Extra Bite #14: Digital Logic

Gates, flip-flops, counters, multivibrators, truth tables, and positive logic conventions.

Group E7A · 11 pool questions · Standalone · 5-10 minute presentation · Practice exams at eham.net/exams

Logic Gates: The Basic Verbs

Digital circuits are built from a handful of gate types. Each gate has 1 or 2 inputs and produces a 1 or 0 output based on a simple rule.

Gate	Rule	Q
OR	Output is **1 if any input is 1** (E7A08). Logical "or."	E7A08
NAND	Output is **0 only if all inputs are 1** (E7A07). NOT-AND: the AND function inverted.	E7A07
XNOR	Two-input exclusive NOR: output **0 if one and only one input is 1** (E7A09). Stated positively: output is 1 when both inputs match.	E7A09

Truth table: a list of inputs and corresponding outputs for a digital device (E7A10). It is the contract that a gate or circuit advertises.

Positive Logic Convention

Positive logic: high voltage represents a 1, low voltage a 0 (E7A11). The opposite convention exists ("negative logic") but the test wants positive.

Flip-Flops And Frequency Division

A **flip-flop** is the simplest **bistable** circuit (E7A01) — it stays in one of two stable states until it gets a clock pulse, then flips to the other. That switch-on-clock behavior makes it a halver: two input pulses produce one output cycle.

Question	Answer	Q
Circuit that is bistable	**A flip-flop** (E7A01).	E7A01
Divide a pulse train by 2	**A flip-flop** (E7A03). One toggle per input edge → output runs at half the input frequency.	E7A03
Flip-flops needed to divide by 16	**4 flip-flops** (E7A04). Each flip-flop divides by 2, and $2^4 = 16$.	E7A04
Function of a decade counter	**Produces one output pulse for every 10 input pulses** (E7A02). A divide-by-10 counter.	E7A02

Multivibrators

Multivibrators are oscillator-like circuits built from two transistors (or gates) with cross-coupled feedback. They come in three flavors based on how many stable states they have.

Type	Behavior	Q
Astable	**Continuously alternates between two states without an external clock signal** (E7A05). A square-wave oscillator.	E7A05
Monostable	**Switches temporarily to an alternate state for a set time** (E7A06). A one-shot pulse generator.	E7A06
Bistable	Stays in either state indefinitely until clocked. Same family as a flip-flop.	—

Mental Cheat Sheet

- OR gate: 1 if any input is 1.
- NAND gate: 0 only if all inputs are 1.
- XNOR (2-input): 0 if exactly one input is 1; 1 when inputs match.
- Truth table = input → output for a digital device.
- Positive logic: high = 1, low = 0.
- Flip-flop = bistable.
- One flip-flop divides by 2.
- Divide by 16 → 4 flip-flops.
- Decade counter = divide by 10.
- Astable multivibrator: free-running square wave.
- Monostable: one-shot for a set time.

Common Traps

- NAND is 0 **only when all inputs are 1**, not "if some but not all inputs are 1."
- XNOR outputs 0 when **exactly one** input is 1; the trap answers say "all 0" or "all 1."
- Bistable = flip-flop, **not** AND/OR gates or bipolar amps.
- Decade counter divides by 10 (not by 100, not "decodes a decimal").
- Astable runs **without** an external clock; monostable needs a trigger and times out.
- Positive logic is just the high-voltage convention, not a "logic state of truth."

Takeaway: Gates do logic, flip-flops store one bit and halve frequency, decade counters divide by ten, multivibrators come in astable (free-running), monostable (one-shot), and bistable (latch) flavors. Truth tables describe everything; positive logic is the default.

Bite 14 Question Bank (E7A)

E7A01 A flip-flop is a type of what?
A. An AND gate.

E7A02. What is the function of a decade counter?
A. It produces one output pulse for every 10 input pulses.
B. It decodes a decimal number for display on a seven-segment LED display.
C. It produces 10 output pulses for every input pulse.
D. It decodes a binary number for display on a seven-segment LED display.

E7A03. Which of the following can divide the frequency of a pulse train by 2?
A. An XOR gate.
B. A flip-flop.
C. An OR gate.
D. A multiplexer.

E7A04. How many flip-flops are required to divide a signal frequency by 16?
A. 4.
B. 6.
C. 8.
D. 16.

E7A05. Which of the following circuits continuously alternates between two states without an external clock signal?
A. Monostable multivibrator.
B. J-K flip-flop.
C. T flip-flop.
D. Astable multivibrator.

E7A06. What is a characteristic of a monostable multivibrator?
A. It switches temporarily to an alternate state for a set time.
B. It produces a continuous square wave.
C. It stores one bit of data.
D. It maintains a constant output voltage, regardless of variations in the input voltage.

E7A07. What logical operation does a NAND gate perform?
A. It produces a 0 at its output only if all inputs are 0.
B. It produces a 1 at its output only if all inputs are 1.
C. It produces a 0 at its output if some but not all inputs are 1.
D. It produces a 0 at its output only if all inputs are 1.

E7A08. What logical operation does an OR gate perform?
A. It produces a 1 at its output if any input is 1.
B. It produces a 0 at its output if all inputs are 1.
C. It produces a 0 at its output if some but not all inputs are 1.
D. It produces a 1 at its output if all inputs are 0.

E7A09. What logical operation is performed by a two-input exclusive NOR gate?
A. It produces a 0 at its output only if all inputs are 0.
B. It produces a 1 at its output only if all inputs are 1.
C. It produces a 0 at its output if one and only one of its inputs is 1.
D. It produces a 1 at its output if one and only one input is 1.

E7A10. What is a truth table?
A. A list of inputs and corresponding outputs for an op-amp.
B. A list of inputs and corresponding outputs for a digital device.
C. A diagram showing logic states when the digital gate output is true.
D. A table of logic symbols that indicate the logic states of an op-amp.

E7A11. What does “positive logic” mean in reference to logic devices?
A. The logic devices have high noise immunity.
B. High voltage represents a 1, low voltage a 0.
C. The logic circuit is in the “true” condition.
D. 1s and 0s are defined as different positive voltage levels.

Answer Key

E7A01: C	E7A02: A	E7A03: B	E7A04: A
E7A05: D	E7A06: A	E7A07: D	E7A08: A
E7A09: C	E7A10: B	E7A11: B	