



TOPICS

1. Windowing and Spectral Leakage

- Why it's needed before FFT
- Common windows: Hamming, Hanning, Blackman
- Effect on frequency resolution and leakage

2. Filtering in Frequency and Time Domains

- FIR vs IIR filters
- Design using Python (`scipy.signal.firwin` , `butter` , `lfilter`)
- Understanding poles, zeros, and frequency response
- Practical: Build a bandpass filter and apply to signal

3. Sampling Theorem and Aliasing

- Nyquist rate
- Aliasing and how to detect/fix it
- Practical resampling using `scipy.signal.resample`

4. Z-Transform and System Stability

- A generalization of the DTFT
- Region of convergence (ROC), causality
- Connection to filter design and stability

5. Correlation and Cross-Correlation

- Matched filtering, signal detection
- Auto-correlation vs cross-correlation
- Application to synchronization, timing, and pattern matching

6. Power Spectral Density (PSD) and Spectrograms

- Welch method, periodogram
- Visualizing time-varying spectra
- Practical with `matplotlib.specgram` or `scipy.signal.welch`

7. Modulation and Demodulation (Analog + Digital)

- AM, FM, BPSK, QPSK, etc.
- IQ representation of modulated signals
- Simulations using NumPy and SDR tools

8. Real-Time DSP Concepts

- Overlap-add / Overlap-save
- Block processing
- Latency and buffer management in SDR

✂ Suggested Python Practicals Alongside

Concept	Python Tool
Windowing	<code>np.hamming</code> , <code>np.blackman</code>
Filtering	<code>scipy.signal.firwin</code> , <code>lfilter</code> , <code>freqz</code>
Spectrogram	<code>matplotlib.pyplot.specgram</code> , <code>scipy.signal.spectrogram</code>
Correlation	<code>np.correlate</code> , <code>scipy.signal.correlate</code>
Modulation	Simulate AM/FM/BPSK using NumPy
PSD	<code>scipy.signal.welch</code> , <code>matplotlib.mlab.psd</code>

💡 Learning Strategy

- Alternate **conceptual topics** (like Z-transform) with **practical labs** (like filtering).
- Consolidate your understanding by **visualizing signals** before and after applying a technique.
- Use **Think DSP**, **PySDR**, and real RTL-SDR signals to practice each concept on actual IQ data.

Would you like me to build a **4-week learning plan** using these topics based on your current pace (e.g. 1–2 topics per week with practice)?