

**2020-2024 Amateur Extra Class  
FCC Element 4 Question Pool  
Effective 7/01/2020 – 6/30/2024**

**SUBELEMENT E6 - CIRCUIT COMPONENTS [6 Exam Questions - 6 Groups]**

E6A Semiconductor materials and devices: semiconductor materials; germanium, silicon, P-type, N-type; transistor types: NPN, PNP, junction, field-effect transistors: enhancement mode; depletion mode; MOS; CMOS; N-channel; P-channel

E6A01

**In what application is gallium arsenide used as a semiconductor material?**

- A. In high-current rectifier circuits
- B. In high-power audio circuits
- C. In microwave circuits
- D. In very low-frequency RF circuits

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E6A02

**Which of the following semiconductor materials contains excess free electrons?**

- A. N-type
- B. P-type
- C. Bipolar
- D. Insulated gate

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E6A03

**Why does a PN-junction diode not conduct current when reverse biased?**

- A. Only P-type semiconductor material can conduct current
- B. Only N-type semiconductor material can conduct current
- C. Holes in P-type material and electrons in the N-type material are separated by the applied voltage, widening the depletion region
- D. Excess holes in P-type material combine with the electrons in N-type material, converting the entire diode into an insulator

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E6A04

**What is the name given to an impurity atom that adds holes to a semiconductor crystal structure?**

- A. Insulator impurity
- B. N-type impurity
- C. Acceptor impurity
- D. Donor impurity

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E6A05

**How does DC input impedance at the gate of a field-effect transistor compare with the DC input impedance of a bipolar transistor?**

- A. They are both low impedance
- B. An FET has lower input impedance
- C. An FET has higher input impedance
- D. They are both high impedance

E6A06

**What is the beta of a bipolar junction transistor?**

- A. The frequency at which the current gain is reduced to 0.707
- B. The change in collector current with respect to base current
- C. The breakdown voltage of the base to collector junction
- D. The switching speed

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E6A07

**Which of the following indicates that a silicon NPN junction transistor is biased on?**

- A. Base-to-emitter resistance of approximately 6 to 7 ohms
- B. Base-to-emitter resistance of approximately 0.6 to 0.7 ohms
- C. Base-to-emitter voltage of approximately 6 to 7 volts
- D. Base-to-emitter voltage of approximately 0.6 to 0.7 volts

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E6A08

**What term indicates the frequency at which the grounded-base current gain of a transistor has decreased to 0.7 of the gain obtainable at 1 kHz?**

- A. Corner frequency
- B. Alpha rejection frequency
- C. Beta cutoff frequency
- D. Alpha cutoff frequency

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E6A09

**What is a depletion-mode FET?**

- A. An FET that exhibits a current flow between source and drain when no gate voltage is applied
- B. An FET that has no current flow between source and drain when no gate voltage is applied
- C. Any FET without a channel
- D. Any FET for which holes are the majority carriers

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E6A10

**In Figure E6-1, what is the schematic symbol for an N-channel dual-gate MOSFET?**

- A. 2
- B. 4
- C. 5
- D. 6

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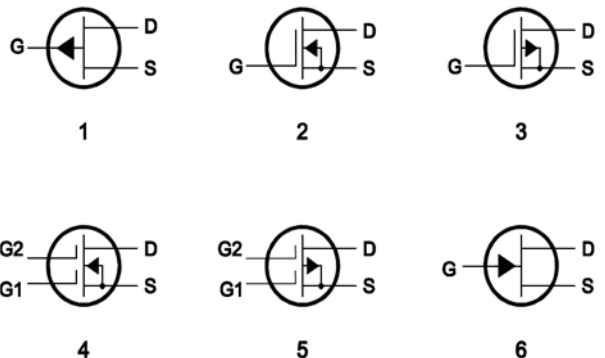
E6A11

**In Figure E6-1, what is the schematic symbol for a P-channel junction FET?**

- A. 1
- B. 2
- C. 3
- D. 6

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**Figure E6-1**



E6A12

**Why do many MOSFET devices have internally connected Zener diodes on the gates?**

- A. To provide a voltage reference for the correct amount of reverse-bias gate voltage
- B. To protect the substrate from excessive voltages
- C. To keep the gate voltage within specifications and prevent the device from overheating
- D. To reduce the chance of static damage to the gate

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E6B Diodes

E6B01

**What is the most useful characteristic of a Zener diode?**

- A. A constant current drop under conditions of varying voltage
- B. A constant voltage drop under conditions of varying current
- C. A negative resistance region
- D. An internal capacitance that varies with the applied voltage

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E6B02

**What is an important characteristic of a Schottky diode as compared to an ordinary silicon diode when used as a power supply rectifier?**

- A. Much higher reverse voltage breakdown
- B. More constant reverse avalanche voltage
- C. Longer carrier retention time
- D. Less forward voltage drop

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E6B03

**What type of bias is required for an LED to emit light?**

- A. Reverse bias
- B. Forward bias
- C. Zero bias
- D. Inductive bias

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E6B04

**What type of semiconductor device is designed for use as a voltage-controlled capacitor?**

- A. Varactor diode
- B. Tunnel diode
- C. Silicon-controlled rectifier
- D. Zener diode

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E6B05

**What characteristic of a PIN diode makes it useful as an RF switch?**

- A. Extremely high reverse breakdown voltage
- B. Ability to dissipate large amounts of power
- C. Reverse bias controls its forward voltage drop
- D. Low junction capacitance

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E6B06

Which of the following is a common use of a Schottky diode?

- A. As a rectifier in high current power supplies
- B. As a variable capacitance in an automatic frequency control circuit
- C. As a constant voltage reference in a power supply
- D. As a VHF/UHF mixer or detector

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E6B07

What is the failure mechanism when a junction diode fails due to excessive current?

- A. Excessive inverse voltage
- B. Excessive junction temperature
- C. Insufficient forward voltage
- D. Charge carrier depletion

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E6B08

Which of the following is a Schottky barrier diode?

- A. Metal-semiconductor junction
- B. Electrolytic rectifier
- C. PIN junction
- D. Thermionic emission diode

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E6B09

What is a common use for point-contact diodes?

- A. As a constant current source
- B. As a constant voltage source
- C. As an RF detector
- D. As a high-voltage rectifier

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E6B10

In Figure E6-2, what is the schematic symbol for a light-emitting diode?

- A. 1
- B. 5
- C. 6
- D. 7

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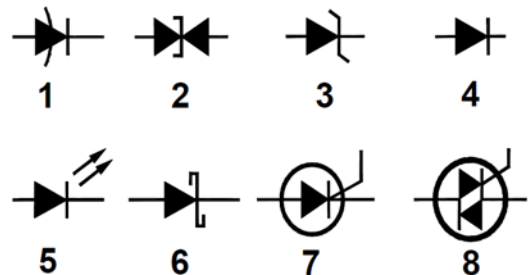
E6B11

What is used to control the attenuation of RF signals by a PIN diode?

- A. Forward DC bias current
- B. A sub-harmonic pump signal
- C. Reverse voltage larger than the RF signal
- D. Capacitance of an RF coupling capacitor

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Figure E6-2



E6C Digital ICs: Families of digital ICs; gates; Programmable Logic Devices (PLDs)

E6C01

**What is the function of hysteresis in a comparator?**

- A. To prevent input noise from causing unstable output signals
- B. To allow the comparator to be used with AC input signals
- C. To cause the output to change states continually
- D. To increase the sensitivity

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E6C02

**What happens when the level of a comparator's input signal crosses the threshold?**

- A. The IC input can be damaged
- B. The comparator changes its output state
- C. The comparator enters latch-up
- D. The feedback loop becomes unstable

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E6C03

**What is tri-state logic?**

- A. Logic devices with 0, 1, and high-impedance output states
- B. Logic devices that utilize ternary math
- C. Low-power logic devices designed to operate at 3 volts
- D. Proprietary logic devices manufactured by Tri-State Devices

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E6C04

**Which of the following is an advantage of BiCMOS logic?**

- A. Its simplicity results in much less expensive devices than standard CMOS
- B. It is immune to electrostatic damage
- C. It has the high input impedance of CMOS and the low output impedance of bipolar transistors
- D. All these choices are correct

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E6C05

**What is an advantage of CMOS logic devices over TTL devices?**

- A. Differential output capability
- B. Lower distortion
- C. Immune to damage from static discharge
- D. Lower power consumption

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E6C06

**Why do CMOS digital integrated circuits have high immunity to noise on the input signal or power supply?**

- A. Large bypass capacitance is inherent
- B. The input switching threshold is about two times the power supply voltage
- C. The input switching threshold is about one-half the power supply voltage
- D. Bandwidth is very limited

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E6C07

**What best describes a pull-up or pull-down resistor?**

- A. A resistor in a keying circuit used to reduce key clicks
- B. A resistor connected to the positive or negative supply line used to establish a voltage when an input or output is an open circuit
- C. A resistor that ensures that an oscillator frequency does not drift
- D. A resistor connected to an op-amp output that prevents signals from exceeding the power supply voltage

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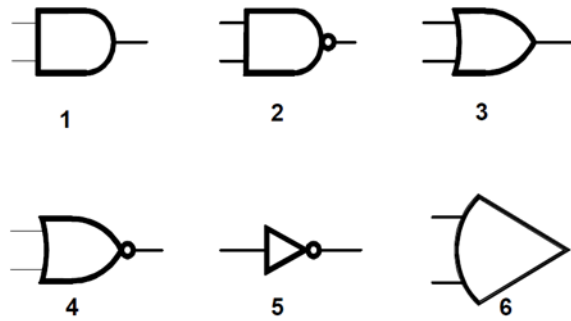
**Figure E6-3**

E6C08

**In Figure E6-3, what is the schematic symbol for a NAND gate?**

- A. 1
- B. 2
- C. 3
- D. 4

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E6C09

**What is a Programmable Logic Device (PLD)?**

- A. A logic circuit that can be modified during use
- B. A programmable collection of logic gates and circuits in a single integrated circuit
- C. Programmable equipment used for testing digital logic integrated circuits
- D. A type of transistor whose gain can be changed by digital logic circuits

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E6C10

**In Figure E6-3, what is the schematic symbol for a NOR gate?**

- A. 1
- B. 2
- C. 3
- D. 4

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E6C11

**In Figure E6-3, what is the schematic symbol for the NOT operation (inverter)?**

- A. 2
- B. 4
- C. 5
- D. 6

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E6D Toroidal and Solenoidal Inductors: permeability, core material, selecting, winding; transformers; piezoelectric devices

E6D01

**Why should core saturation of an impedance matching transformer be avoided?**

- A. Harmonics and distortion could result
- B. Magnetic flux would increase with frequency
- C. RF susceptance would increase
- D. Temporary changes of the core permeability could result

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E6D02

**What is the equivalent circuit of a quartz crystal?**

- A. Motional capacitance, motional inductance, and loss resistance in series, all in parallel with a shunt capacitor representing electrode and stray capacitance
- B. Motional capacitance, motional inductance, loss resistance, and a capacitor representing electrode and stray capacitance all in parallel
- C. Motional capacitance, motional inductance, loss resistance, and a capacitor representing electrode and stray capacitance all in series
- D. Motional inductance and loss resistance in series, paralleled with motional capacitance and a capacitor representing electrode and stray capacitance

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E6D03

**Which of the following is an aspect of the piezoelectric effect?**

- A. Mechanical deformation of material by the application of a voltage
- B. Mechanical deformation of material by the application of a magnetic field
- C. Generation of electrical energy in the presence of light
- D. Increased conductivity in the presence of light

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E6D04

**Which materials are commonly used as a core in an inductor?**

- A. Polystyrene and polyethylene
- B. Ferrite and brass
- C. Teflon and Delrin
- D. Cobalt and aluminum

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E6D05

**What is one reason for using ferrite cores rather than powdered iron in an inductor?**

- A. Ferrite toroids generally have lower initial permeability
- B. Ferrite toroids generally have better temperature stability
- C. Ferrite toroids generally require fewer turns to produce a given inductance value
- D. Ferrite toroids are easier to use with surface mount technology

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E6D06

**What core material property determines the inductance of an inductor?**

- A. Thermal impedance
- B. Resistance
- C. Reactivity
- D. Permeability

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E6D07

**What is current in the primary winding of a transformer called if no load is attached to the secondary?**

- A. Magnetizing current
- B. Direct current
- C. Excitation current
- D. Stabilizing current

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E6D08

**What is one reason for using powdered-iron cores rather than ferrite cores in an inductor?**

- A. Powdered-iron cores generally have greater initial permeability
- B. Powdered-iron cores generally maintain their characteristics at higher currents
- C. Powdered-iron cores generally require fewer turns to produce a given inductance
- D. Powdered-iron cores use smaller diameter wire for the same inductance

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E6D09

**What devices are commonly used as VHF and UHF parasitic suppressors at the input and output terminals of a transistor HF amplifier?**

- A. Electrolytic capacitors
- B. Butterworth filters
- C. Ferrite beads
- D. Steel-core toroids

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E6D10

**What is a primary advantage of using a toroidal core instead of a solenoidal core in an inductor?**

- A. Toroidal cores confine most of the magnetic field within the core material
- B. Toroidal cores make it easier to couple the magnetic energy into other components
- C. Toroidal cores exhibit greater hysteresis
- D. Toroidal cores have lower Q characteristics

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E6D11

**Which type of core material decreases inductance when inserted into a coil?**

- A. Ceramic
- B. Brass
- C. Ferrite
- D. Powdered iron

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E6D12

**What is inductor saturation?**

- A. The inductor windings are over-coupled
- B. The inductor's voltage rating is exceeded causing a flashover
- C. The ability of the inductor's core to store magnetic energy has been exceeded
- D. Adjacent inductors become over-coupled

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E6D13

**What is the primary cause of inductor self-resonance?**

- A. Inter-turn capacitance
- B. The skin effect
- C. Inductive kickback
- D. Non-linear core hysteresis

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E6E Analog ICs: MMICs, IC packaging characteristics

E6E01

**Why is gallium arsenide (GaAs) useful for semiconductor devices operating at UHF and higher frequencies?**

- A. Higher noise figures
- B. Higher electron mobility
- C. Lower junction voltage drop
- D. Lower transconductance

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E6E02

**Which of the following device packages is a through-hole type?**

- A. DIP
- B. PLCC
- C. Ball grid array
- D. SOT

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E6E03

**Which of the following materials is likely to provide the highest frequency of operation when used in MMICs?**

- A. Silicon
- B. Silicon nitride
- C. Silicon dioxide
- D. Gallium nitride

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E6E04

**Which is the most common input and output impedance of circuits that use MMICs?**

- A. 50 ohms
- B. 300 ohms
- C. 450 ohms
- D. 10 ohms

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E6E05

**Which of the following noise figure values is typical of a low-noise UHF preamplifier?**

- A. 2 dB
- B. -10 dB
- C. 44 dBm
- D. -20 dBm

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E6E06

**What characteristics of the MMIC make it a popular choice for VHF through microwave circuits?**

- A. The ability to retrieve information from a single signal even in the presence of other strong signals
- B. Plate current that is controlled by a control grid
- C. Nearly infinite gain, very high input impedance, and very low output impedance
- D. Controlled gain, low noise figure, and constant input and output impedance over the specified frequency range

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E6E07

**What type of transmission line is used for connections to MMICs?**

- A. Miniature coax
- B. Circular waveguide
- C. Parallel wire
- D. Microstrip

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E6E08

**How is power supplied to the most common type of MMIC?**

- A. Through a resistor and/or RF choke connected to the amplifier output lead
- B. MMICs require no operating bias
- C. Through a capacitor and RF choke connected to the amplifier input lead
- D. Directly to the bias voltage (VCC IN) lead

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E6E09

**Which of the following component package types would be most suitable for use at frequencies above the HF range?**

- A. TO-220
- B. Axial lead
- C. Radial lead
- D. Surface mount

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E6E10

**What advantage does surface-mount technology offer at RF compared to using through-hole components?**

- A. Smaller circuit area
- B. Shorter circuit-board traces
- C. Components have less parasitic inductance and capacitance
- D. All these choices are correct

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E6E11

**What is a characteristic of DIP packaging used for integrated circuits?**

- A. Package mounts in a direct inverted position
- B. Low leakage doubly insulated package
- C. Two chips in each package (Dual In Package)
- D. A total of two rows of connecting pins placed on opposite sides of the package (Dual In-line Package)

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E6E12

**Why are DIP through-hole package ICs not typically used at UHF and higher frequencies?**

- A. Too many pins
- B. Epoxy coating is conductive above 300 MHz
- C. Excessive lead length
- D. Unsuitable for combining analog and digital signals

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E6F Electro-optical technology: photoconductivity; photovoltaic devices; optical sensors and encoders; optical isolation

E6F01

**What absorbs the energy from light falling on a photovoltaic cell?**

- A. Protons
- B. Photons
- C. Electrons
- D. Holes

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E6F02

**What happens to the conductivity of a photoconductive material when light shines on it?**

- A. It increases
- B. It decreases
- C. It stays the same
- D. It becomes unstable

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E6F03

**What is the most common configuration of an optoisolator or optocoupler?**

- A. A lens and a photomultiplier
- B. A frequency modulated helium-neon laser
- C. An amplitude modulated helium-neon laser
- D. An LED and a phototransistor

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E6F04

**What is the photovoltaic effect?**

- A. The conversion of voltage to current when exposed to light
- B. The conversion of light to electrical energy
- C. The conversion of electrical energy to mechanical energy
- D. The tendency of a battery to discharge when exposed to light

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E6F05

**Which describes an optical shaft encoder?**

- A. A device that detects rotation of a control by interrupting a light source with a patterned wheel
- B. A device that measures the strength of a beam of light using analog to digital conversion
- C. A digital encryption device often used to encrypt spacecraft control signals
- D. A device for generating RTTY signals by means of a rotating light source

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E6F06

**Which of these materials is most commonly used to create photoconductive devices?**

- A. A crystalline semiconductor
- B. An ordinary metal
- C. A heavy metal
- D. A liquid semiconductor

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E6F07

**What is a solid-state relay?**

- A. A relay using transistors to drive the relay coil
- B. A device that uses semiconductors to implement the functions of an electromechanical relay
- C. A mechanical relay that latches in the on or off state each time it is pulsed
- D. A semiconductor passive delay line

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E6F08

**Why are optoisolators often used in conjunction with solid-state circuits when switching 120 VAC?**

- A. Optoisolators provide a low impedance link between a control circuit and a power circuit
- B. Optoisolators provide impedance matching between the control circuit and power circuit
- C. Optoisolators provide a very high degree of electrical isolation between a control circuit and the circuit being switched
- D. Optoisolators eliminate the effects of reflected light in the control circuit

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E6F09

**What is the efficiency of a photovoltaic cell?**

- A. The output RF power divided by the input DC power
- B. Cost per kilowatt-hour generated
- C. The open-circuit voltage divided by the short-circuit current under full illumination
- D. The relative fraction of light that is converted to current

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E6F10

**What is the most common type of photovoltaic cell used for electrical power generation?**

- A. Selenium
- B. Silicon
- C. Cadmium Sulfide
- D. Copper oxide

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E6F11

**What is the approximate open-circuit voltage produced by a fully illuminated silicon photovoltaic cell?**

- A. 0.1 V
- B. 0.5 V
- C. 1.5 V
- D. 12 V

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