Basic Electronics Solutions

DI01000051 – Winter 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Define Active and Passive Components with example.

Solution

Table 1: Active vs Passive Components

Component Type	Definition	Power	Examples
Active Components	Components that can amplify signals and control current flow	Can provide power gain	Transistor, Diode, IC
Passive Components	Components that cannot amplify signals	Cannot provide power gain	Resistor, Capacitor, Inductor

- **Active components**: Control and amplify electrical signals using external power
- **Passive components**: Store or dissipate energy without amplification

Mnemonic

"Active Amplifies, Passive Preserves"

Question 1(b) [4 marks]

Explain construction and working of LDR.

Solution

Construction:

- **Serpentine track** of cadmium sulfide on ceramic substrate
- **Metal electrodes** at both ends for connections
- **Protective coating** prevents moisture damage

Working Principle:

```
   Light ↓

     CdS Track      Resistance decreases
    { }
        LDR


     Terminal Terminal
```

- **Light intensity** ↑: Resistance ↓ (conducts more)
- **Darkness**: Resistance ↑ (conducts less)
- **Applications**: Street lights, automatic cameras

Mnemonic

"Light Low Resistance"

Question 1(c) [7 marks]

Define Capacitance and explain Aluminum Electrolytic wet type capacitor.

Solution

Capacitance Definition: Ability to store electrical charge. C = Q/V (Farads)
Aluminum Electrolytic Capacitor:

```
    Positive Terminal



      Al Foil    Anode
      Oxide      Dielectric
      Electro    Cathode
      Al Foil    Negative



    Negative Terminal
```

Construction:

- **Anode**: Aluminum foil with oxide layer
- **Dielectric**: Thin aluminum oxide film
- **Cathode**: Liquid electrolyte with aluminum foil
- **Polarity**: Must be connected correctly

Features:

- **High capacitance** values (1µF to 10,000µF)
- **Polarized** - has positive and negative terminals
- **Applications**: Power supply filtering, coupling

Mnemonic

"Aluminum Always Amplifies"

Question 1(c OR) [7 marks]

Explain the color band coding method of Resistor. Write color band of 32 Ω $\pm 10\% resistance.$

Solution

Color Code Table:

Color	Digit	Multiplier	Tolerance
Black	**0**	**1**	**-**
Brown	**1**	**10**	±1%
Red	**2**	**100**	±2%
Orange	**3**	**1K**	**-**
Yellow	**4**	**10K**	**-**
Green	**5**	**100K**	±0.5%
Blue	**6**	**1M**	±0.25%
Violet	**7**	**10M**	±0.1%
Gray	**8**	**100M**	±0.05%
White	**9**	**1G**	**-**
Silver	**-**	**0.01**	±10%
Gold	**-**	**0.1**	±5%

For 32 Ω $\pm 10\%$:

```
Orange Red Gold Silver
  3     2   0.1  10\%
  ↓     ↓    ↓    ↓
 1st   2nd Mult Tol
```

Calculation: 3 $\times 2 \times 0.1 = 3.2 \times 10 = 32$

Mnemonic

"Big Boys Race Our Young Girls But Violet Generally Wins"

Question 2(a) [3 marks]

Define following terms: 1) Rectifier 2) Ripple factor 3) Filter

Solution

Term	Definition
Rectifier	Circuit that converts AC to pulsating DC
Ripple Factor	Ratio of AC component to DC component in output
Filter	Circuit that smooths pulsating DC to pure DC

- **Rectifier:** Uses diodes to allow current in one direction
- **Ripple factor:** Lower value means better filtering
- **Filter:** Uses capacitors/inductors to reduce ripples

Mnemonic

"Rectify Ripples, Filter Fixes"

Question 2(b) [4 marks]

Draw and explain positive clipper circuit with waveform.

Solution

Circuit Diagram:

```
Input        Output

          D1 ↓ (Diode)

            +V (Clipping Level)
```

Working:

- **When Vin > +V: Diode conducts, output = +V**
- **When Vin < +V: Diode off, output follows input**
- **Result: Clips positive peaks above +V level**

Waveform:

```
Input          Output

                 V
```

Applications: Signal limiting, protection circuits

Mnemonic

"Positive Peaks Prevented"

Question 2(c) [7 marks]

Explain working of full wave rectifier with two diodes.

Solution

Circuit Diagram:

```
AC Input    D1       RL


{   Center{-}tap       Output}
      Transformer



          D2
```

Working:

- Positive half-cycle: D1 conducts, D2 off
- Negative half-cycle: D2 conducts, D1 off
- Both diodes work alternately
- Output frequency = 2 $\times input frequency$

Key Parameters:

Parameter	Value
Peak Inverse Voltage	2Vm
Efficiency	81.2%
Ripple Factor	0.48
Form Factor	1.11

Advantages:

- Better efficiency than half-wave
- Lower ripple content
- Higher transformer utilization

Mnemonic

"Two Diodes, Two Halves"

Question 2(a OR) [3 marks]

Define rectifier and write its applications.

Solution

Definition: Electronic circuit that converts alternating current (AC) into direct current (DC) using diodes.

Applications:

Application	Use
Power Supplies	DC voltage for electronic circuits
Battery Chargers	Converting AC mains to DC
DC Motors	Providing DC for motor drives

Electronic Devices	Laptops, phones, LED drivers

- Primary function: AC to DC conversion
- Essential component: In all electronic devices

Mnemonic

"Rectify AC, Deliver DC"

Question 2(b OR) [4 marks]

Explain working of Pi( ) type capacitor filter.

Solution

Circuit Diagram:

```
Input   C1    L    C2   Output
    ||  UUU  ||



           Ground
```

Working:

- C1: Filters initial ripples from rectifier
- Inductor L: Opposes current changes, smooths further
- C2: Final filtering for smooth DC output
- Combined effect: Excellent ripple reduction

Characteristics:

Parameter	Value
Ripple Factor	Very low (< 0.01)
Regulation	Good
Cost	Higher due to inductor
Applications	High-quality power supplies

Advantages:

- Excellent filtering performance
- Low ripple content
- Good voltage regulation

Mnemonic

"Pi Provides Perfect"

Question 2(c OR) [7 marks]

Compare half wave and full wave bridge rectifier.

Solution

Comparison Table:

Parameter	Half Wave	Full Wave Bridge
Diodes Required	1	4
Transformer	Simple	No center-tap needed
Efficiency	40.6%	81.2%
Ripple Factor	1.21	0.48

PIV	Vm	Vm
Output Frequency	f	2f
Transformer Utilization	28.7%	81.2%
Cost	Low	Moderate

Circuit Diagrams:
Half Wave:

```
AC    D1    Output

         RL
```

Full Wave Bridge:

```
     D1
AC        Output
        RL

AC
     D2
```

Key Differences:
- Full wave: Better efficiency and lower ripple
- Half wave: Simpler but poor performance
- Bridge: No center-tap transformer required

Mnemonic

"Half Wastes, Full Works"

Question 3(a) [3 marks]

Draw the symbols of following: 1) Zener diode 2) LED 3) Varactor diode

Solution

Electronic Symbols:

```
Zener Diode:       LED:          Varactor Diode:



       Z
```

Symbol Details:

Component	Symbol Feature
Zener Diode	Normal diode with Z-shaped cathode
LED	Diode with arrows showing light emission
Varactor Diode	Diode with parallel lines (variable capacitor)

- Zener: Z indicates zener characteristics
- LED: Arrows show light output direction
- Varactor: Lines represent variable capacitance

Mnemonic

"Zener Zigs, LED Lights, Varactor Varies"

Question 3(b) [4 marks]

Explain construction and working of LED.

Solution

Construction:

```
        Light Output ↑

         Wire Bond

          P{-N Junction  }


         Cathode  Anode

             LED Chip
```

Materials:

- **P-type: Boron-doped semiconductor**
- **N-type: Phosphorus-doped semiconductor**
- **Common materials: GaAs, GaP, GaN**

Working Principle:

- **Forward bias: Electrons recombine with holes**
- **Energy release: In form of photons (light)**
- **Color: Depends on semiconductor material and bandgap**
- **Efficiency: High light output with low power**

Applications:

- **Indicators: Status lights, displays**
- **Lighting: LED bulbs, strips**
- **Electronics: Seven-segment displays**

Mnemonic

"Light Emitting, Energy Efficient"

Question 3(c) [7 marks]

Explain working characteristics of Zener diode.

Solution

V-I Characteristics:

```
                     Forward


                        If
                   V
     Vz



                   Reverse
              Iz


         Zener
        Region
```

Key Regions:

Region	Characteristics
Forward Bias	Normal diode operation (0.7V)
Reverse Bias	Small leakage current
Zener Region	Constant voltage (Vz)
Breakdown	Sharp voltage breakdown

Important Parameters:

- **Zener Voltage (Vz):** Breakdown voltage
- **Zener Current (Iz):** Current in breakdown region
- **Maximum Power:** Vz $\times Iz(max)$
- **Temperature coefficient:** Voltage variation with temperature

Applications:

- **Voltage regulation:** Maintains constant output
- **Reference voltage:** Precise voltage source
- **Overvoltage protection:** Protects circuits

Advantages:

- **Sharp breakdown:** Well-defined voltage
- **Low dynamic resistance:** Good regulation
- **Wide range:** Available in many voltages

Mnemonic

"Zener Zones Zero variation"

Question 3(a OR) [3 marks]

Enlist the applications of varactor diode.

Solution

Applications Table:

Application	Function
Voltage Controlled Oscillators	Frequency tuning with voltage
Automatic Frequency Control	Maintains oscillator frequency
Electronic Tuning	Radio/TV channel selection
Phase Locked Loops	Frequency synchronization
Frequency Multipliers	Harmonic generation
Parametric Amplifiers	Low-noise amplification

Key Features:

- **Voltage variable:** Capacitance changes with reverse voltage
- **No mechanical parts:** Electronic tuning only
- **Fast response:** Quick frequency changes

Mnemonic

"Voltage Varies Capacitance"

Question 3(b OR) [4 marks]

Explain working of photo diode.

Solution

Construction & Symbol:

```
Light ↓ ↓ ↓
```

```
P{-type     Anode}
     P{-N Junction}
N{-type     Cathode}



  Cathode Anode
```

Working Principle:

- **Light absorption: Creates electron-hole pairs**
- **Reverse bias: Widens depletion region**
- **Photocurrent: Proportional to light intensity**
- **Fast response: Quick detection capability**

Characteristics:

Parameter	Description
Dark Current	Current without light
Photocurrent	Current proportional to light
Responsivity	Current per unit light power
Response Time	Speed of detection

Applications:

- **Light sensors: Automatic lighting systems**
- **Optical communication: Fiber optic receivers**
- **Safety systems: Smoke detectors**
- **Solar panels: Light to electrical energy**

Mnemonic

"Photo Produces Proportional current"

Question 3(c OR) [7 marks]

Explain Zener diode as a voltage regulator.

Solution

Voltage Regulator Circuit:

```
Vin   Rs      Vout = Vz

            Z ↓ (Zener)

              Ground
```

Working Principle:

- **Zener operates in breakdown region**
- **Output voltage remains constant at Vz**
- **Series resistor Rs limits current**
- **Load changes don't affect output voltage**

Design Equations:

Parameter	Formula
Series Resistance	Rs = (Vin - Vz) / Iz
Load Current	IL = Vz / RL
Zener Current	Iz = Is - IL
Power Dissipation	Pz = Vz $\times Iz$

Regulation Characteristics:

- **Line regulation: Output change with input variation**
- **Load regulation: Output change with load variation**
- **Efficiency: Generally low due to Zener power loss**

Advantages:

- **Simple circuit: Few components required**
- **Good regulation: Stable output voltage**
- **Fast response: Quick voltage correction**

Limitations:

- **Poor efficiency: Power wasted in Zener**
- **Limited current: Cannot supply high currents**
- **Temperature sensitivity: Voltage varies with temperature**

Applications:

- **Reference voltage: Precise voltage source**
- **Simple regulators: Low current applications**
- **Protection circuits: Overvoltage protection**

Mnemonic

"Zener Zones provide Zero variation"

Question 4(a) [3 marks]

Draw the symbol and construction of PNP and NPN transistor with proper notation.

Solution

Transistor Symbols:

```
NPN Transistor:       PNP Transistor:

Collector (C)         Collector (C)



Base                 Base

      Emitter               Emitter
      (E)                   (E)
```

Construction Diagrams:

```
NPN Structure:        PNP Structure:

  Collector             Collector
  N{-type                P{-}type}

  P{-type    Base        N{-}type    Base  }

  N{-type                P{-}type}
  Emitter               Emitter
```

Terminal Identification:

- **Emitter: Heavily doped, arrow shows current direction**
- **Base: Thin, lightly doped middle region**
- **Collector: Moderately doped, collects charge carriers**

Current Direction:

- **NPN: Arrow points outward (emitter to base)**
- **PNP: Arrow points inward (base to emitter)**

Mnemonic

"NPN: Not Pointing iN, PNP: Pointing iN Please"

Question 4(b) [4 marks]

Draw and Explain characteristics of CE amplifier.

Solution

CE Amplifier Circuit:

```
Vcc

 Rc

  Vout

 C   Collector

 B   Base   Vin

 E   Emitter

 Re

  Ground
```

Input Characteristics (IB vs VBE):

```
IB
(mA)



          VBE (V)
     0   0.7
```

Output Characteristics (IC vs VCE):

```
IC    IB = 40µA
(mA)
        IB = 30µA

       IB = 20µA

      IB = 10µA
            VCE (V)
     0    5   10
```

Key Features:

Parameter	CE Configuration
Current Gain	= IC/IB (high)
Voltage Gain	High
Power Gain	Very high
Input Impedance	Medium
Output Impedance	High
Phase Shift	180°

Regions of Operation:

- **Cut-off: Both junctions reverse biased**
- **Active: BE forward, BC reverse biased**
- **Saturation: Both junctions forward biased**

Mnemonic

"Common Emitter, Current Enlarged"

Question 4(c) [7 marks]

Derive relation between current gains , and .

Solution

Current Gain Definitions:

Gain	Configuration	Formula
(Alpha)	Common Base	= IC/IE
(Beta)	Common Emitter	= IC/IB
(Gamma)	Common Collector	= IE/IB

Derivation:
Step 1: Basic Current Relation IE = IB + IC ... (Kirchhoff's Current Law)
Step 2: Express IC in terms of IE = IC/IE Therefore: IC = $\times IE \ldots (1)$
Step 3: Substitute in current equation IE = IB + $\times IEIE - \times IE = IBIE(1 -) = IBIE = IB/(1 -) \ldots (2)$
Step 4: Find = IC/IB From (1): IC = $\times IEFrom(2) : IE = IB/(1 -)Therefore : IC = \times IB/(1 -)$
Step 5: Final relation for = IC/IB = /(1 -) ... (3)
Step 6: Express in terms of From equation (3): (1 -) = - =
= + = (1 +) Therefore:
= /(1 +) ... (4)
Step 7: Find = IE/IB From (2): = 1/(1 -) Substituting from (4):
= 1/(1 - /(1 +))
= (1 +)/(1 + -)
= 1 +
... (5)
Final Relations:

Relation	Formula
in terms of	= /(1 -)
in terms of	= /(1 +)
in terms of	= 1 +
Verification	+ × =

Typical Values:

- $\approx 0.98 to 0.995$
- $\approx 50 to 200$
- $\approx 51 to 201$

Mnemonic

"Alpha Beta Gamma, Always Better Gains"

Question 4(a OR) [3 marks]

Define Active, Saturation and Cut-off region for transistor amplifier.

Solution

Operating Regions:

Region	Base-Emitter	Base-Collector	Characteristics
Active	Forward Biased	Reverse Biased	Amplification region
Saturation	Forward Biased	Forward Biased	Switch ON state
Cut-off	Reverse Biased	Reverse Biased	Switch OFF state

Detailed Description:
Active Region:

- Normal amplification mode
- IC = $\times IBrelationshipholds$
- Linear operation for small signals

Saturation Region:

- Both junctions forward biased
- Maximum collector current flows
- VCE $\approx 0.2V(verylow)$
- Used in switching applications

Cut-off Region:

- No base current (IB = 0)
- No collector current (IC = 0)

- Transistor acts like open switch

Mnemonic

"Active Amplifies, Saturated Switches, Cut-off Cuts"

Question 4(b OR) [4 marks]

Explain working of Transistor as an amplifier.

Solution

Amplifier Circuit:

```
    Vcc

     Rc

      Vout (amplified)

    C   NPN Transistor

      Vin  B

    E

     Re

      Ground
```

Working Principle:

- Small input signal applied to base-emitter
- Input resistance is low (few kΩ)
- Small base current controls large collector current
- Output taken from collector-emitter
- Current amplification: IC = $\times IB$

Amplification Process:

Parameter	Input	Output
Signal Level	Small	Large
Current	µA range	mA range
Voltage	mV range	V range
Power	µW range	mW range

Key Features:

- Current gain: (50-200 typical)
- Voltage gain: Depends on load resistance
- Power gain: Product of current and voltage gains
- Phase inversion: $180^\circ inCEconfiguration$

Applications:

- Audio amplifiers: Music systems
- RF amplifiers: Radio transmitters
- Op-amp stages: Integrated circuits

Mnemonic

"Tiny signal Triggers Tremendous output"

Question 4(c OR) [7 marks]

Compare CB, CC, and CE amplifier configuration.

Solution

Comprehensive Comparison:

Parameter	Common Base (CB)	Common Emitter (CE)	Common Collector (CC)
Input Terminal	Emitter	Base	Base
Output Terminal	Collector	Collector	Emitter
Common Terminal	Base	Emitter	Collector
Current Gain	< 1	» 1	$= (1 + \ )$
Voltage Gain	High	High	< 1 (≈ 1)
Power Gain	Medium	Very High	Medium
Input Resistance	Very Low (20-50Ω)	Medium (1-5kΩ)	Very High (100kΩ)
Output Resistance	Very High (1MΩ)	High (50kΩ)	Low (25Ω)
Phase Shift	0°	180°	0°
Frequency Response	Excellent	Good	Good
Applications	RF Amplifiers	Audio Amplifiers	Buffer, Impedance Matching

Circuit Diagrams:
Common Base:

```
  Vcc         Vcc         Vcc

   Rc          Rc          Re

   Vout       Vout       Vin

   C           C           C

   B  Ground   Vin B      B

   Vin E       E  Ground  E  Vout
```

Key Characteristics:
Common Base (CB):

- High frequency performance
- No current gain but high voltage gain
- Input-output isolation excellent
- Used in: RF amplifiers, high-frequency circuits

Common Emitter (CE):

- Most popular configuration
- High current and voltage gain
- Good compromise of all parameters
- Used in: Audio amplifiers, general amplification

Common Collector (CC):

- Unity voltage gain (voltage follower)
- High current gain
- Impedance transformation (high to low)
- Used in: Buffer amplifiers, impedance matching

Selection Criteria:

Application	Best Configuration	Reason
High Frequency	CB	Excellent frequency response
General Amplification	CE	High power gain
Buffer/Isolation	CC	High input, low output impedance
Power Amplifiers	CE	Maximum power gain

Mnemonic

"CB for Communication, CE for Common use, CC for Coupling"

Question 5(a) [3 marks]

Draw the pin diagram of IC 555.

Solution

IC 555 Pin Diagram:

```
        IC 555
 1   Ground          8   Vcc
 2   Trigger         7   Discharge
 3   Output          6   Threshold
 4   Reset           5   Control Voltage

          DIP{-8 Package}
```

Pin Functions:

Pin	Name	Function
1	Ground	0V reference
2	Trigger	Start timing cycle
3	Output	Timer output
4	Reset	Master reset (active low)
5	Control	Voltage reference control
6	Threshold	Stop timing cycle
7	Discharge	Timing capacitor discharge
8	Vcc	Power supply (+5V to +18V)

Key Points:

- Dual-in-line 8-pin package
- Power supply: 5V to 18V DC
- Output current: Up to 200mA
- Reset pin: Normally connected to Vcc

Mnemonic

"Great Timer, Great Pins"

Question 5(b) [4 marks]

List out Features of 555 Timer IC.

Solution

Key Features:

Feature	Specification
Supply Voltage	5V to 18V
Output Current	200mA source/sink
Temperature Range	0$^to70$
Timing Range	µs to hours
Accuracy	$\pm1\%typical$
Modes	Monostable, Astable, Bistable

Technical Features:

- CMOS/TTL compatible output levels
- High current output capability
- Wide supply voltage range
- Temperature stable operation

Functional Features:

- Three operating modes available
- External timing components
- Reset capability for control
- Low power consumption design

Advantages:

- Versatile timer for multiple applications
- Easy to use with minimal external components
- Reliable operation in various conditions

Mnemonic

"Fantastic Features, Flexible Functions"

Question 5(c) [7 marks]

Explain Mono stable multivibrator using 555 timer IC.

Solution

Monostable Circuit:

```
    Vcc

          8 (Vcc)

     R     7 (Discharge)

          6 (Threshold)

     2    4 (Reset)
        5   (Control)
     3
            1 (Ground)

     C

      Ground
```

Working Principle:

Stable State:

- Output LOW (approximately 0V)
- Capacitor discharged through pin 7
- Threshold voltage below Vcc/3

Triggered State:

- Negative pulse applied to trigger (pin 2)
- Output goes HIGH immediately
- Discharge transistor turns OFF
- Capacitor starts charging through R

Timing Period:

- Duration: T = 1.1 $\times R \times C$
- Output remains HIGH for calculated time
- Automatic return to stable state

Return to Stable:

- Capacitor voltage reaches 2Vcc/3
- Threshold triggered (pin 6)
- Output returns to LOW
- Discharge begins again

Key Characteristics:

Parameter	Description
Pulse Width	T = 1.1 RC
Trigger Level	Vcc/3
Threshold Level	2Vcc/3
Output High	~Vcc - 1.5V
Output Low	~0.1V

Applications:

- Pulse generation: Fixed width pulses
- Time delays: Switch-on delays
- Missing pulse detection: Watchdog timers
- Debouncing circuits: Switch contact cleaning

Design Example: For T = 1ms: If C = 0.1μF, then R = 9.1kΩ

Mnemonic

"Mono means One pulse Only"

Question 5(a OR) [3 marks]

List out applications of IC 555.

Solution

Timer Applications:

Category	Applications
Timing Circuits	Delay timers, Pulse generators
Oscillators	Clock generators, Frequency dividers
Control Circuits	PWM controllers, Motor speed control
Detection	Missing pulse detectors, Burglar alarms
Communication	Tone generators, Frequency shift keying
Automotive	Turn signal flashers, Windshield wipers

Mode-wise Applications:
Monostable Mode:

- Time delays in circuits
- Pulse width generation
- Debouncing switches

Astable Mode:

- LED flashers and blinkers
- Clock signals generation
- Tone generation for buzzers

Bistable Mode:

- Flip-flop circuits
- Memory elements
- Latch circuits

Common Projects:

- Electronic dice using LEDs
- Traffic light controllers
- Digital clocks and timers

Mnemonic

"Timer for Tremendous Tasks"

Question 5(b OR) [4 marks]

Draw and explain the internal block diagram of IC 555.

Solution

Internal Block Diagram:

```
        Vcc (8)



      Voltage
     Divider     5V
        5kΩ        Control (5)


       10V
        5kΩ


       10V
        5kΩ




         +
```

```
Threshold(6)    Compartor
         {-         A      }


                              SR
                       Flip       Output (3)
         +                  Flop
Trigger(2)    Compartor
         {-         B          }
                      Reset(4)



          Discharge Transistor       Discharge (7)



                          Ground (1)
```

Block Functions:

Block	Function
Voltage Divider	Creates Vcc/3 and 2Vcc/3 references
Comparator A	Compares threshold with 2Vcc/3
Comparator B	Compares trigger with Vcc/3
SR Flip-Flop	Controls output state
Discharge Transistor	Discharges timing capacitor
Output Buffer	Provides high current output

Working:

- Comparators set and reset flip-flop
- Output buffer amplifies flip-flop output
- Discharge transistor controlled by flip-flop
- Reference voltages set trigger levels

Mnemonic

"Internal Intelligence, Integrated Implementation"

Question 5(c OR) [7 marks]

Explain astable multivibrator using 555 timer IC.

Solution

Astable Circuit:

```
    Vcc

          8 (Vcc)
             4 (Reset)
     R1    7 (Discharge)
            6 (Threshold)
     R2
            5 (Control)
    2
            3 (Output)
           1 (Ground)

     C

      Ground
```

Working Principle:

Charging Phase:

- Capacitor charges through R1 + R2
- Output HIGH during charging
- Charging time: T1 = 0.693(R1 + R2)C
- Voltage rises from Vcc/3 to 2Vcc/3

Discharging Phase:

- Capacitor discharges through R2 only
- Output LOW during discharging

- Discharging time: T2 = 0.693 $\times R2 \times C$
- Voltage falls from 2Vcc/3 to Vcc/3

Frequency Calculations:

Parameter	Formula
Time HIGH	T1 = 0.693(R1 + R2)C
Time LOW	T2 = 0.693 $\times R2 \times C$
Total Period	T = T1 + T2 = 0.693(R1 + 2R2)C
Frequency	f = 1.44/[(R1 + 2R2)C]
Duty Cycle	D = (R1 + R2)/(R1 + 2R2) $\times 100\%$

Waveforms:

```
Vout




           T1   T2
                     Time
              Period T
```

Design Example: For f = 1kHz, D = 60%:

- Choose C = 0.1µF
- Calculate R1 = 7.2kΩ, R2 = 3.6kΩ

Key Features:

- Continuous oscillation without external trigger
- Frequency adjustable by R and C values

- Duty cycle always > 50% in basic circuit
- Stable operation over wide temperature range

Applications:

- LED flashers and blinkers
- Clock generators for digital circuits
- Tone generators for alarms
- PWM signal generation

Modifications for 50% Duty Cycle:

- Add diode in parallel with R2
- Separate paths for charge and discharge
- Equal charge/discharge times possible

Mnemonic

"Astable Always Alternates Automatically"