

Homework 4: Read “The History of the 4004” (See class website under “links” and then Real Microprocessors and answer in the space provided the following:

1. What was the original purpose for building the 4004?
2. What was the size of a single data word in bits?
3. Consider a 4004 system as pictured on page 11. How many types of chips were needed
4. How many total chips were used?
5. What was the maximum RAM (in bits) and ROM (in bits) could it support?
6. What kind of memory was used in “conventional” calculators of the day and why did the 4004 designers decide on a different style?
7. What was the clock frequency
8. How many cycles did most instructions take?
9. Given the above numbers about how many instructions per second could the chip execute?
10. List all the registers that the 4004 programmer could “see” or manipulate.
11. What chip followed the 4004 and how did it differ?
12. Assuming the technology was 10,000 nm, fill in below, specifying what scaling regime each column is in. The Column labelled “?” should be filled in using the feature size (rounded to the nearest hundred) where scaling switches from Dennard to constant voltage (assume $V_{dd} = 0.9V$ is the lowest permissible V_{dd}).

Feature Size	10,000 nm	2,000nm (ND process)	?	100 nm	10 nm
Scaling Type					
Area	12mm ²				
V _{dd}	15 V		0.9		
Clock					
Transistors/sq. mm					
Relative power	Assume “1”				

13. The web site has both a die photo of the chip and a schematic. From the schematic, generate a list (on a separate sheet) of what the logic blocks are and how many were used. Note that this was in NMOS logic so only “n-type” transistors were used, with the entire p-type side replaced by a resistor.