Cost of Semiconductor RAM Over 50 Years: 1970 to 2020

Cost of RAM and RAM Chips by Generation and Year

Showing Sequence of Maturity for each Generation of RAM (Random Access Memory)
And Showing Simultaneous Presence of Multiple Generations in each Year

Year	Mature Generation				Latest Generation				Lab Generation		Research Generation	
	Generation	Cost Per Chip	Size of Mature RAM Chip Given in bits	Cost of One GigaByte of RAM	Generation	Cost Per Chip	Size of Latest RAM Chip Given in bits	Cost of One GigaByte of RAM	Generation	Size of RAM Chip Shown in laboratory	Generation	One Transistor for RAM Chip in laboratory
1958	-	-	-	-	-	-	-	-	-	-	-4	1 bit
1961	-	-	-	-	-	-	-	-	-4	1 bit	-3	4 bit
1966	-	-	-	-	-4	$8,192.00	1 bit	$8,192,000,000,000.00	-3	4 bit	-2	16 bit
1966	-4	$512.00	1 bit	$512,000,000,000.00	-3	$4,096.00	4 bit	$1,024,000,000,000.00	-2	16 bit	-1	64 bit
1967	-3	$512.00	4 bit	$256,000,000,000.00	-2	$4,096.00	16 bit	$512,000,000,000.00	-1	64 bit	0	256 bit
1968	-2	$512.00	16 bit	$64,000,000,000.00	-1	$4,096.00	64 bit	$128,000,000,000.00	0	256 bit	1	1 Kilobit
1968	-1	$256.00	64 bit	$8,000,000,000.00	0	$2,048.00	256 bit	$16,000,000,000.00	1	1 Kilobit	2	4 Kilobit
1970	0	$256.00	256 bit	$2,000,000,000.00	1	$2,048.00	1 Kilobit	$4,000,000,000.00	2	4 Kilobit	3	16 Kilobit
1973	1	$128.00	1 Kilobit	$256,000,000.00	2	$1,024.00	4 Kilobit	$512,000,000.00	3	16 Kilobit	4	64 Kilobit
1976	2	$128.00	4 Kilobit	$128,000,000.00	3	$1,024.00	16 Kilobit	$256,000,000.00	4	64 Kilobit	5	256 Kilobit
1979	3	$128.00	16 Kilobit	$32,000,000.00	4	$1,024.00	64 Kilobit	$64,000,000.00	5	256 Kilobit	6	1 Megabit
1982	4	$64.00	64 Kilobit	$4,000,000.00	5	$512.00	256 Kilobit	$8,000,000.00	6	1 Megabit	7	4 Megabit
1985	5	$64.00	256 Kilobit	$1,000,000.00	6	$512.00	1 Megabit	$2,000,000.00	7	4 Megabit	8	16 Megabit
1988	6	$32.00	1 Megabit	$128,000.00	7	$256.00	4 Megabit	$256,000.00	8	16 Megabit	9	64 Megabit
1991	7	$32.00	4 Megabit	$64,000.00	8	$256.00	16 Megabit	$128,000.00	9	64 Megabit	10	256 Megabit
1994	8	$32.00	16 Megabit	$16,000.00	9	$256.00	64 Megabit	$32,000.00	10	256 Megabit	11	1 Gigabit
1997	9	$16.00	64 Megabit	$2,000.00	10	$128.00	256 Megabit	$4,000.00	11	1 Gigabit	12	4 Gigabit
2000	10	$16.00	256 Megabit	$500.00	11	$128.00	1 Gigabit	$1,000.00	12	4 Gigabit	13	16 Gigabit
2003	11	$8.00	1 Gigabit	$64.00	12	$64.00	4 Gigabit	$128.00	13	16 Gigabit	14	64 Gigabit
2006	12	$8.00	4 Gigabit	$32.00	13	$64.00	16 Gigabit	$64.00	14	64 Gigabit	15	256 Gigabit
2009	13	$8.00	16 Gigabit	$8.00	14	$64.00	64 Gigabit	$16.00	15	256 Gigabit	16	1 Petabit
2012	14	$4.00	64 Gigabit	$1.00	15	$32.00	256 Gigabit	$2.00	16	1 Petabit	17	4 Petabit
2015	15	$4.00	256 Gigabit	$0.25	16	$32.00	1 Petabit	$0.50	17	4 Petabit	18	16 Petabit
2018	16	$2.00	1 Petabit	$0.03	17	$16.00	4 Petabit	$0.06	18	16 Petabit	19	64 Petabit
2021	17	$2.00	4 Petabit	$0.02	18	$16.00	16 Petabit	$0.03	19	64 Petabit	20	256 Petabit
2024	18	$2.00	16 Petabit	$0.0040	19	$16.00	64 Petabit	$0.0080	20	256 Petabit	21	1 Exabit
2027	19	$1.00	64 Petabit	$0.0005	20	$8.00	256 Petabit	$0.0010	21	1 Exabit	22	4 Exabit
2030	20	$1.00	256 Petabit	$0.0001	21	$8.00	1 Exabit	$0.0003	22	4 Exabit	23	16 Exabit

RAM (Random Access Memory) (As implemented in semiconductor integrated chip technology) Years per generation after 1970: 3.0

RAM: (Random Access Memory) In this case it is semiconductor RAM. Previously, it was magnetic core RAM.

Generation: In each generation of RAM the number of bits store on a chip increases by a factor of 4. In twenty generations, the number of bits on a chip would increase by a factor of 4 raised to the 20th power or 1 trillion.

Length of Generation: Since 1970 the length of a RAM generation has been 3 years.

Children: With each generation, the previous generation stays around because it is less expensive. Generally, the latest generation chips costs 8 times as much as the mature generation chips. Because the latest generation chips store 4 times as many bits, the cost per bit on the latest generation is twice as much. However, the latest generation is faster because the transistors on the chips are smaller, and the chips take up less real estate on the printed circuit boards, so the computers can be made smaller. The balancing point between the two generations is a cost differential of about 2 to 1.

Negative Generations: Before 1970 the generations are a little less clear. The integrated circuit was invented by Jack Kilby at Texas Instruments and Robert Noyce at Fairchild Semiconductor in 1958. The one transistor memory cell (which stores 1 bit) was invented by Dr. Robert Dennard, at IBM, in 1966. Intel leadership in RAM was established by the 1101 256 bit RAM chip in 1968-9, and the 1103 1K RAM chip in 1970.

Will this stop – The law of successive 'S' curves: In the study of the history of Technology, each new technology starts off slowly, accelerates rapidly, and then tapers off. The speed of the new technology describes an 'S' or 'S' curve when graphed. Then a new technology appears and repeats the process. This is called the law of successive 'S' curves. The middle part of the 'S; curves line up on the graph and the overall picture is one of a constantly increasing speed over a long period of time. For example, the technology of wagons, trains, airplanes, and space ships follows this pattern. For RAM, quantum electronics, 3D (3 dimensional) integrated circuits, and nanotechnology [http://www.Foresight.org], stand ready to add to the succession of S curves, and keep the increase in speed constant.

Design Rule: because the wires and components, including transistors, on chips are drawn photographically, the pixel size of the imaging process determines the width of the wires and the size of the transistors. The size of the transistors determines how many will fit on a chip of a given size. (The optimal size of a chip depends on the chip manufacturing processes. In general, chip size increases slowly over time.) The smaller the transistors, the more will fit on the chip, determining the chip's transistor budget. The size of the transistors also determines the transistor's switching speed. Smaller transistors switch faster. One micron is one one-millionth of a meter or about 40 millionths of one inch. Finally, the power required to switch smaller transistors is less, so smaller pixels in the design rules allow the batteries in laptop computers to last longer.

Geometric, exponential growth: A constant increase in speed over time results in a geometric increase in speed. If a wagon could go 10 miles per hour and its speed was increased by 10 percent, it could go 11 miles per hour. If a train could go 100 miles per hour, and its speed was increase 10 percent, it could go 110 miles per hour. If the wagon's speed were increased 10 times, it would go 100 miles per hour, like a train. If the train's speed was increased 10 times, it could go 1 thousand miles per hour, like an airplane. Because these increase are multiples of one another, they can be expressed as exponents that increase linearly: with 10 to the 1st power representing a wagon, 10 to the 2nd representing a train, and 10 to the 3rd power representing an airplane.

Moore's Law: in 1965, Gordon Moore, who founded Intel along with Robert Noyce in 1968, observed that integrated circuits capacity increased exponentially, and this fact was memorialized as Moore's law.

Assumptions: This chart fits constant exponential increase to a few cost points around 1970 and 2002. The beginning of and the end of the chart are therefore less certain in terms of matching actual costs.