR INFORMATION

Parameter	Min.	Nom.	Max.	Units
Resistance, Active	1000	1200	1400	Ω
Resistance, Dummy	1000	1200	1400	Ω
"1" Signal ①	2.1			mV/mA
"0" Signal ②			1.0	mV/mA
Detector Sensitivity	1.1			mV/mA
Induced Noise/Leg			3.0	mV
Differential Induced Noise			0.5	mV
Detector Current		5	8	mA



Detector Signal Definitions

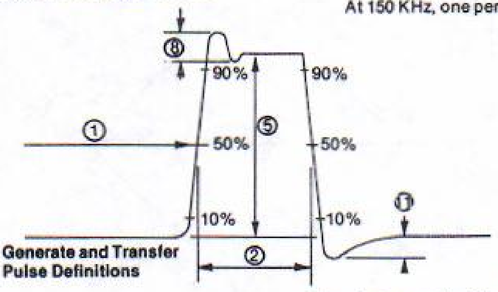
Note: Signal polarity shown for detector common at lower potential.

OPERATOR INFORMATION

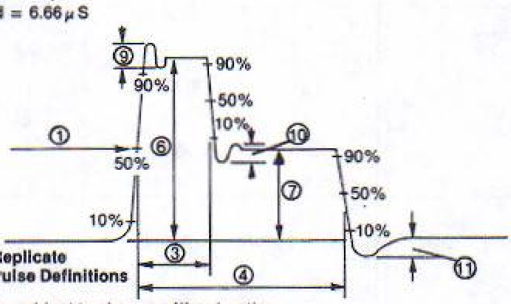
Operator	Resistance (Ω)	Delay ① (Deg.)*	Width (Deg.)*	Amplitude (mA)	Amplitude Deviation (mA)	Maximum Undershoot ⑪ (mA)
Generator	10 ± 1	120 ± 30	10 ± 5②	200 ± 25⑤	± 28⑧	10
Transfer In	315 ± 30	280 ± 30	220 ± 20②	25 ± 5⑤	± 2⑧	2
Transfer Out		280 ± 30	220 ± 20②	25 ± 5⑤	± 2⑧	2
Replicate — Cut	330 ± 30	12.5 ± 7.5	15 ± 5③	100 ± 20⑥	± 5⑨	3
Replicate — Xfer			100 ± 20④	35 ± 7⑦	± 2⑩	

Note:
$t_{rise} \leq 100$ nS; $t_{fall} \leq 200$ nS

*360 degrees per period.
At 100 KHz, one period = 10 μS
At 150 KHz, one period = 6.66 μS



Generate and Transfer Pulse Definitions



Replicate Pulse Definitions

Note: Data contained herein subject to change without notice.