The input power range is -20 dBm to 6 dBm, with a 600 Ω balanced impedance. We need to convert these power levels to voltage levels to design the circuit.

Power to Voltage Formula: The power in dBm is defined as:

$$P_{\text{dBm}} = 10 \cdot \log_{10}\left(\frac{P_{\text{watt}}}{0.001}\right)$$

where

P_{watt}

is the power in watts, and 0.001 W = 1 mW is the reference.

Power in watts is related to RMS voltage :

$$P_{\text{watt}} = \frac{V_{\text{rms}}^2}{R}$$

Substituting into the dBm formula:

$$P_{\text{dBm}} = 10 \cdot \log_{10}\left(\frac{\frac{V_{\text{rms}}^2}{R}}{0.001}\right) = 10 \cdot \log_{10}\left(\frac{V_{\text{rms}}^2}{R \cdot 0.001}\right)$$

Solving for

$$\frac{V_{\text{rms}}^2}{R \cdot 0.001} = 10^{\frac{P_{\text{dBm}}}{10}}$$

$$V_{\text{rms}} = \sqrt{10^{\frac{P_{\text{dBm}}}{10}} \cdot R \cdot 0.001}$$

Given

R = 600 ohm,

$$R \cdot 0.001 = 600 \cdot 0.001 = 0.6$$

$$V_{\text{rms}} = \sqrt{10^{\frac{P_{\text{dBm}}}{10}} \cdot 0.6}$$

So Calculate for -20 dBm:

$$10^{\frac{-20}{10}} = 10^{-2} = 0.01$$

$$V_{\text{rms}} = \sqrt{0.01 \cdot 0.6} = \sqrt{0.006} \approx 0.07746\text{V} = 77.46\text{mV}$$

Peak voltage

$$V_{\text{peak}} = 0.07746 \cdot 1.4142 \approx 0.1096\text{V} = 109.6\text{mV}$$

Calculate for 6 dBm:

$$10^{\frac{6}{10}} = 10^{0.6} \approx 3.981$$

$$V_{\text{rms}} = \sqrt{3.981 \cdot 0.6} = \sqrt{2.3886} \approx 1.5455\text{V}$$

Peak voltage:

$$V_{\text{peak}} = 1.5455 \cdot 1.4142 \approx 2.189\text{V}$$

Voltage Range:

- RMS: 77.46 mV to 1.5455 V
- Peak: 109.6 mV to 2.189 V

Modulation Ratio Impact

The modulation ratio of 2:1 to 6:1 means the high amplitude

$$\frac{V_{\text{high}}}{V_{\text{low}}} = 2 \text{ to } 6$$

For the minimum input (-20 dBm, 109.6 mV peak), the low amplitude at 6:1 is:

$$V_{\text{low}} = \frac{109.6}{6} \approx 18.27\text{mV}$$

The circuit must resolve this low amplitude, requiring high-resolution ADC and low-noise amplification.

Frequency and Bandwidth

- Carrier: 1 kHz
- Frame Rate: 1 Hz (100 bits/s, B122 format)
- Bandwidth: Modulation sidebands are narrow (<10 Hz), but harmonics and noise require a bandwidth of ~10 kHz for anti-aliasing.