Here's a **well-organized reference table** of commonly used **discrete-time filters** — especially useful for DSP and SDR applications — with their:

- **Type & Impulse Response (`h[n]`)**
- **Purpose**
- **Physical Interpretation**
- **Key Use Cases / Notes**

📃 Practical Filters Reference Table (for DSP/SDR)

Type of Filter	Impulse Response `h[n]`	Purpose	Interpretation	Notes / Use Case
Moving Average	`[1/N, 1/N, ..., 1/N]` (length N)	Smoothing / noise reduction	Averages local values to reduce random fluctuations	Low-pass filter; reduces high-frequency noise in IQ signals
First Difference	`[1, -1]`	Change detection	Outputs slope between adjacent points	Edge detection, start of signal burst, FM demodulation
Second Difference	`[1, -2, 1]`	Curvature detection	Measures rate of change of slope	Detects inflection points or fast changes; useful in BPSK demod
Echo Filter	`[1, 0, 0.5]`	Simulate multipath /	Adds delayed version of	Models wireless

Type of Filter	Impulse Response `h[n]`	Purpose	Interpretation	Notes / Use Case
		echoes	signal	reflections or reverberation
Spike Detector	`[-1, 2, -1]`	Peak emphasis	Highlights central peaks over neighbors	Used in transient or attack detection (e.g. radar, sonar)
Matched Filter	Time-reversed known sequence	Signal detection	Maximizes SNR for that pattern	Used in packet/ preamble detection in SDRs
Sinc Filter	`sinc()` (windowed)	Ideal low-pass filter	Preserves slow-varying trends; removes fast ones	Basis of anti-aliasing filters, resampling IQ data
Gaussian Filter	Discrete Gaussian (e.g., `[0.25, 0.5, 0.25]`)	Gentle smoothing	Smooths without harsh cutoffs	Better than moving average for preserving shape
High-Pass Filter	`[1, -2, 1]`, or `[-1, 1]`	Isolate sharp variations	Removes slow background changes	Detects fast signal transitions (used in envelope removal)

Type of Filter	Impulse Response `h[n]`	Purpose	Interpretation	Notes / Use Case
Band-Pass Filter	Derived from difference of low-pass filters	Keep signal in certain freq range	Keeps modulated carrier, removes baseband or out-of-band	Used in demodulators, channel extraction
Integrator	`[1, 1, 1, ..., 1]` (cumulative sum)	Energy accumulation	Summed energy over time	Used in power detection, moving average of amplitude
Differentiator	`[1, -1]`, or `[0.5, 0, -0.5]` (central diff)	Detect rate of change	Tracks signal slope	Basis for phase/ frequency tracking in SDRs
Impulse (Identity)	`[1, 0, 0, ...]`	No filtering	Pass-through (reference)	Used to validate convolution system behavior
Delta Comb	`[1, 0, 0, 1, 0, 0, 1, ...]`	Sub-sampling / echo-like response	Regular echoes	Used in modeling pulse trains or sampling effects

⯑ Bonus: How to Design or Recognize a Filter

Feature	What to Look For
Smoothing	Positive taps summing to 1, centered
High-pass	Positive and negative taps, sum = 0
Matched	Reverse of known pattern (maximize correlation)
Symmetry	Linear phase; non-distorting
Decay	Echo or reverberation
Spike-like	Central large value with flanking negatives (second derivative)

🎯 Relevance to Your SDR Standards Project

When handling IQ data:

- You'll need to **simulate channel effects** → use echo, multipath filters.
- For **pre/post-processing**: smooth noise (`moving average`), detect modulation changes (`difference filters`), extract carriers (`band-pass`).
- When testing compliance → use **matched filters** to detect known signal structures.