Assignment 1 – Exploring Digital vs. Analog Signal Processing with GenAI

Course: Introduction to Signal Processing (Statistics & Data Science, HUJI)
Instructor: Dr. Barak Sober

Why this assignment?

Signal processing spans two complementary worlds:

- **Analog processing** (continuous-time signals) using circuits and physical media.
- **Digital processing** (discrete-time signals) using algorithms on sampled data.

Large language models (LLMs) and multimodal GenAI tools can help you map this landscape quickly—*but only if you prompt and validate thoughtfully*. This assignment warms you up for the course by having you interrogate AI tools and then synthesize what you learn with your own reasoning.

Learning goals

By the end, you should be able to:

1. Distinguish analog vs. digital processing and identify common operations in each domain.
2. Recognize typical **signal chains** (sensor → conditioning → sampling/ADC → DSP → actuation/DAC) and where analog/digital steps live.
3. Practice **prompt engineering**, **source checking**, and **reproducible reporting** when using GenAI.
4. Communicate findings clearly with concise tables and diagrams.

Your task (at a glance)

1. **Pick any GenAI chat interface** you like (e.g., ChatGPT, Claude, Gemini, Copilot, Perplexity, etc.).
2. **Investigate**: For at least **six** different real-world signals/domains, ask the model which parts of the processing pipeline are analog vs. digital today, and why.
3. **Compare across at least two models** (e.g., ChatGPT vs. Gemini). Note divergences and hallucinations.
4. **Synthesize** your findings in a short report with a summary table, mini case studies, and a reflection on limitations.

5. **Tip**: If a model gives confident but dubious claims, *cross-examine* another model or search engine. Note disagreements.

Signals / domains (choose ≥6)

Pick broadly across science/engineering; feel free to add your own. Examples:

- **Audio & speech** (microphones, preamps, ADC, DSP for noise reduction, codecs).
- **Images / video** (CMOS sensor, color filter array, ISP pipeline, compression, CV).
- **Wireless RF** (mixers/filters/LNAs, SDRs, channelization, demodulation, beamforming).
- **Biomedical** (ECG/EEG/EMG, analog front-ends, sampling, filtering, feature extraction).
- **Seismology & geophysics** (geophones, anti-aliasing filters, spectral analysis).
- **Radar / LiDAR / sonar** (chirp generation, analog mixing, ADC, FFT/CFAR).
- **IoT sensors** (temperature/pressure/IMU pipelines, sensor fusion).
- **Power/energy systems** (phasor measurement, PWM control, inverters).
- **Financial time series** (entirely digital; discuss sampling/aggregation).
- **Natural language** (token streams; discuss what "signal" means here).

Deliverables

A. Two-page report (max ~1000 words) as PDF, containing:

- **Executive summary (≤150 words).**
- **Table** mapping domain → example signal → key components → **Analog vs. Digital** classification → sampling rate/bit depth (typical) → notes on why.
- **Two mini case studies** (≈150–200 words each) with small block diagrams for two different domains.
- **Reflection (≈200 words)** on: (i) where analog persists and why, (ii) where digital dominates and why, (iii) limits of the GenAI tools you used.

B. Appendix (no page limit):

- The **exact prompts**, model names/versions, and dates/times, plus key screenshots or transcripts.

Required summary table (template)

DOMAIN	EXAMPLE SIGNAL	ANALOG STAGES	DIGITAL STAGES	SAMPLING RATE (TYPICAL)	BIT DEPTH (TYPICAL)	NOTES/WHY
AUDIO	Speech via electret mic	Mic, preamp, anti-alias, Low Pass Filter	Analog to Digital Converter (ADC), noise reduction, codec	16–48 kHz	16–24 bit	Front-end analog for SNR; DSP for features/compression
…	…	…	…	…	…	…

Hints and pitfalls

- **Analog isn't obsolete.** Front-ends (mixers, filters) remain analog in many RF/biomed chains due to noise figure, linearity, and sampling limits.
- Digital excels at flexible, complex algorithms (adaptive filtering, FFT-based spectral methods, ML), once data are sampled.
- **Beware of overclaims.** Some models misstate feasible sampling rates/bit-depths for certain sensors; sanity-check with first principles (Nyquist, dynamic range) or a quick authoritative search.
- **Diagrams help.** A tidy block diagram often reveals misunderstandings immediately.

Submission & format

- Submit via **Moodle**.
- **Due:** 27.10.2025
- PDF only; include your name, ID, and course code on the first page.

Academic integrity & AI use policy

- You are **encouraged** to use GenAI for discovery and drafting, but **you are accountable** for the correctness of your submission.
- **Disclose** exactly which tools you used and how.
- **Cite** any external sources the model or you rely on.
- **Do not** submit AI output verbatim without verification.

Have fun—and be skeptical.