BJT Phase Shift Oscillator design

Let take $V_{CC} = 5\,\text{V}, \quad \beta = 110, \quad f = 4096\,\text{Hz}, \quad I_C = 2.5\,\text{mA}, \quad C = 5{\times}10^{-9}\,\text{F(feedback)}$

Since the quiescent point is at the center of the load line,

$$V_{CE} = 0.5V_{CC} = 2.5\,\text{V}, \quad V_{RE} = 0.1V_{CC} = 0.5\,\text{V}$$

Collector Resistor (R_C)

$$V_{RC} = V_{CC} - V_{CE} - V_{RE} = 5 - 2.5 - 0.5 = 2\,\text{V}$$

$$R_C = \frac{V_{RC}}{I_C} = \frac{2}{0.0025} = 800\,\Omega$$

Emitter Resistor (R_E)

$$R_E = \frac{V_{RE}}{I_C} = \frac{0.5}{0.0025} = 200\,\Omega$$

Base Current (I_B)

$$I_B = \frac{I_C}{\beta} = \frac{2.5 \times 10^{-3}}{110}$$

$$= 0.0227\,\text{mA} = 22.7\,\mu\text{A}$$

Bias Resistors (R_1, R_2)

$$I_2 = 10I_B = 0.227\,\text{mA},$$

$$I_1 = I_2 + I_B = 0.25\,\text{mA}$$

$$V_B = V_{RE} + 0.7 = 1.2\,\text{V}$$

$$R_2 = \frac{V_B}{I_2} = \frac{1.2}{0.000227} = 5286\,\Omega \approx 5.3\,\text{k}\Omega$$

$$R_1 = \frac{V_{CC} - V_B}{I_1} = \frac{5 - 1.2}{0.00025} = 15\,200\,\Omega \approx 15.2\,\text{k}\Omega$$

Input Coupling Capacitor (C_{C1})

Capacitor impedance should be less than the input impedance of the amplifier (R_{in}).

$$r_e = \frac{26}{I_E} = \frac{26}{2.5} = 10.4\,\Omega$$

$$h_{ie} = \beta r_e = 110 \times 10.4 = 1144\,\Omega$$

$$R_{in} = R_1 \parallel R_2 \parallel h_{ie} = 15\,\text{k}\Omega \parallel 5.6\,\text{k}\Omega \parallel 1.144\,\text{k}\Omega = 1.05\,\text{k}\Omega$$

$$X_{C1} \leq \frac{R_{in}}{10} = 105\,\Omega$$

Calculate for a lower cut off frequency of 200 Hz

$$C_{C1} = \frac{1}{2\pi f X_{C1}} = \frac{1}{2\pi \times 200 \times 105}$$
$$= 7.57\,\mu\text{F}$$

Bypass Capacitor (C_E)

$$X_{CE} \leq \frac{R_E}{10} = 20\,\Omega$$

Calculate for a lower cut off frequency of 500 Hz

$$C_E = \frac{1}{2\pi f X_{CE}} = \frac{1}{2\pi \times 500 \times 20}$$
$$= 15.9\,\mu\text{F}$$

Feedback Resistor (R)

$$f = \frac{1}{2\pi RC\sqrt{6}} \implies$$
$$R = \frac{1}{2\pi \times 4096 \times 5 \times 10^{-9} \times \sqrt{6}}$$
$$= 3173\,\Omega \approx 3.17\,\text{k}\Omega$$

Final Component Values

Component values are changed little bit by trial and error method for proper working. Parallel combination of components used for non-standard values of components.

Component	**Calculated Value**	**Used Value**
R_C	$800\,\Omega$	$825\,\Omega$
R_E	$200\,\Omega$	$224\,\Omega$
R_1	$15.2\,\text{k}\Omega$	$23.5\,\text{k}\Omega$
R_2	$5.3\,\text{k}\Omega$	$5\,\text{k}\Omega$
R	$3.17\,\text{k}\Omega$	$3.195\,\text{k}\Omega$
C_{C1}	$7.57\,\mu\text{F}$	$10\,\mu\text{F}$
C_E	$15.9\,\mu\text{F}$	$22\,\mu\text{F}$