DIGITAL COMMUNICATION LAB

Electrical Engineering Department

Experiment 4: Power Spectral Density

AIM: Power Spectral Density of a signal using sample and hold circuit.

Components Required:

- Breadboard
- Arbitrary Function Generator (AFG)
- Mixed Signal Oscilloscope (MSO)
- BJT 547
- Resistors: 100 Ω,1k Ω
- Capacitor: 0.1μF
- Wires and Probes

Theory

Sample-and-Hold circuit

A sample-and-hold circuit samples the input signal (in this case, a sine wave) at regular intervals and holds the sampled value until the next sampling period.Basically it creates the sample of voltages as the input term and after that holds these samples for a definite period of time. Capacitor stores the sampled voltage during the holding phase.

Power Spectral Density (PSD) of the Sampled Signal

When a sine wave is passed through a sample-and-hold circuit, the output signal is a series of pulses, which can be considered as a multiplication of the sine wave with a pulse train. This operation modulates the sine wave, and its spectrum will be affected. The key steps to calculate the PSD include: Original Sine Wave: The input sine wave has a frequency f_0 and its power spectral is a delta function centered at - f_0 and $+f_0$.

Sampling Process: The sampling introduces a repetition of the spectrum at multiples of the sampling frequency f_s.

Sample-and-Hold Effect: The sample-and-hold circuit adds a sinc function envelope to the spectrum.

The resulting power spectral density S(f) can be approximated as:

$$S(f) \approx \operatorname{sinc}^2\left(\frac{\pi f}{f_s}\right) \cdot \delta\left(f - f_0\right) \tag{0}$$

Bandwidth Measurements:

3 dB Bandwidth (Half-Power Bandwidth): This is the bandwidth within which the power drops by 3 dB from the peak power level. For the sinc function, the 3 dB bandwidth is determined where the sinc functionâs magnitude falls to $\frac{1}{\sqrt{2}}$ of its maximum value.

Absolute Bandwidth: The absolute bandwidth can extend beyond the 3 dB point, but is often considered to be the bandwidth of the main lobe (where the spectrum has significant power), which can be taken as fs.

Null-to-Null Bandwidth: The bandwidth between the first nulls.

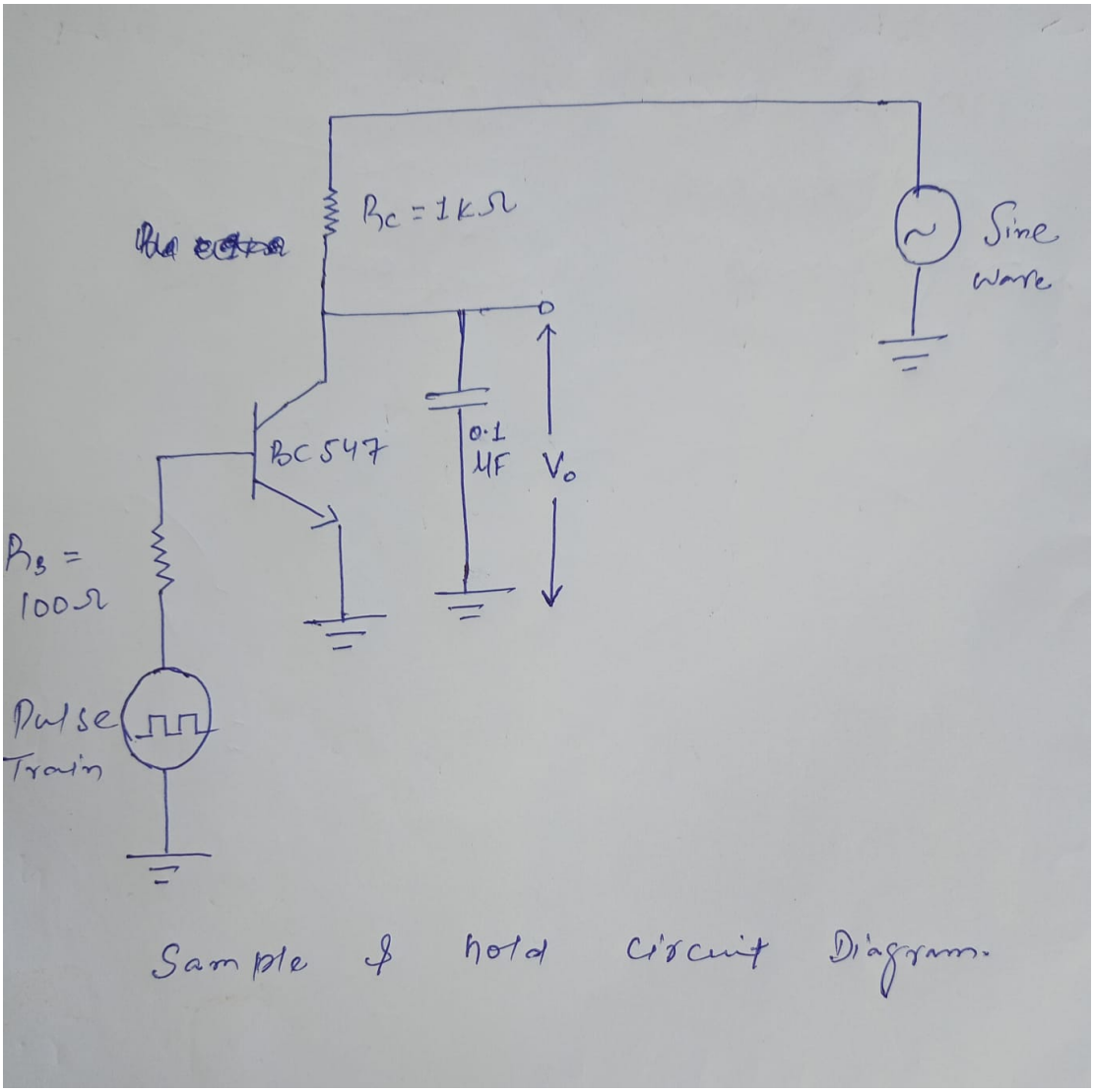

Figure 1: Circuit Diagram of Sample and hold circuit

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Take the sine wave as input from the function generator.
3. Fix the frequency, amplitude, and offset voltage for the input signals.
4. Take Pulse train signal at the base of BJT.
5. Take the output through capacitor and observe the sampled data.

Plot the waveform of input, output signal and PSD

Observation Table

I/P	f_0	f_s	**3 dB BW**	**Absolute BE**	**Null-null BW**
SINE WAVE					
SQUARE WAVE					

Conclusion: Successfully observed the PSD of Sine and Square wave analog input signal.