2-D Mapping with Sonar

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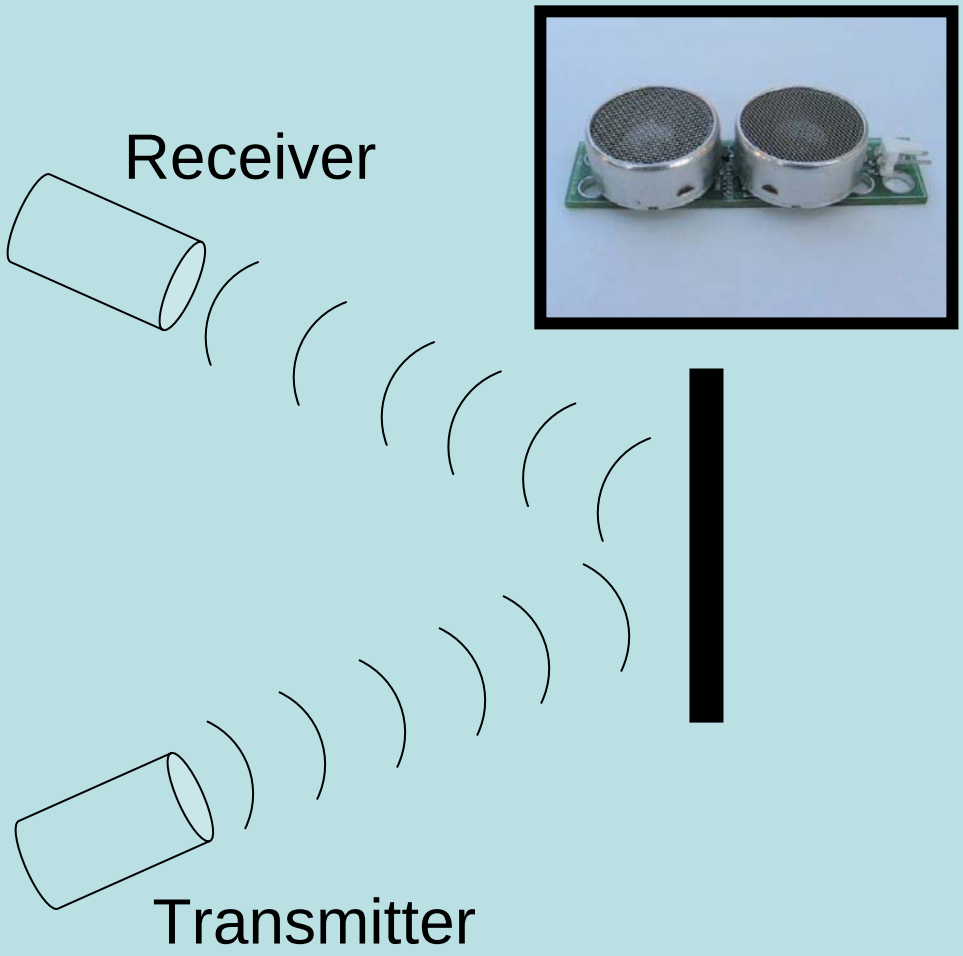
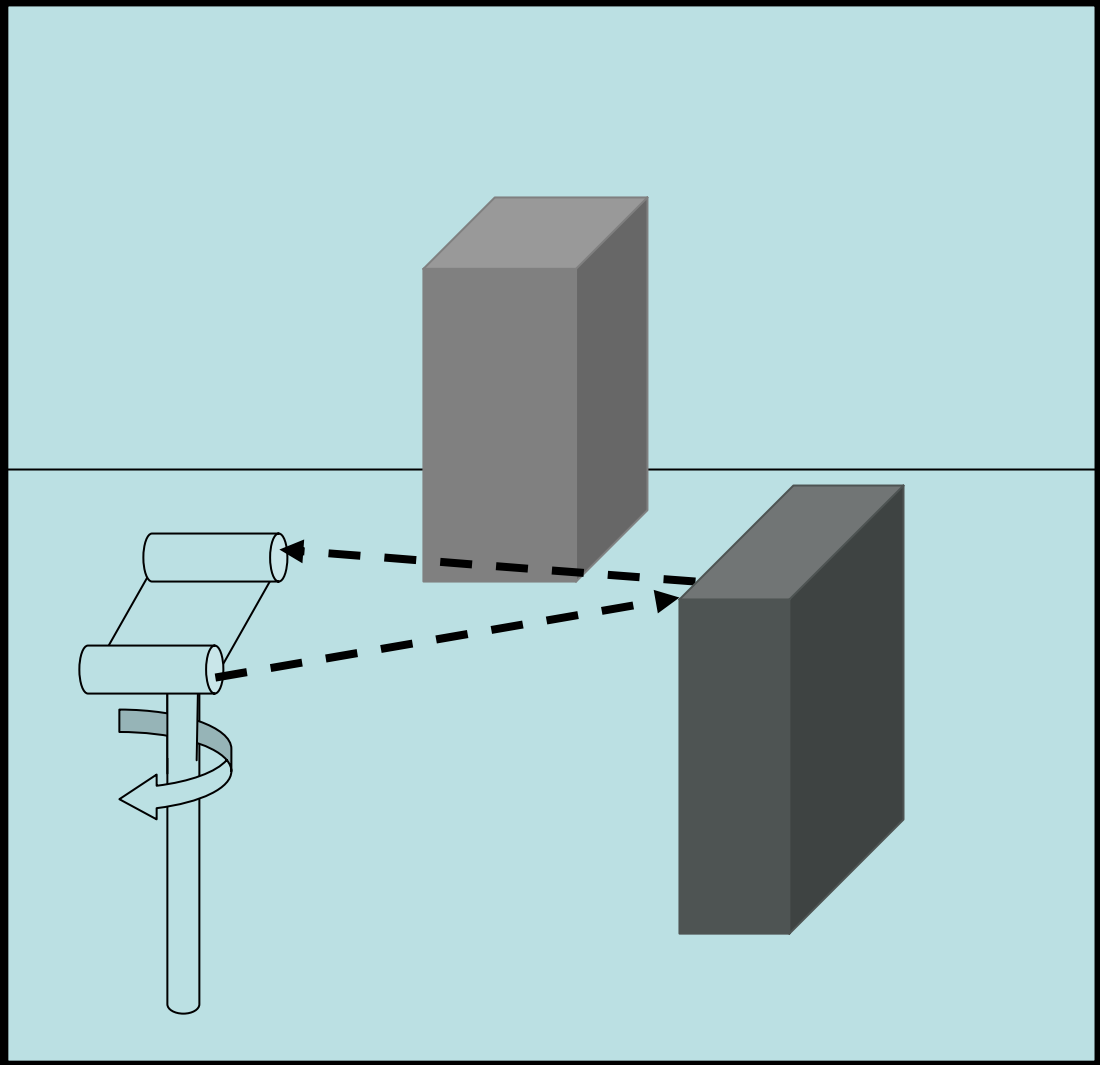
Basic Sonar



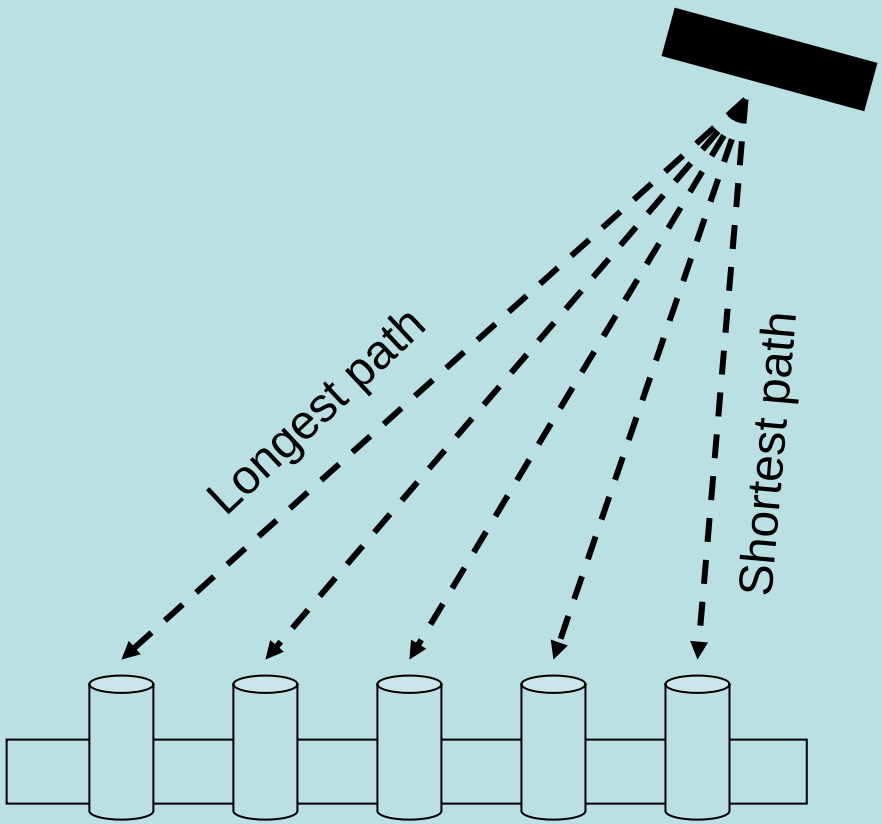
- Ultrasound cannot be heard by people
- Small wavelength => good for short distances
- Time of flight can be used to estimate distance

Basic Mapping



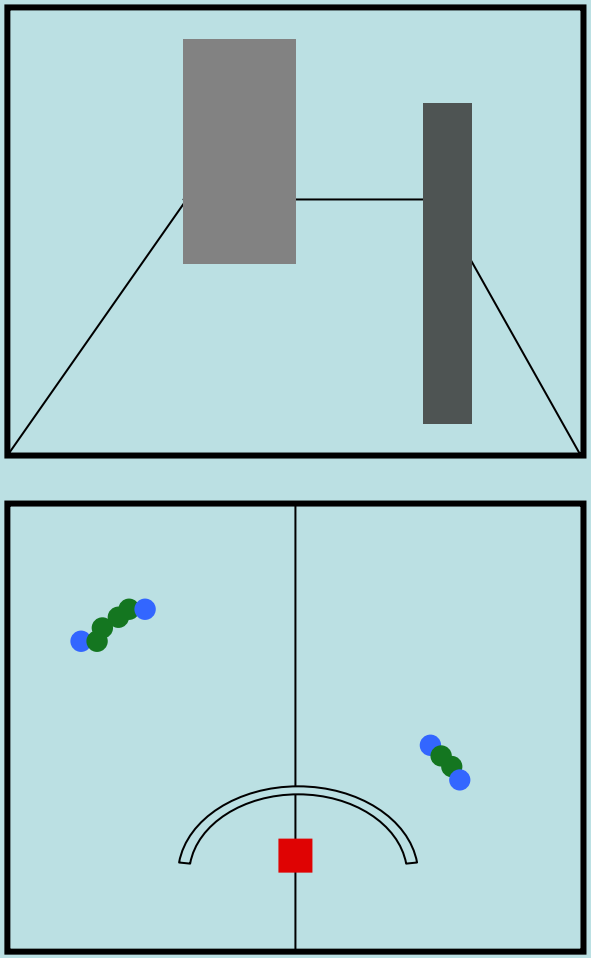
- Rotate receiver/ transmitter to measure distance at every angle
- Slow update rates because of many distance measurements

Phase Array



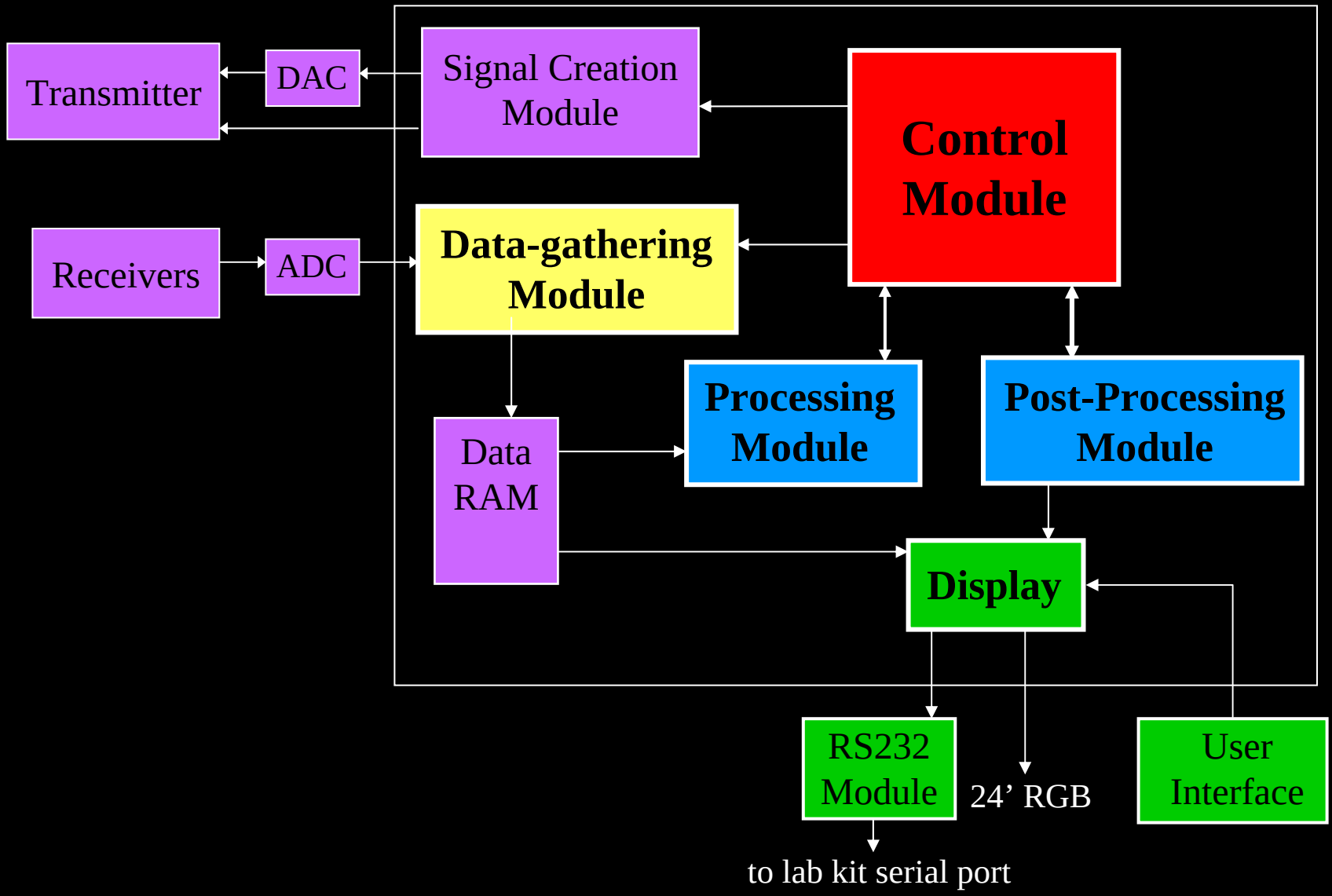
- Use multiple receivers, measure different angles using phase relationships
- No moving parts => more reliable
- Faster update rate

Applications



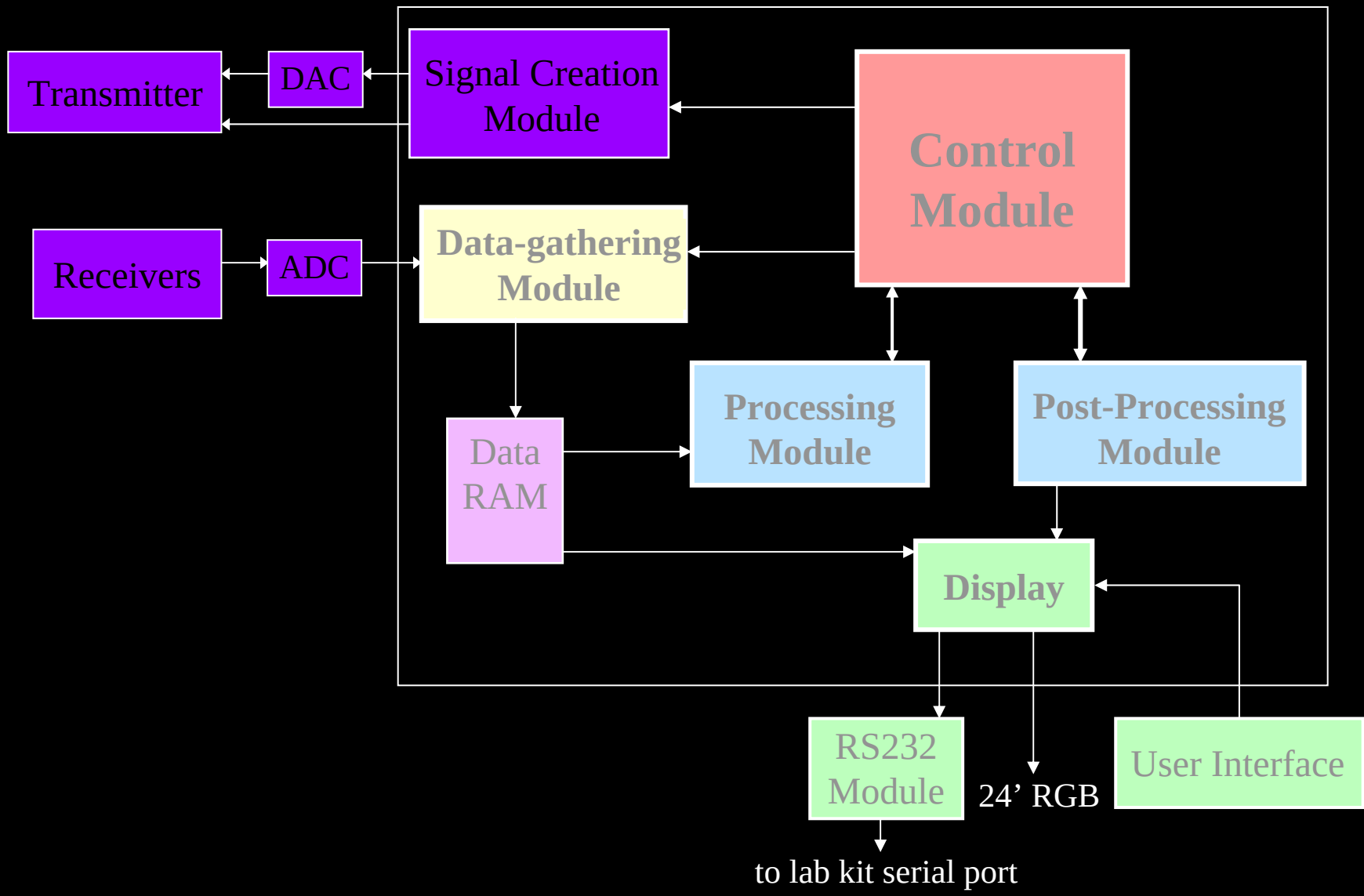
- Draw a top view map of environment
- Security system that detects changes in surroundings

Simplified Block Diagram

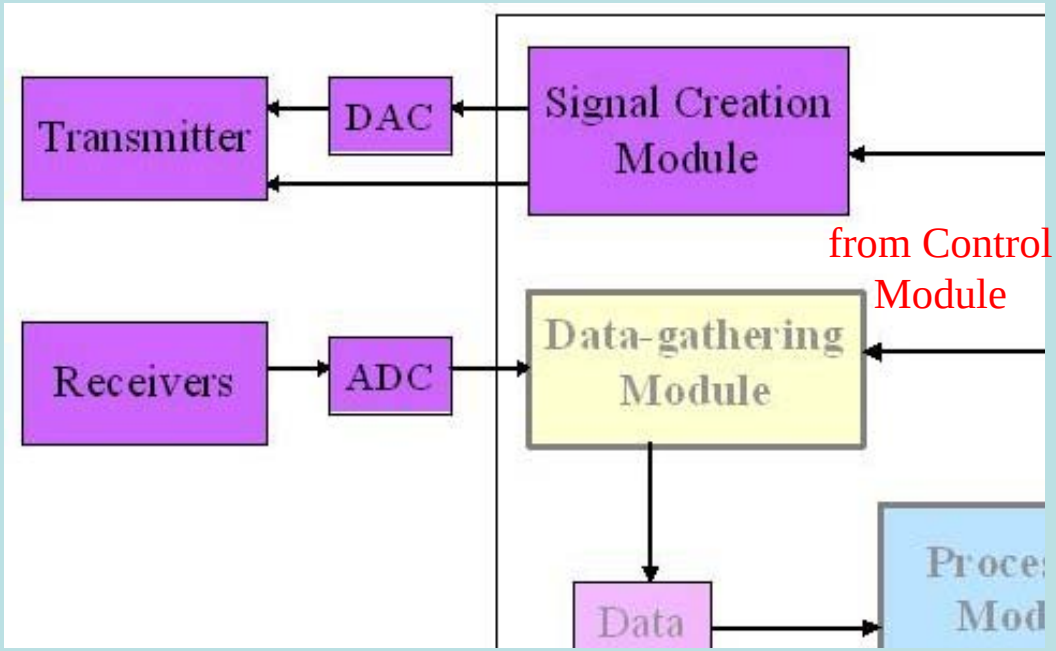


Transmit/Receive

Data-gathering | Control/Process | Display/Interface



Transmit/Receive



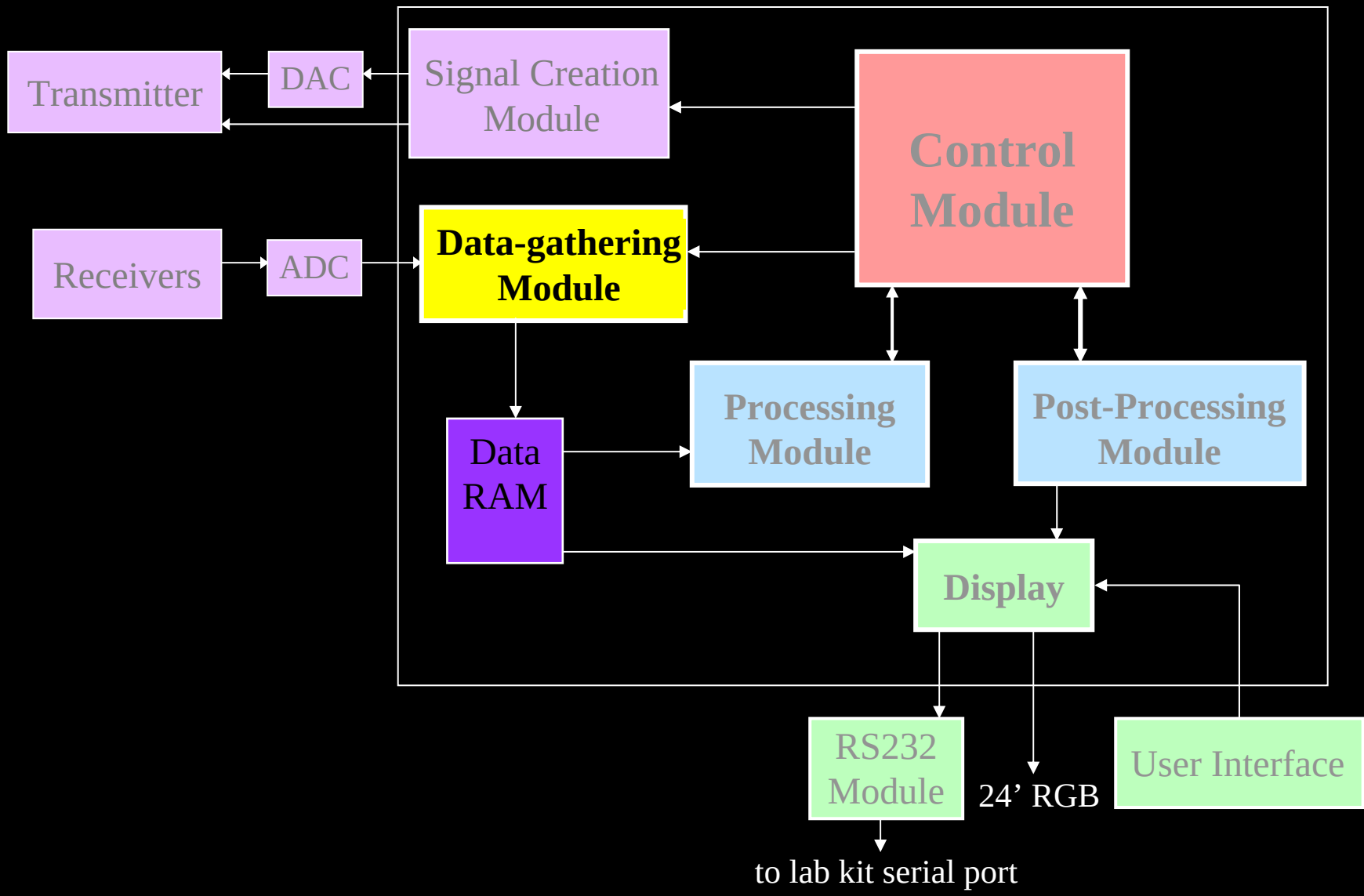
- Transmit a single 40-kHz sine wave pulse (generated from stored values played through DAC)
- Multiple receivers
- Enable signals from Control Module for transmitting and receiving

Data-gathering

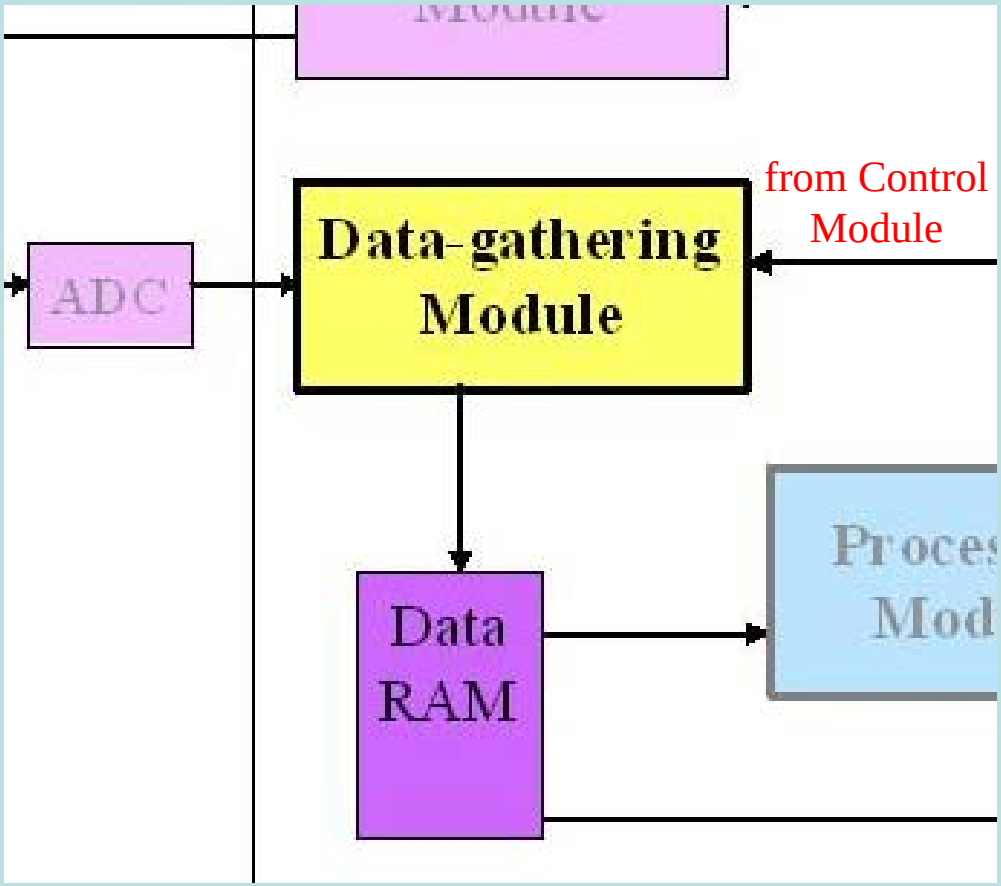
Transmit/ Receive

Control/ Process

Display/ Interface



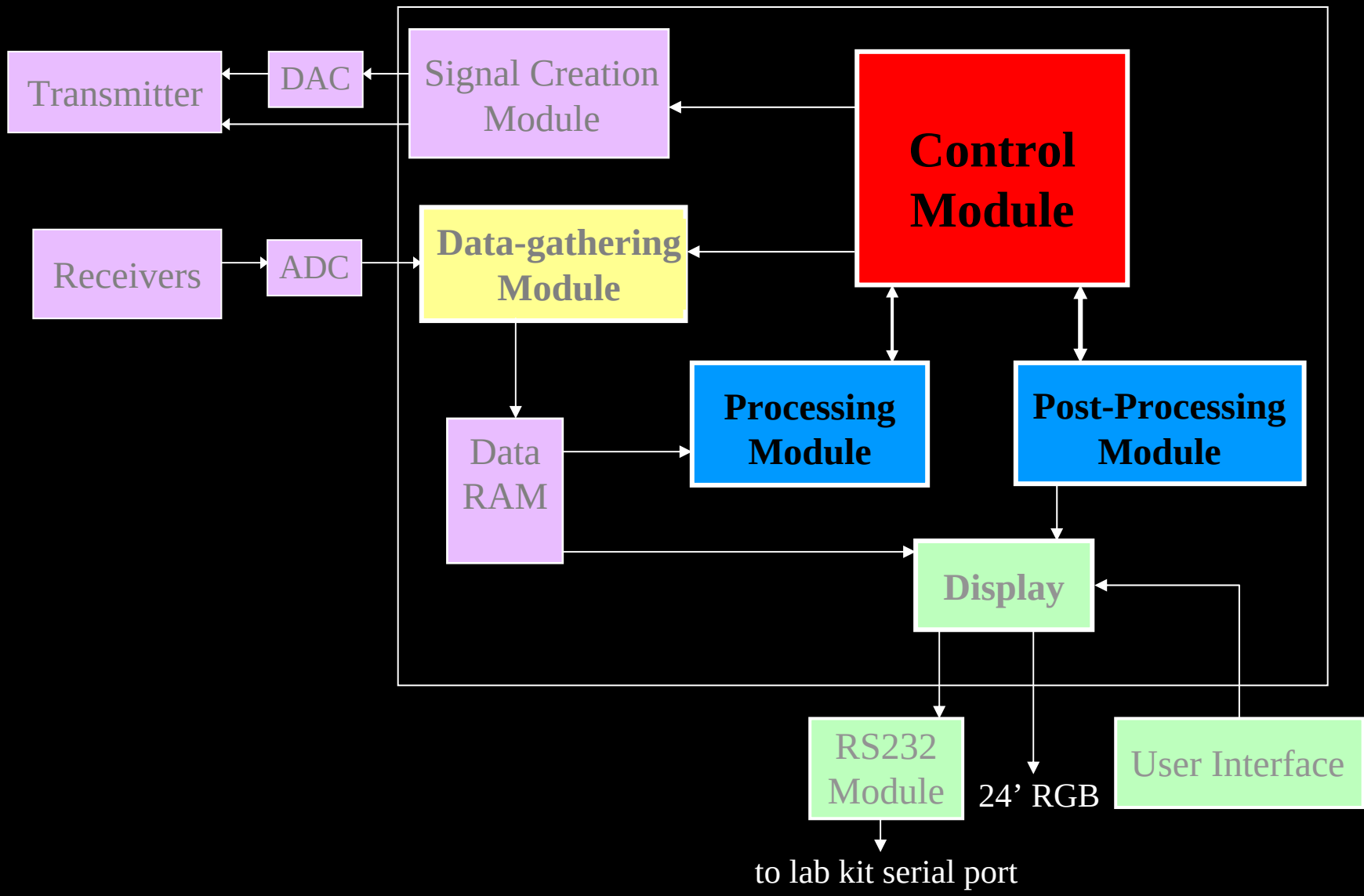
Data-gathering



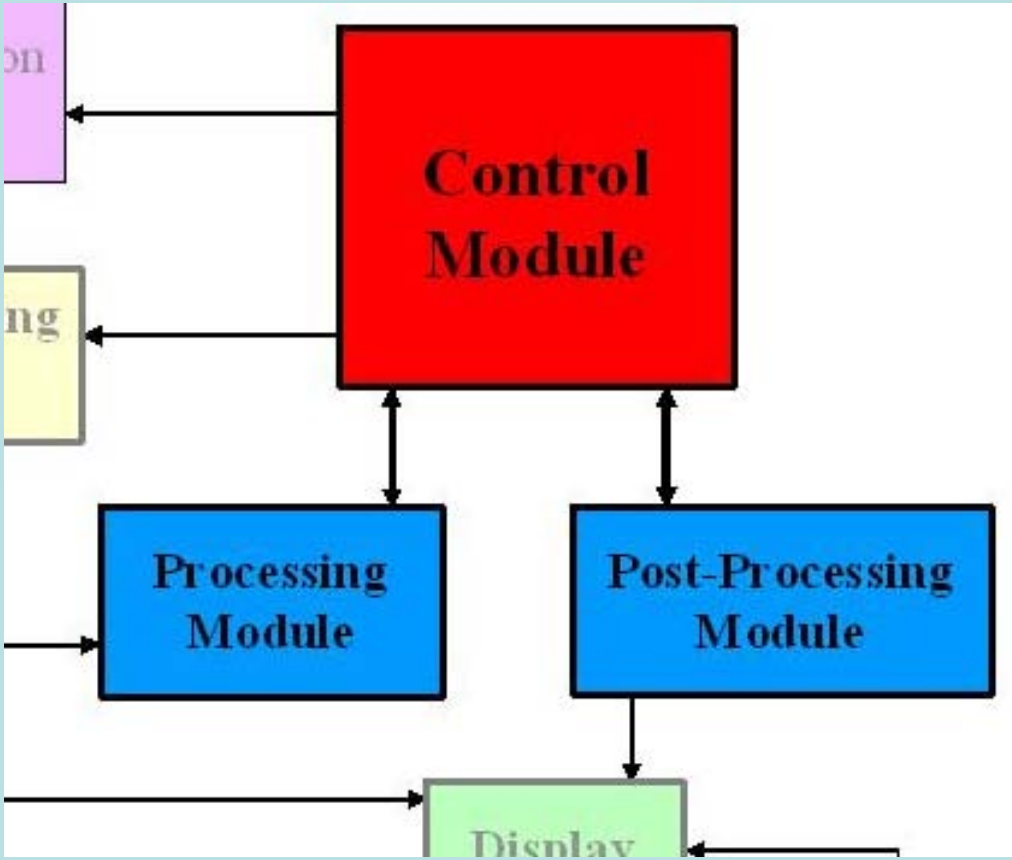
- Samples data from receivers at intervals dictated by Control Module
- Data stored in one of two RAMs
- Simultaneous storage and processing of data—“double buffering”

Control/Process

Transmit/ Receive | Data-gathering | Display/ Interface



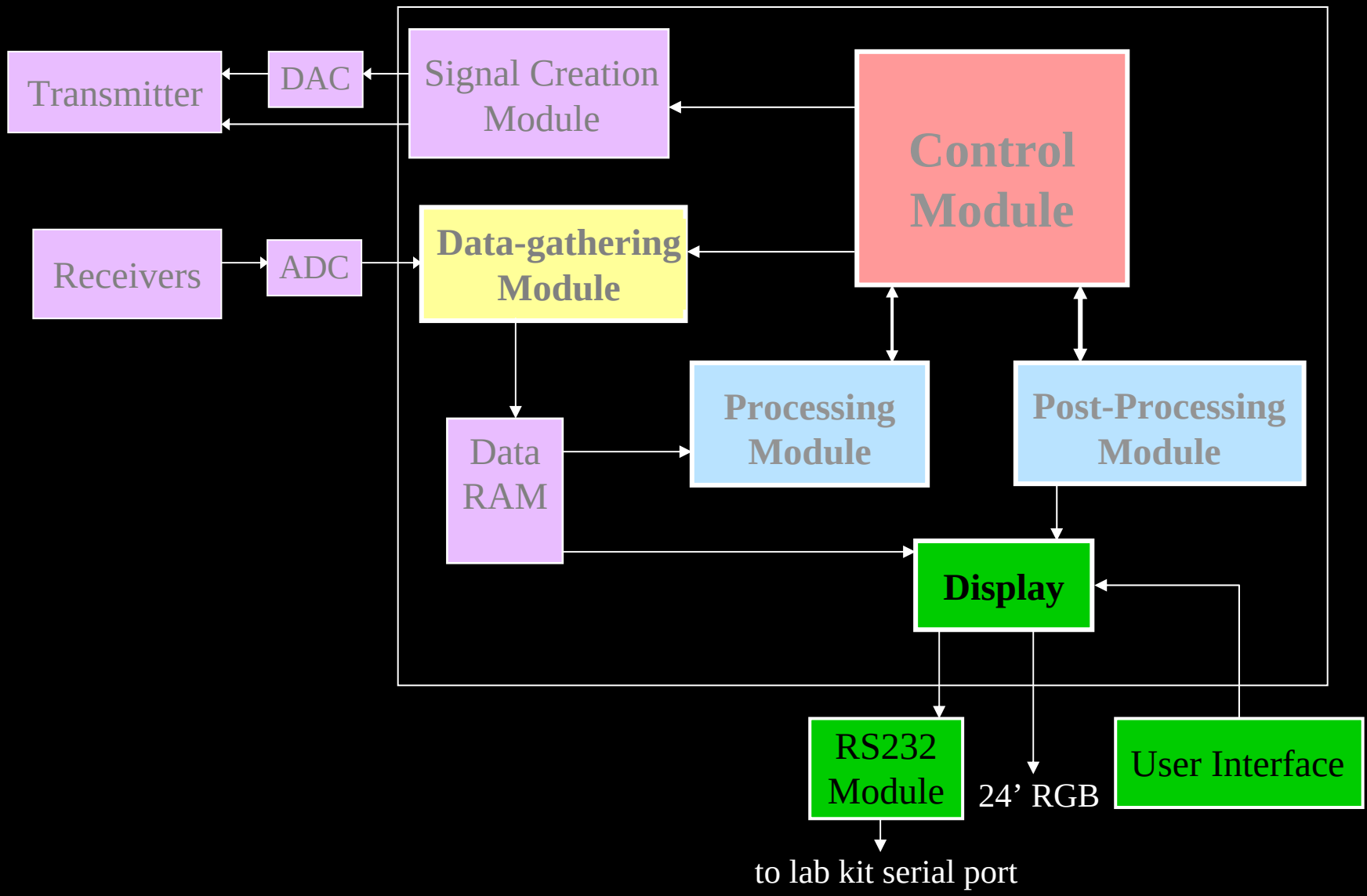
Control/Process



- Control Module gives Processing Module an angle; Processing Module gives back distance at that angle
- Post-Processor gets angle/distance pairs ready for display and tells Control Module if more data is needed

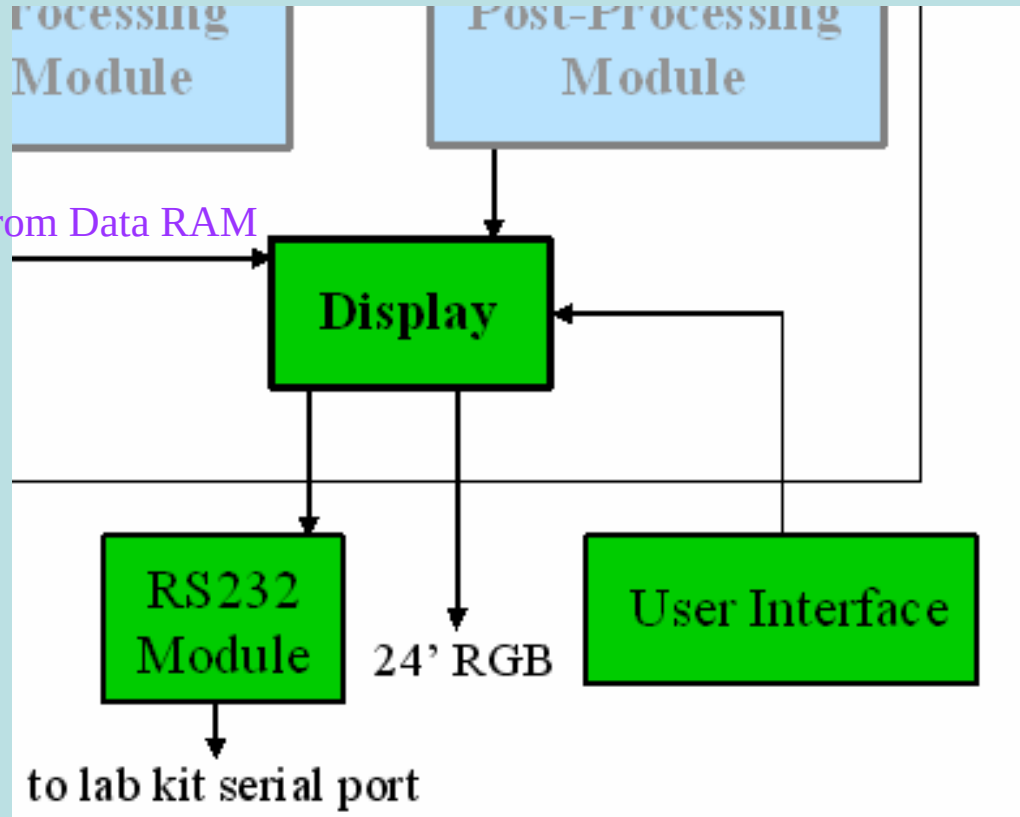
Display/Interface

Transmit/ Receive | Data-gathering | Control/ Process



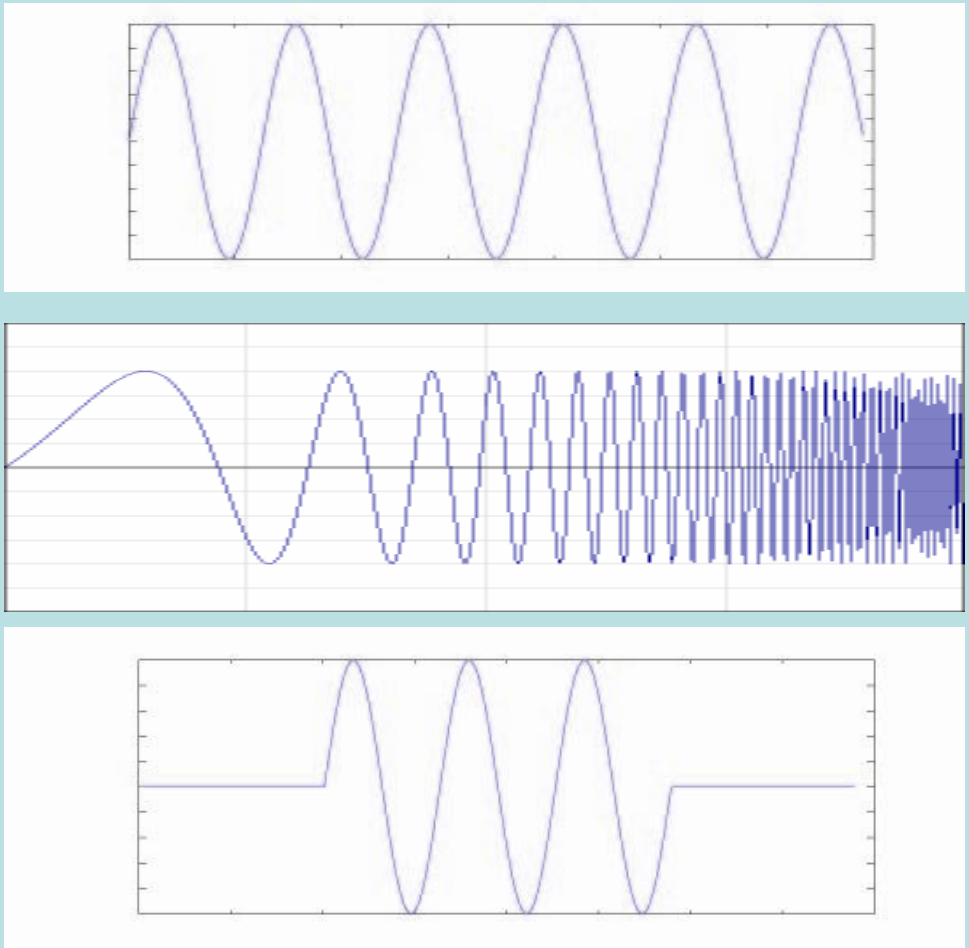
Transmit/ Receive | Data-gathering | Control/ Process

Display/Interface



- Display Module gives VGA controller appropriate RGB signals
- Main purpose is to draw a 2-D, color-coded map of the environment
- RS232 Module is for debugging
- User can choose what is displayed

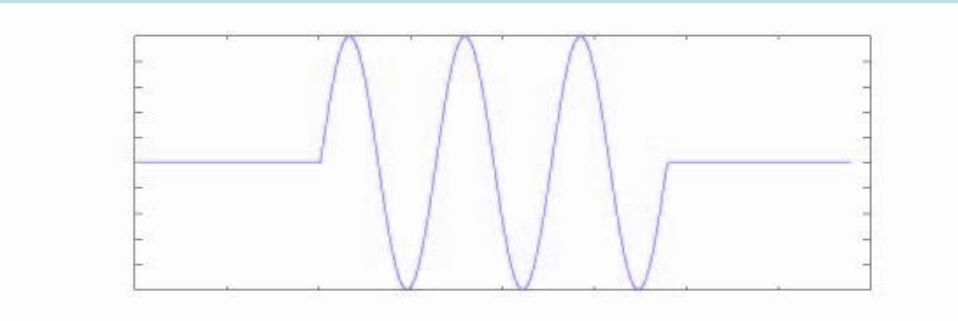
Sines, Chirps, and Pulses



- What kind of signal to transmit?

- Steady Sine Wave
- Chirp (linearly changing frequency)
- Short pulsed sine wave

Sines, Chirps, and Pulses



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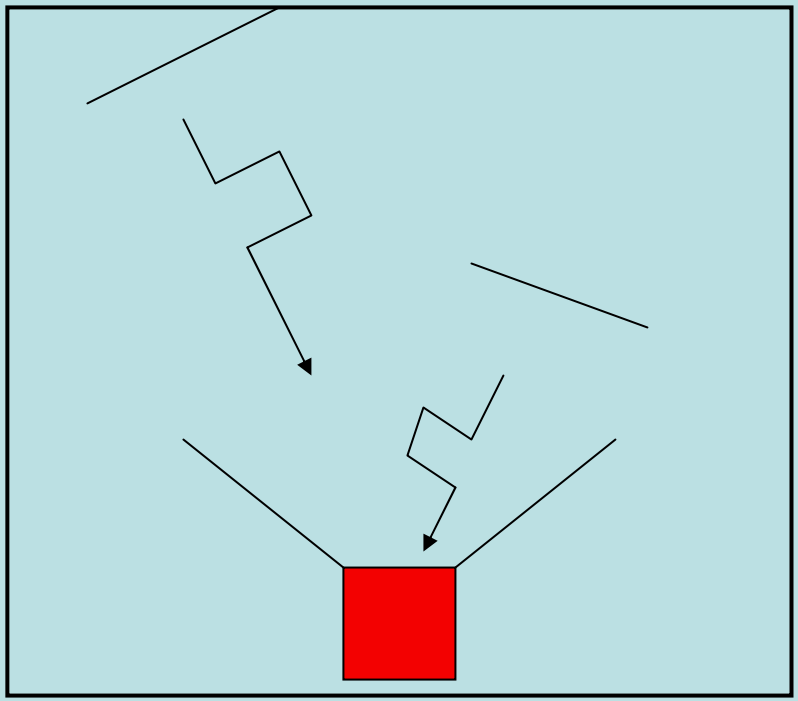
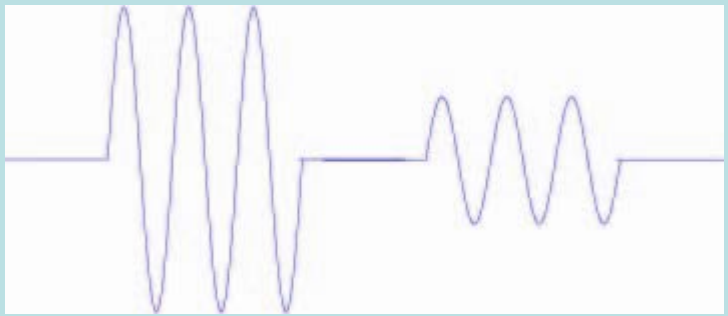
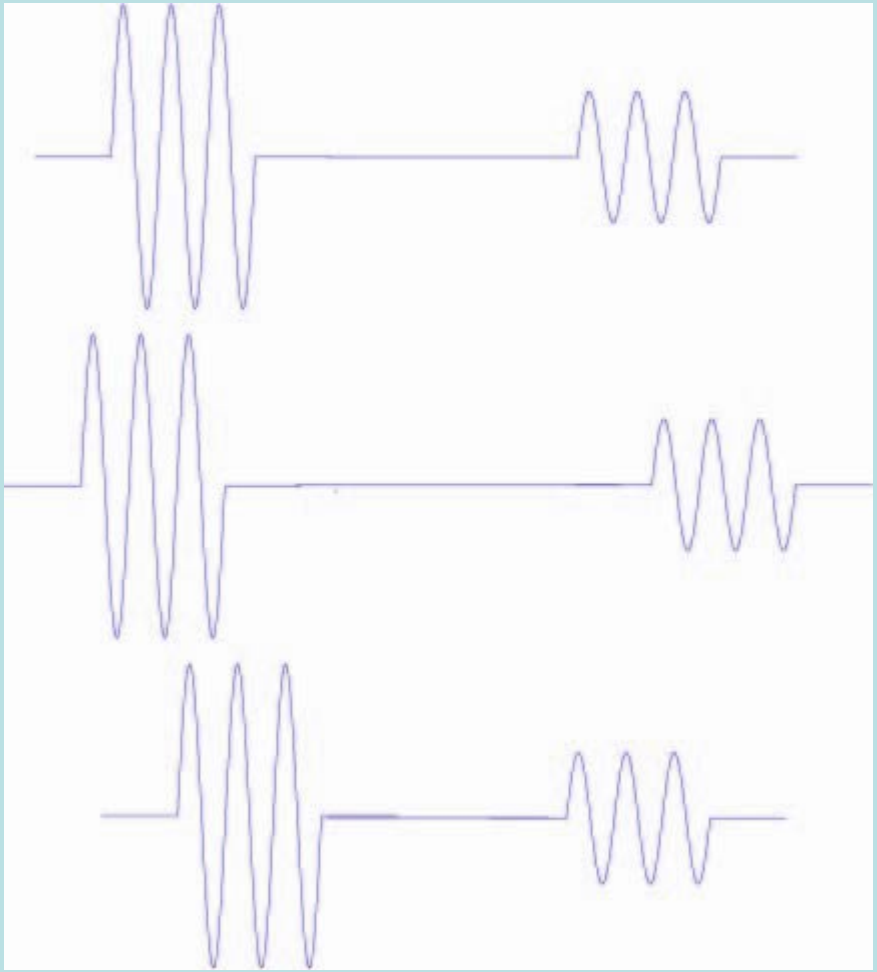
Game Plan





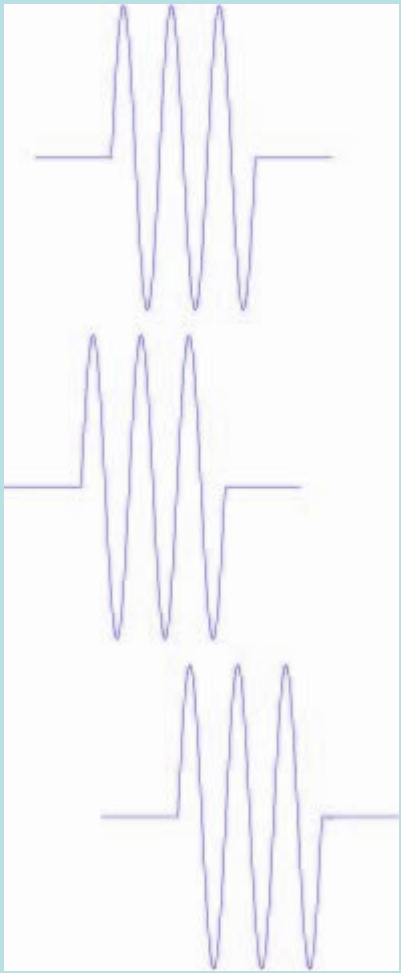
- Send a pulse, receive attenuated & shifted signal

Game Plan



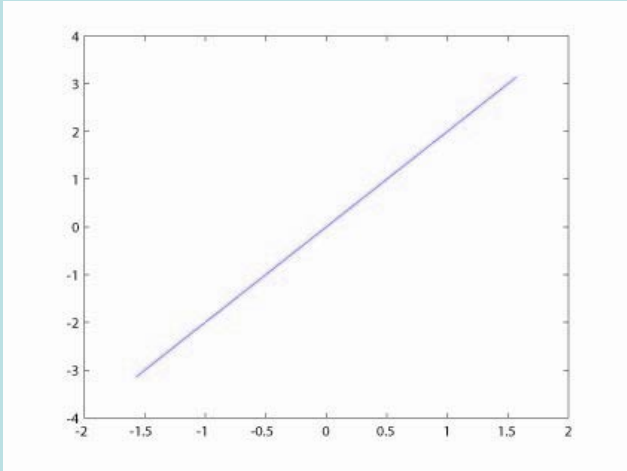
- For each reflection, different receivers have similar attenuation, but slight phase shifts.
- Can expand as 2 delays:
  - Object to receiver 1 - **DISTANCE**
  - Receiver 1 to Receiver N - **DIRECTION**

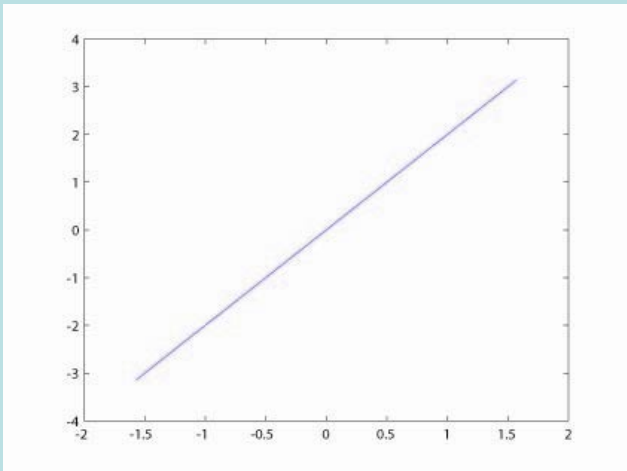
The Process



1. Find where a certain phase relation is most likely to have occurred (similar to matched filtering)
2. Record the delay to this region of the signal
3. Distance = (half delay to max) * (speed of sound)

The Process





After post-processing, matches almost perfectly in simulation.