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TWO-WAY RANGING DURING EARLY MISSION PHASE

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The Problem

- When doing two-way ranging, the uplink ranging modulation is demodulated by the spacecraft, filtered, and then modulated onto the downlink carrier.
- Normally, for deep space ranging, the noise in the filter dominates the uplink ranging signal.
  - Uplink noise is modulated onto the downlink carrier
  - Normally noise is well below the noise of the ground system
- When the spacecraft is near the Earth (e.g., during early launch phase), these assumptions may not hold.
  - Uplink ranging signal may dominate the noise
  - Noise on carrier may be stronger than system noise

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Sequential Ranging

- Sequential ranging is currently used for deep space ranging
- Clock tone (highest frequency) sent
  - Determines accuracy
- Subsequent tones sent to resolve the ambiguity
  - Each tone half the previous tone's frequency
- At some point, ambiguity tones are chopped with the clock tone
  - Done to avoid interfering with carrier or data tracking
- Tones can be square wave or sine wave

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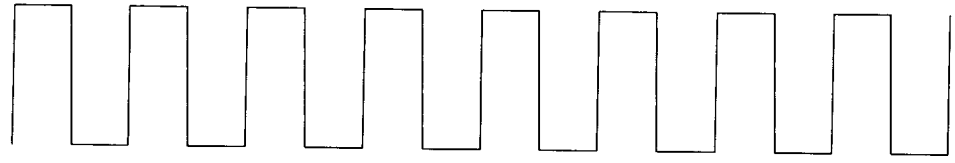
An Example

Range Code Components

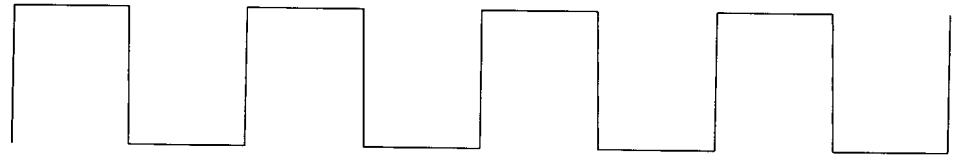
Component Frequency

F

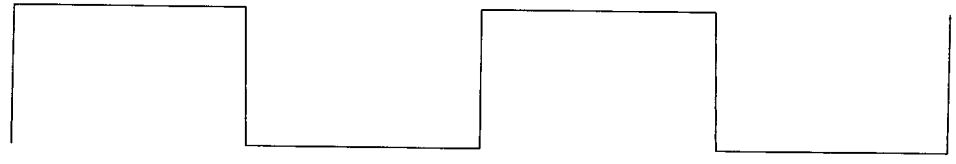


Range Clock

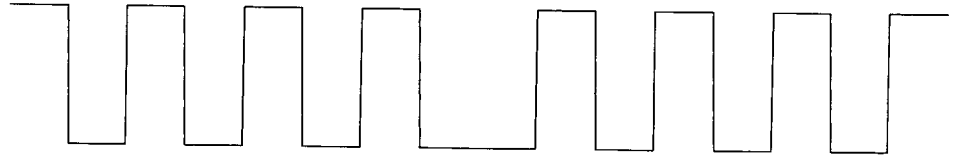
F/2



F/4



F/8



Component Chopped by Range Clock

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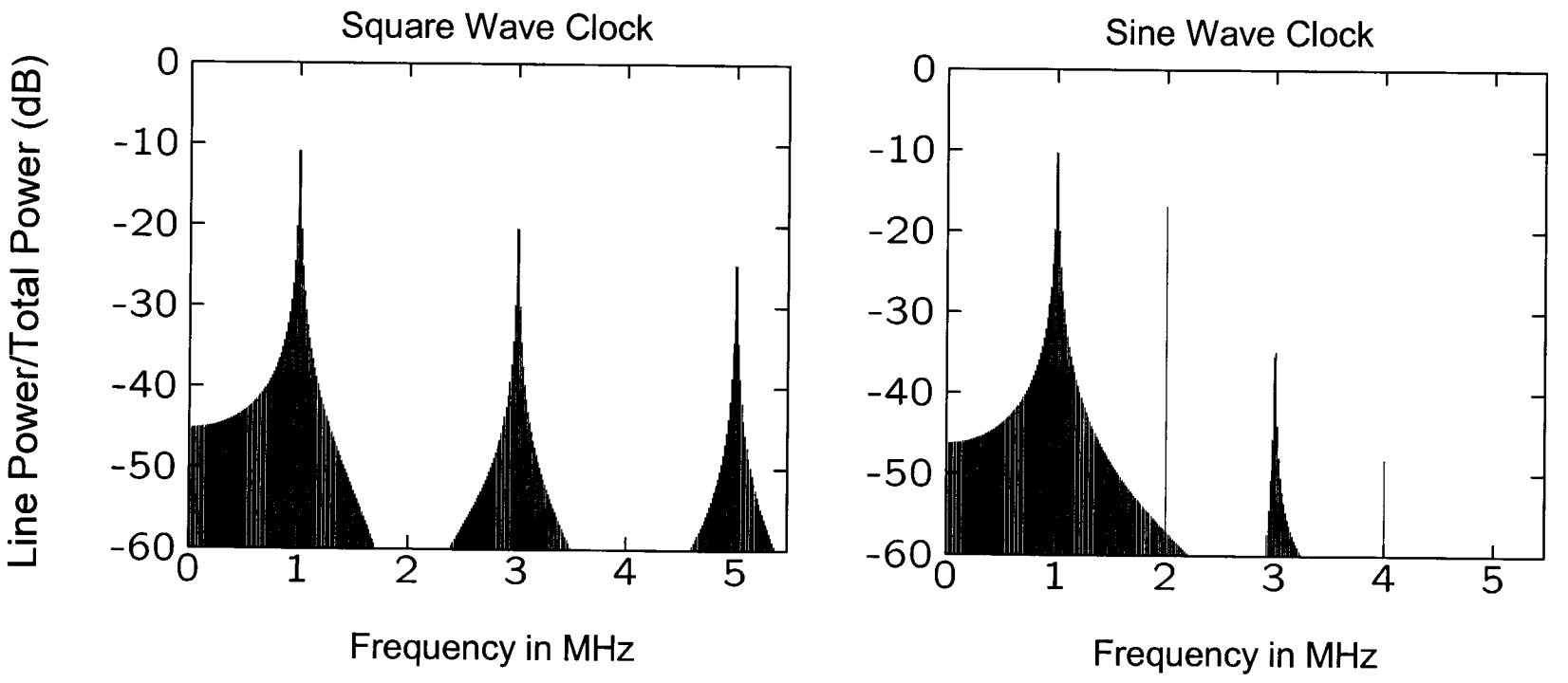
Uplink Spectrum Comparison

Chop Frequency (1 MHz) factor of 128 higher than Tone Frequency



(Assumes perfect phase modulator)

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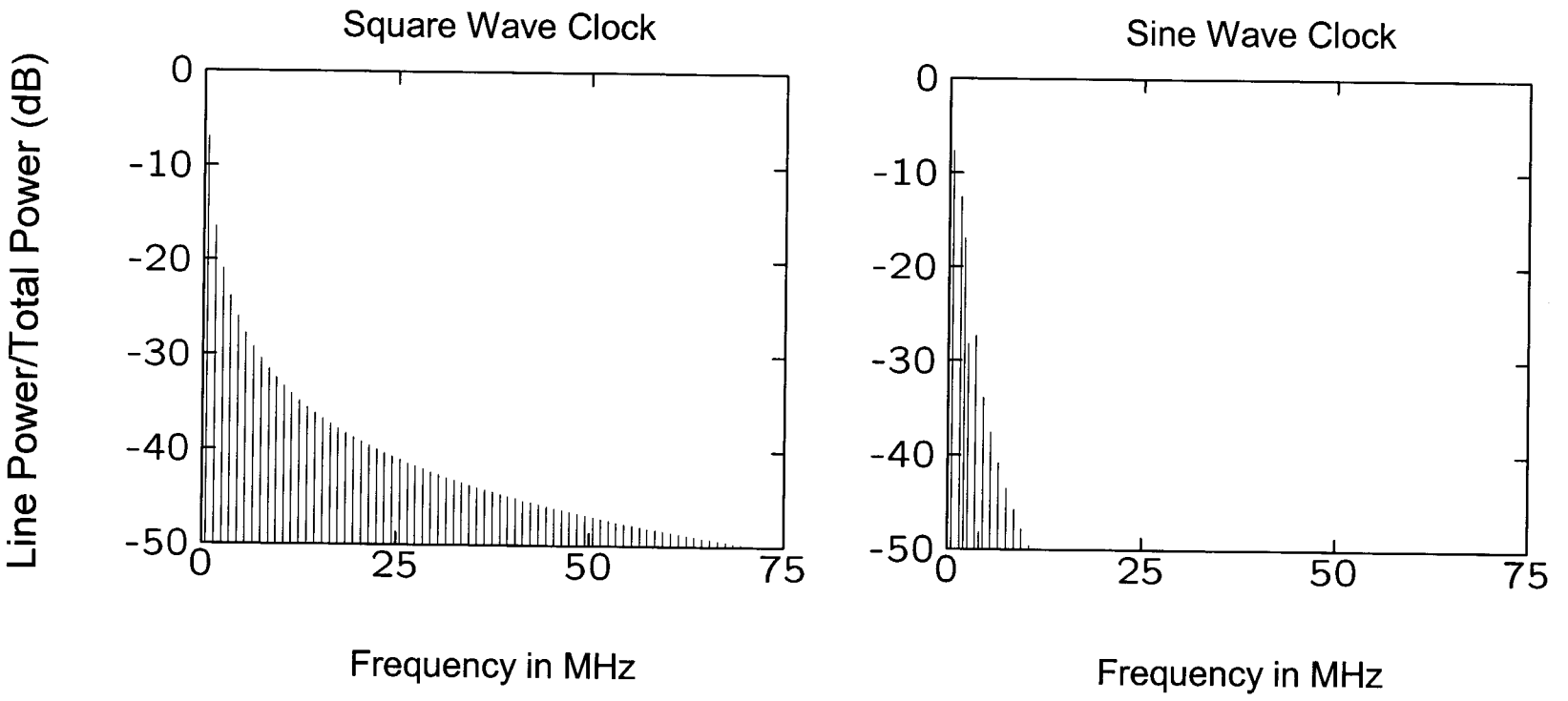
Uplink Spectrum Comparison (Cont.)

Chop Frequency (1 MHz) factor of 2 higher than Tone Frequency



(Assumes perfect phase modulator)

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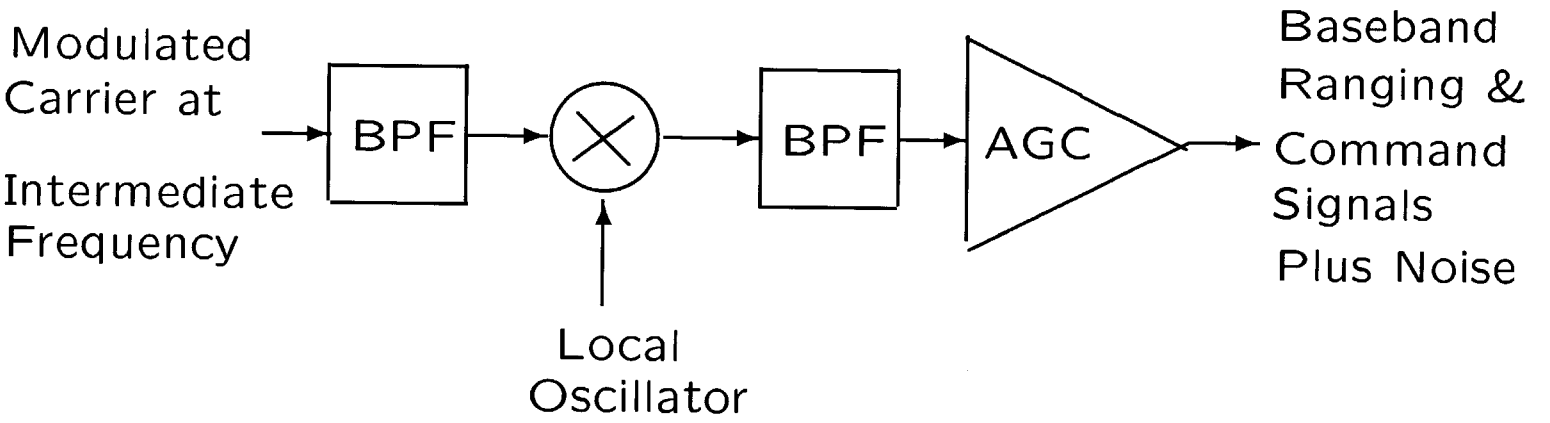
S/C Transponder Ranging Channel



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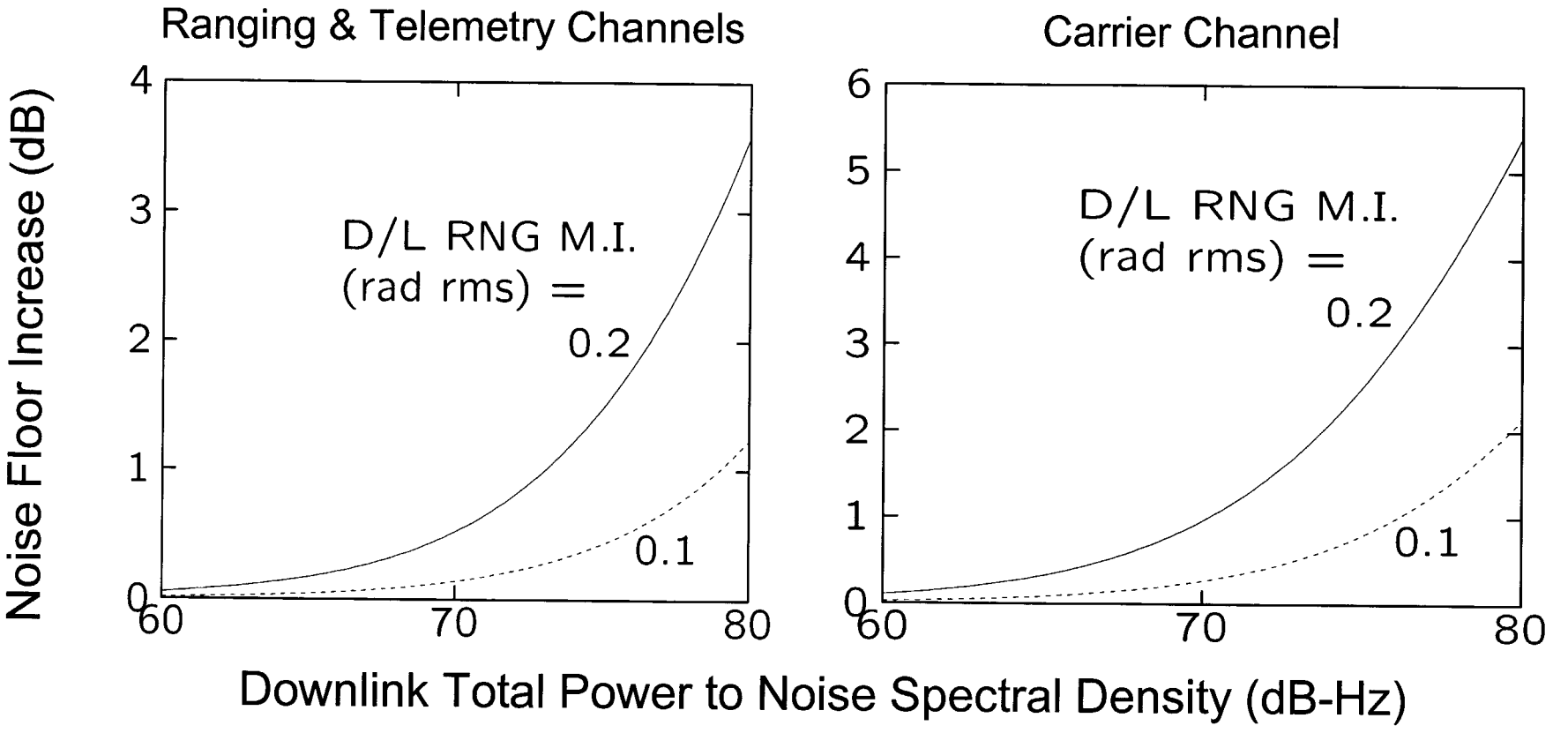
Pedestal Effect (Worst Case)



- No command or ranging modulation on uplink
- Ra nging channel on spacecraft enabled

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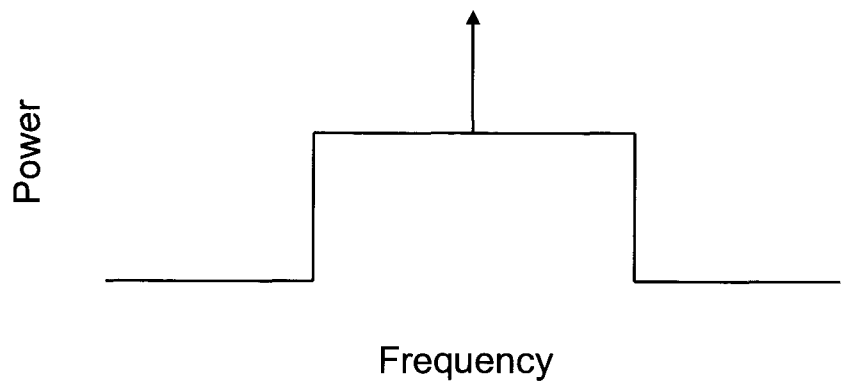
Pedestal Effect



- Pe destal caused when transponder noise floor is stronger than the ground system noise
  - Causes limiting effect with Pc/N0 measurements, which can affect antenna conscanning
  - Depending on operating point, floor may appear and disappear as antenna moves
- Uplink modulation (command and/or ranging) will decrease the noise, due to AGC of transponder
- Ca rrier channel effect caused by intermodulation with downlink telemetry
  - Affects the bandwidth of the pedestal

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Conclusion

- Ranging channel does more than just "rob" power from telemetry
- When the ranging channel on the spacecraft is enabled, uplink noise can be modulated onto the downlink
  - Causes a noise floor on the transponder downlink signal
- When the downlink signal is strong, the noise floor may actually be greater than the ground system noise floor
  - Causes pedestal effect
- This effect needs to be accounted for in link budgets for launch and near Earth operations