**Problem statement**

To design and test a circuit to find the zero crossing of AC 1 phase line within the delay range of 1ms at zero crossing.

**Test Equipment required**

1. DMM
2. DSO
3. Rigol power supply
4. Single-phase autotransformer

**BOM**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl no** | **Ref designator** | **mfr part number** | **mfr name** | **description** | **quantity** | **type** | **availability** | **price** |
| 1 | C1 | K104M15X7RF53H5 | Vishay | Ceramic Capacitors - Leaded 100V 100nF 10% | 1 | Through-hole | 1476 | ₹9.70 |
| 2 | D1, D2, D3, D4 | RL1N4007-T | Rectron | Diode 1000V,1A, Vf is 1.1V | 4 | Through-hole | 3365 | ₹11.94 |
| 3 | R1, R2 | CF1/4CT26A105J | KOA Speer | Carbon Film Resistors - Through Hole 1/4W 1MEG, 5%, 300V | 2 | Through-hole | 6900 | ₹7.47 |
| 4 | R3 | CF1/4CT52R104J | KOA Speer | Carbon Film Resistors 100K ohm 5%, 300V, 1/4W | 1 | Through-hole | 66768 | ₹7.47 |
| 5 | R4 | CFS1/4CT52R473J | KOA Speer | Carbon Film Resistors 47K OHM 5% 1/4W,250V | 1 | Through-hole | 8263 | ₹7.47 |
| 6 | R5 | CFS1/4CT52R223J | KOA Speer | Carbon Film Resistors 22K OHM 5% 1/4W,150V | 1 | Through-hole | 1496 | ₹7.47 |
| 7 | R6 | CF1/4CT52R103J | KOA Speer | Carbon Film Resistors 10K ohm 5%1/4W,300V | 2 | Through-hole | 24719 | ₹7.47 |
| 8 | R7 | CFS1/4CT52R242J | KOA Speer | Carbon Film Resistors 2.4K OHM 5% 1/4W,250V | 1 | Through-hole | 2579 | ₹7.47 |
| 9 | R8 | MFR-25FBF52-95K3 | Yageo | Metal Film Resistors 95.3K OHM 1/4W 1% | 1 | Through-hole | 5954 | ₹7.47 |
| 10 | U1 | LM393N | Texas | Analog Comparators  +/-18V,operating voltage range +/-36V | 1 | DIP | 375 | ₹99.28 |

**Theoretical calculations**

**Bridge rectifier Calculations**

Input voltage = 230V AC (RMS)

Bridge rectifier output Vm =

Vm = 325.26V

**Voltage divider Calculations**

Vout= Vin\* Rdown / (Rup+Rdown)

Choose Rdown =22kΩ and required output voltage level = 3.3V

Then 325.26\*22k/(22k+Rup) =3.3

Rup = 2146.4KΩ

**Comparator With hysteresis Calculations**

Total time taken for complete 1 cycle = 1/50 =20ms

Time taken for zero peak value =5ms

Voltage at peak = 3.3V

Then Voltage at 1ms time changes = 3.3/5 = 0.66V

Choose Hysteresis percentage 5%

VL = 0.66+(0.66\*5%) = 0.627

VH = 0.66-(0.66\*5%) = 0.693

R8/ R6 = VL/(VH-VL)

R7 /R6 = VL/(Vcc-VH)

R8/R6 =9.5 R7/R6 = 0.240

Choose R6 = 10kΩ

Then R8 = 95 kΩ

R7 = 2.4 kΩ

**Simulation results**

**Simulation diagram**

**Diagram, schematic

Description automatically generated**

**Input voltage**

Graphical user interface

Description automatically generated

**Bridge rectifier output**

A picture containing text, green, light

Description automatically generated

**Input voltage(Blue) & Bridge rectifier output (Green)**

Graphical user interface

Description automatically generated with medium confidence

**Divider output**

A picture containing text, green, light

Description automatically generated

**Divider output (Green) & Output(Blue)**

A screenshot of a computer

Description automatically generated with low confidence

**Zero crossing at with in 1ms delay range**

A screenshot of a computer

Description automatically generated

**Test table**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl no** | **Vin** | **Bridge rectifier output** | | **Divider output** | | **Comparator Output** | **Result Pass/fail** |
| **Theoretical** | **Practical** |
| **Theoretical** | **Practical** |
| 1 | 50 | 70.7 |  | 0.72 |  |  |  |
| 2 | 100 | 141.4 |  | 1.44 |  |  |  |
| 3 | 150 | 212.3 |  | 2.17 |  |  |  |
| 4 | 200 | 282.8 |  | 2.89 |  |  |  |
| 5 | 230 | 325.26 |  | 3.3 |  |  |  |