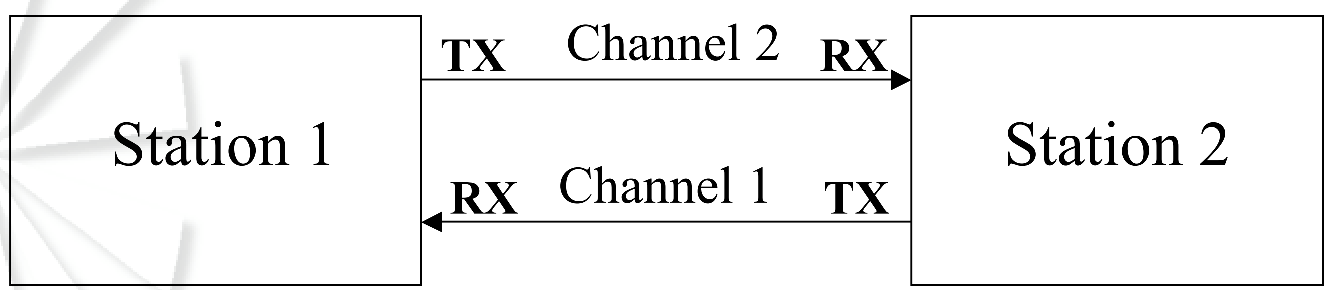
RF Links Overview

PTP and PMP Links

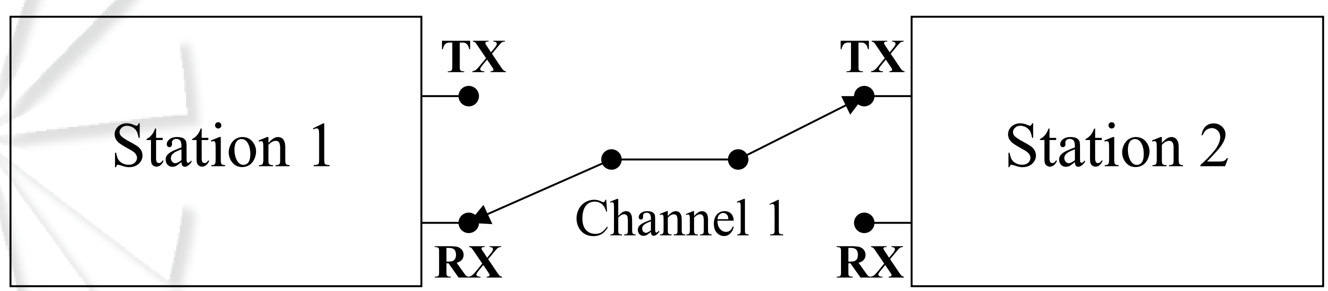
Full Duplex Communications

- Two stations can talk and listen to each other at the same time.
- This requires two separate media.
- In the case of a wireless link, 2 separate channels are required. This is referred to as Frequency Division Duplex (FDD)



Half Duplex Communications

- Two stations have to take turns talking and listening. Simultaneous communications is not possible. Requires handshaking.
- Two stations share a common media
- This is referred to as time division duplex (TDD)



Advantages of FDD

- More efficient data transfer due to lower overhead (required for handshaking).
- More efficient use of spectrum in high traffic systems
- Most ITU frequency bands are structured for FDD.
- Half the data rate for equivalent data transfer as TDD.
- Does not have latency issues associated with handshaking.

Advantages of TDD

- Easier to coordinate channels than FDD.
- RF Hardware is potentially less complicated and thus lower cost.
- Installation may be simpler.
- Only one antenna per T/R
- In low traffic networks the spectrum is utilized more efficiently.

Point to Point (PTP) Links

- A point to point link is one station communicating with another station, 1 to 1.
- Both stations are usually similar in data-rate, modulation and overhead format.
- FDD PTP links do not require media access control which reduces overhead.

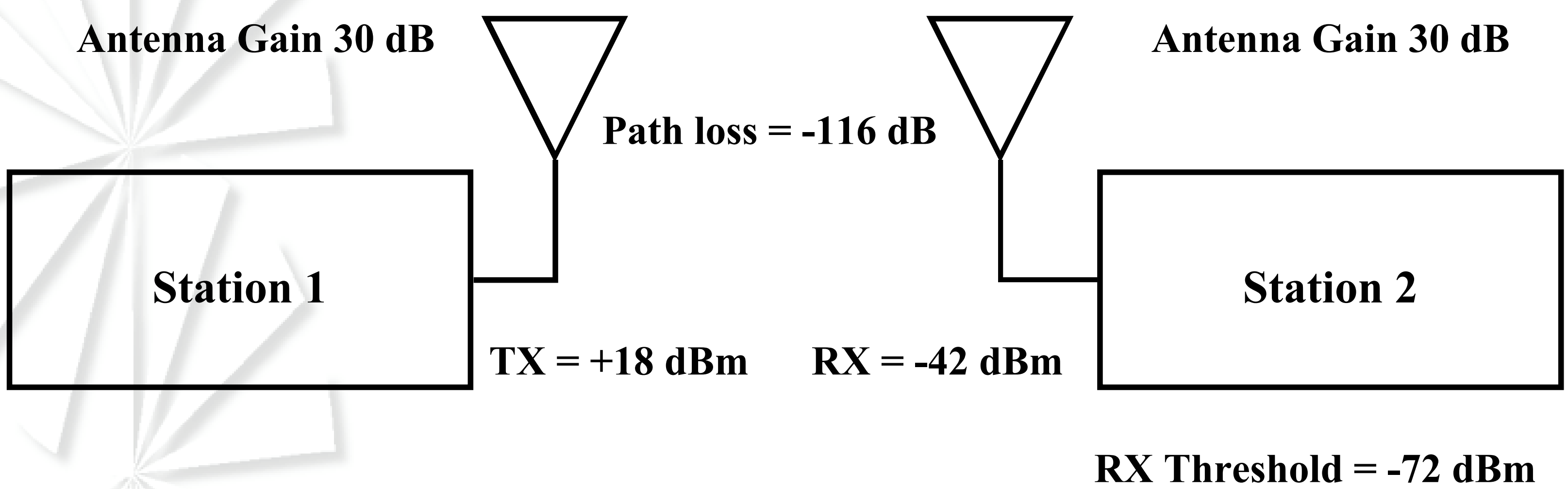
Point to Point (PTP) Links

- FDD PTP links do not require handshaking, this minimizes latency.
- PTP links are usually used in constant bit rate applications, such as synchronous data transport and trunking applications.
- PTP links can be built with extra margin to deal with fades and other impairments.

System Power Levels

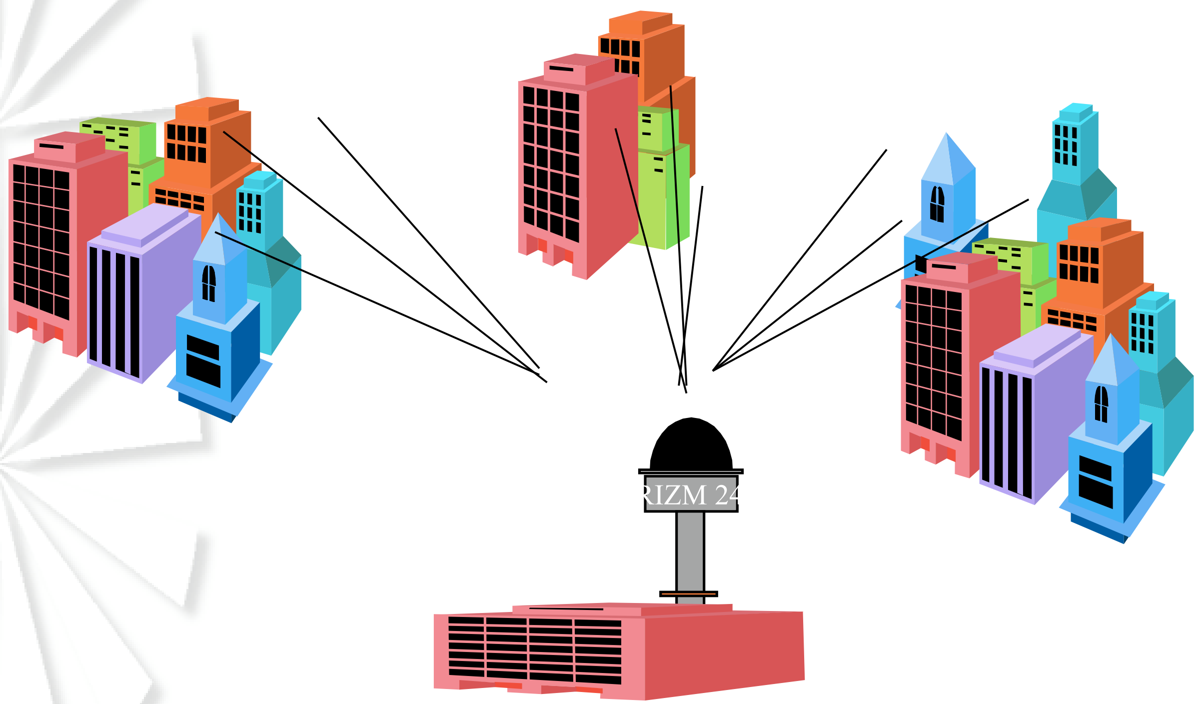
- Point to point link has extra system gain to increase availability.
- Low probability of interference to or from other stations.
- P to P links typically have narrow beam antennas.

System Power Levels PTP Links



Point to Multipoint (PMP) Links

- One base station communicating with more than one subscriber on shared media.



Point to Multipoint (PMP) Links

- Downstream path is from the hub to the sub.
- Upstream path is from the sub to the hub.
- Can use either FDD or TDD
- With many subscribers PMP is more economical than PTP in both hardware and spectrum utilization.

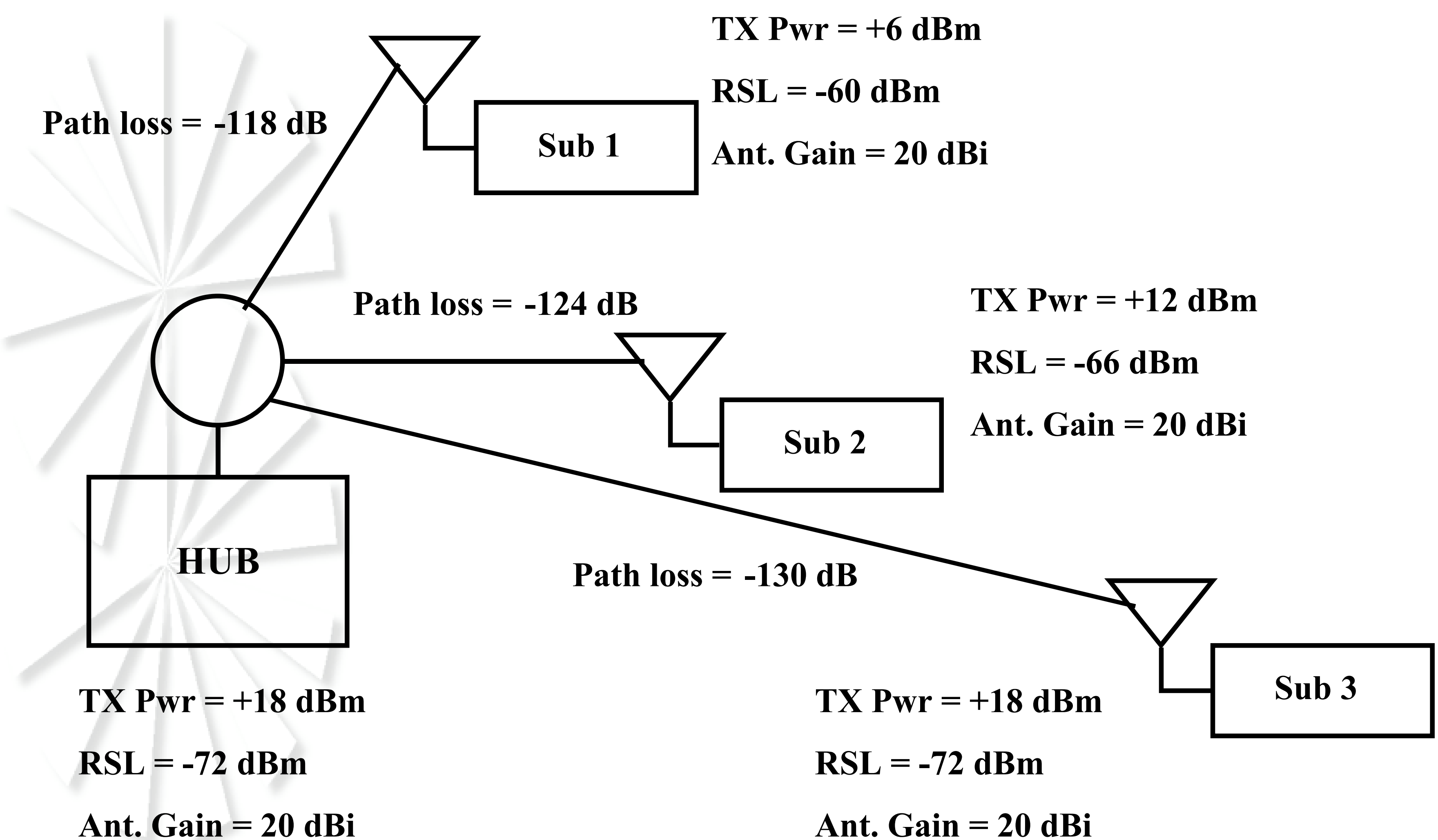
Point to Multipoint (PMP) Links

- Data-rates and modulation tend to be asymmetrical to reflect the the asymmetric flow of data in this type of system.
- Media Access Control (MAC) is mandatory for a PMP system.
- Typically IP based, does not work well for constant bit rate applications.

System Power Levels PMP Links

- In a point to multi-point system power levels must be controlled to prevent self interference.
  - **The Hub TX has a fixed output power.**
  - **The Hub RX has a fixed gain.**
  - **The Sub TX has a variable output power that is controlled by the RSL at the Hub RX.**
  - **The Sub RX will adjust its gain for proper RSL.**

System Power Level PMP Links



System Power Levels PMP Links

- If an unlimited number of channels are available then self interference is not a consideration.
- Within a sector subscribers will not interfere with each other due to TDMA.
- Between Sectors of the same channel interference can occur, TDMA control no longer applies.
- Co-channel interference occurs due to antenna side lobes, back lobes, improperly aimed antennas and reflections.

System Power Levels PMP Links

- To minimize self interference...
  - **Use minimum necessary hub TX power to reach farthest out subscriber.**
  - **Keep farthest out subscribers in center of beam if possible.**
  - **Carefully adjust elevation angle to give good signal to farthest out subscribers while still providing useable signal to close in Subs.**
  - **Make sure Sub antennas are pointed correctly, use elevation brackets if necessary.**
  - **Use maximum number of channels that is practical.**
  - **All links should be LOS, avoid reflections and obstructions.**

Media Access Control

- **The MAC is implemented by the hub modem and controls access of the subscriber modems to the shared channel. Spike uses the DOCSIS (IEEE 802.14) MAC.**
- **Each Subscriber is assigned one or more exclusive time slots in which they may transmit data. This is referred to as time domain multiple access (TDMA).**
- **The Hub modem adjusts the power level of the Sub TX.**
- **The Hub modem synchronizes all subs with the Hub and equalizes path delay.**

Media Access Control

- The MAC provides a means for new subscribers to join the network.
- The MAC also provides for equitable sharing of bandwidth and arbitrating contention among subscribers.
- The MAC must assure that all similarly provisioned subscribers have similar quality of service regardless of their location.

Broadband Wireless Example

- Transceiver
- Modulation Techniques
- Path Analysis
- Amplifier Parameters
- Filter Types
- Filter Technologies
- PLL and Attenuators

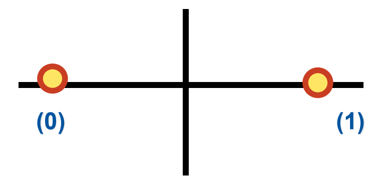
Transceiver Design Outline

- Overview
  - Functionality
  - Versions
- Design Features
- Basic RF Concepts

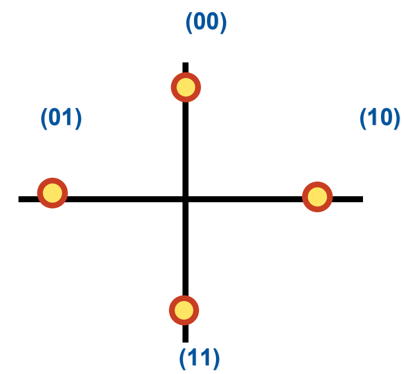
Key RF Parameters for Wireless Systems

- Antenna
  - Gain
  - Sidelobe Level
- Transceiver
  - Frequency Accuracy
  - Spurious Response (Regulatory Agency)
  - RMS Phase Error
  - Output Power
- Modem
  - Data rates
  - Required Signal to Noise
  - Spurious Response (Regulatory Agency)

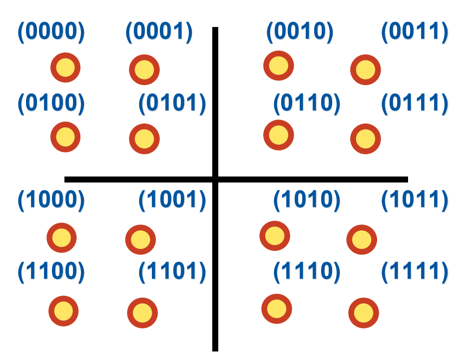
Modulation Techniques



BPSK

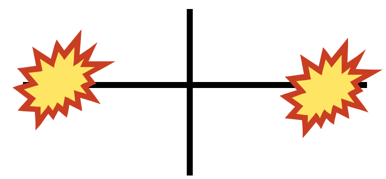


QPSK

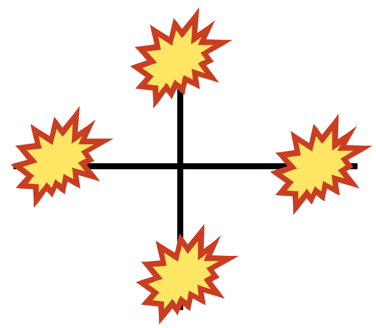


16QAM

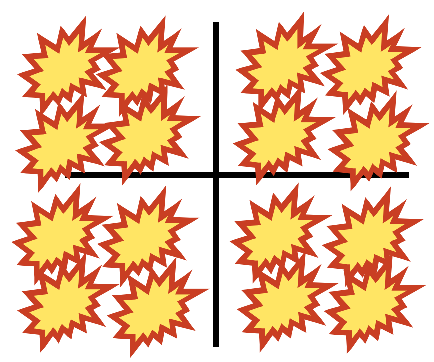
Modulation With Noise



BPSK



QPSK



16QAM

PRIZM 3500 RF PATH ANALYSIS

Manufacturer:	SPIKE Technologies
Subscriber Station	
Transmit Frequency	3.550 GHz
Antenna Transmit Gain	19.0 dBi
Antenna Receive Gain	19.0 dBi
IF Bandwidth	6.000 MHz
Receiver Noise Figure	6.5 dB

Path Length	**15.0** mi.
Base Station	
Transmit Frequency	3.450 GHz
Antenna Transmit Gain	20.0 dBi
Antenna Receive Gain	19.6 dBi
IF Bandwidth	6.000 MHz
Receiver Noise Figure	5.5 dB

UPLINK

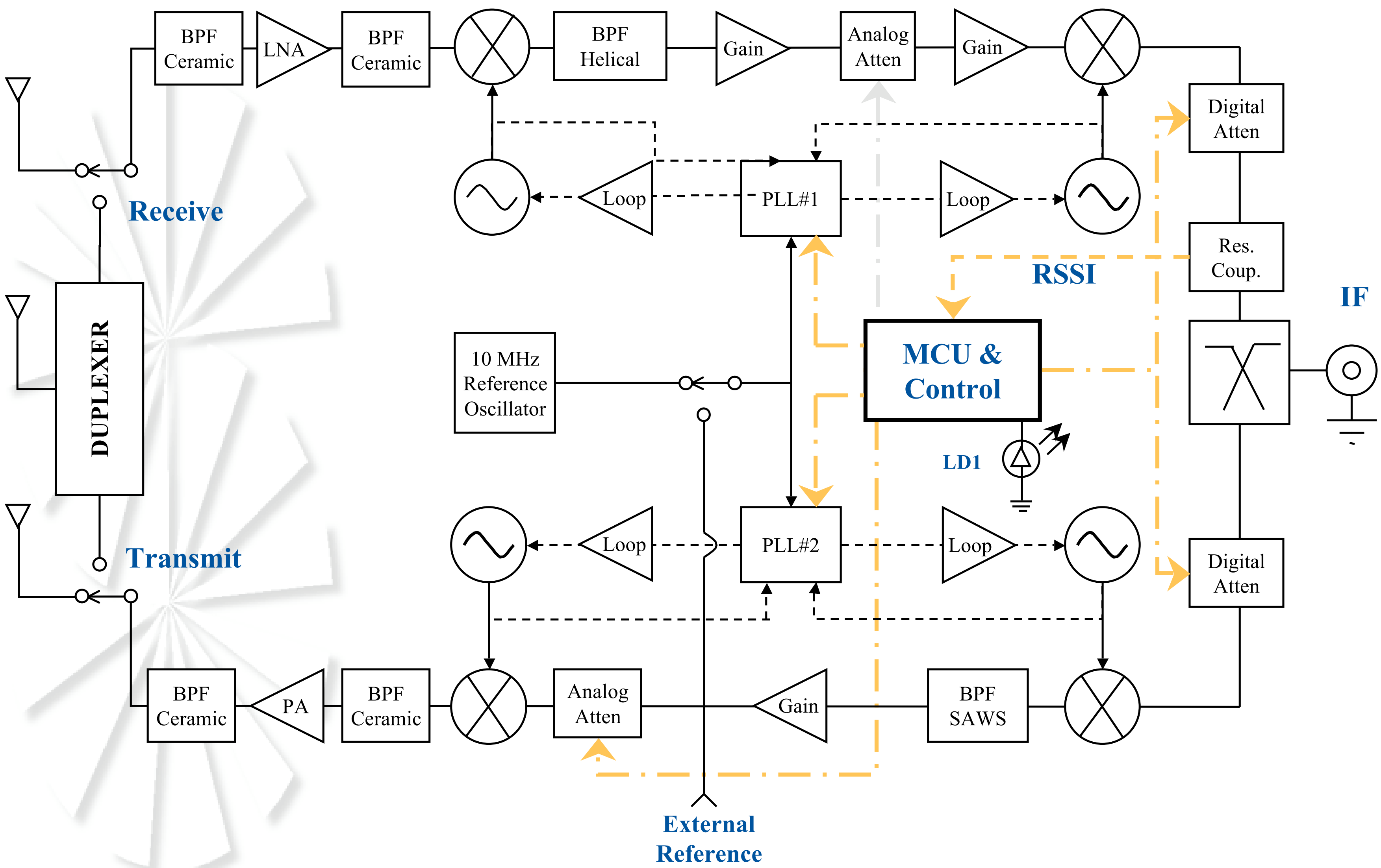
Subscriber Unit Tx Output	**25.0** dBm
Output Backoff	5.0 dB
Subscriber Transmit Power	20.0 dBm
Back-off to Balance Path	0.0 dB
Tx Filter Loss	0.0 dB
Transmission Line Loss	1.0 dB
Tx Duplexer Loss	0.0 dB
Subscriber Tx Antenna Gain	19.0 dBi
Subscriber EIRP (dBm)	38.0 dBm
Subscriber Average EIRP (Watts)	6.3 W
Subscriber Max EIRP (Watts)	20.0 W
Up Link Path Loss	131.1 dB
Base Rx Antenna Gain	19.6 dBi
Transmission Line Loss	1.0 dBi
Base Rx Signal Level	-74.5 dBm
Thermal Noise Power	-102.1 dBm
Required C/N (LanCity)	25.0 dB
Final Margin	2.6 dB

DOWNLINK

Base Transmitter Output	**27.0** dBm
Output Backoff	5.0 dB
Base Transmit Power	22.0 dBm
Back-off to Balance Path	0.0 dB
Tx Filter Loss	0.0 dB
Transmission Line Loss	1.2 dB
Tx Duplexer Loss	1.5 dB
Base Tx Antenna Gain	20.0 dBi
Base EIRP (dBm)	39.3 dBm
Base Average EIRP (Watts)	8.5 W
Base Max EIRP (Watts)	26.9 W
Down Link Path Loss	130.9 dB
Subscriber Rx Antenna Gain	19.0 dBi
Transmission Line Loss	1.2 dB
Sub Rx Signal Level	-73.8 dBm
Thermal Noise Power	-100.8 dBm
Required C/N (LanCity)	25.0 dB
Final Margin	2.0 dB

Downlink Limited By:	0.6 dB
Usable Margin:	**2.0 dB**

Transceiver Block Diagram

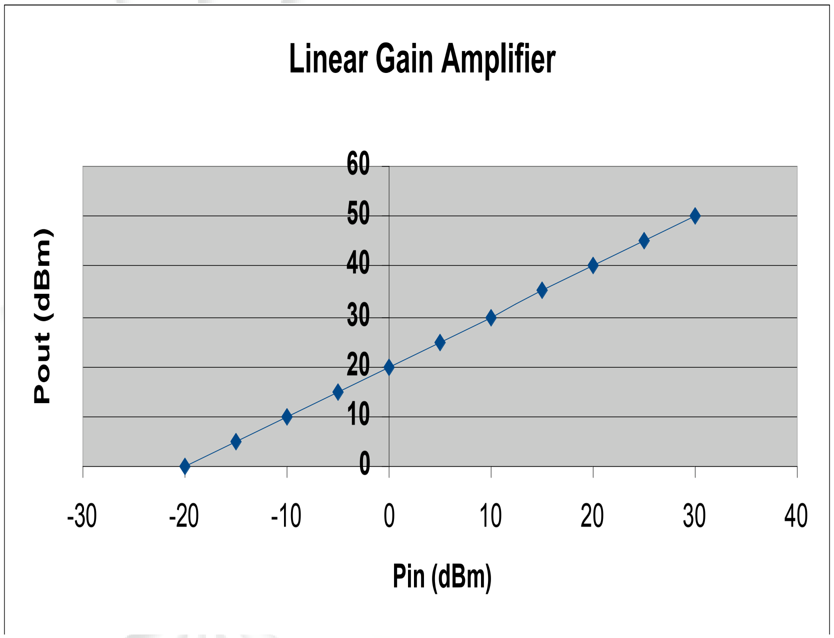


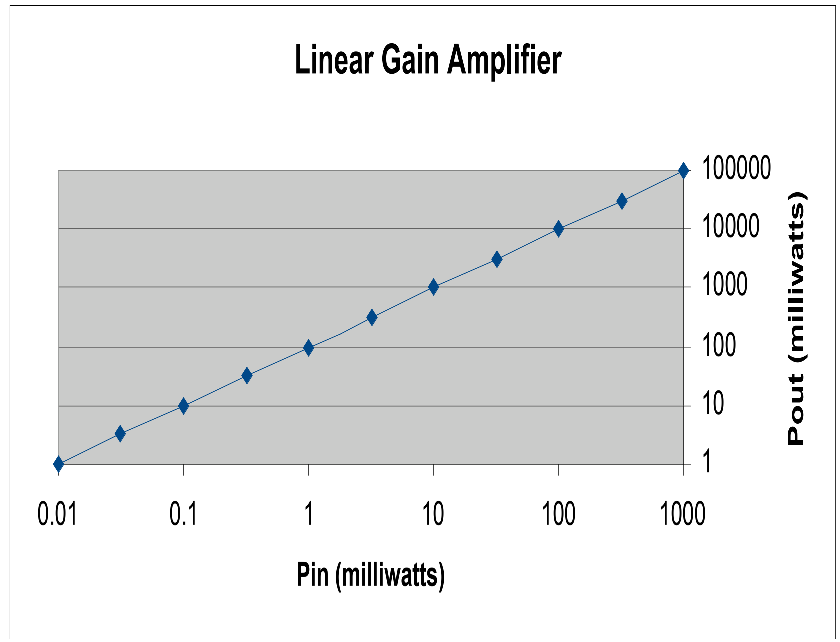
Amplifiers - Critical Parameters

- **Gain / Stability**
- **Linearity / Output 3rd Order Intercept Point (OIP3)**
- **Output Power / 1dB Compression Point**

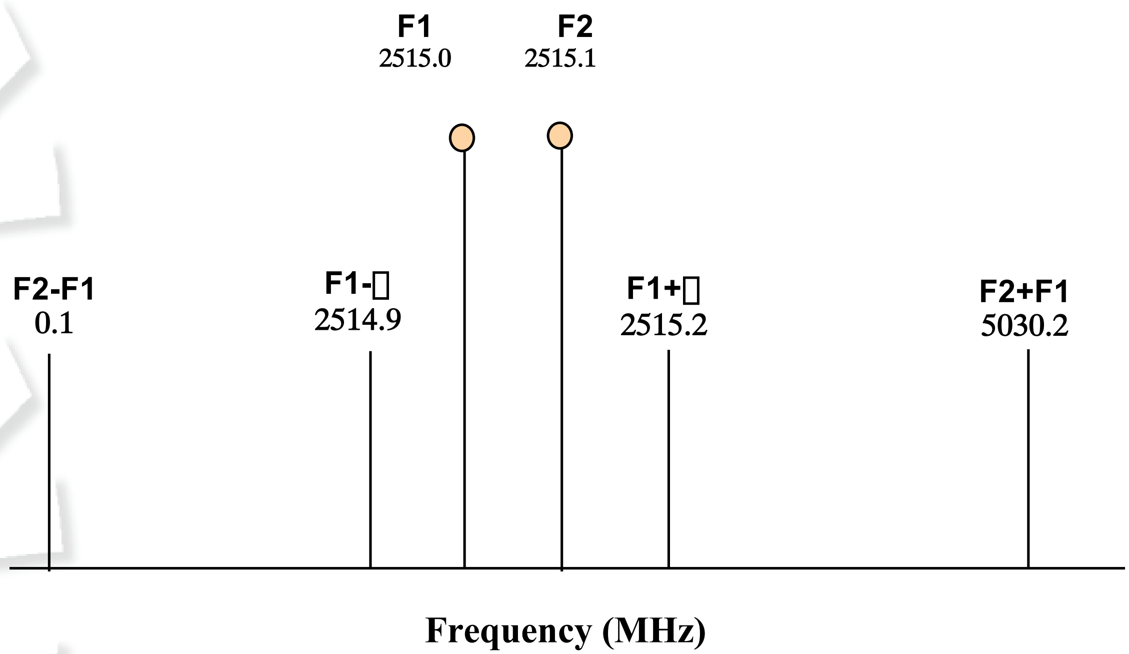
❑ **Noise Figure**

“Ideal” Amplifier Gain



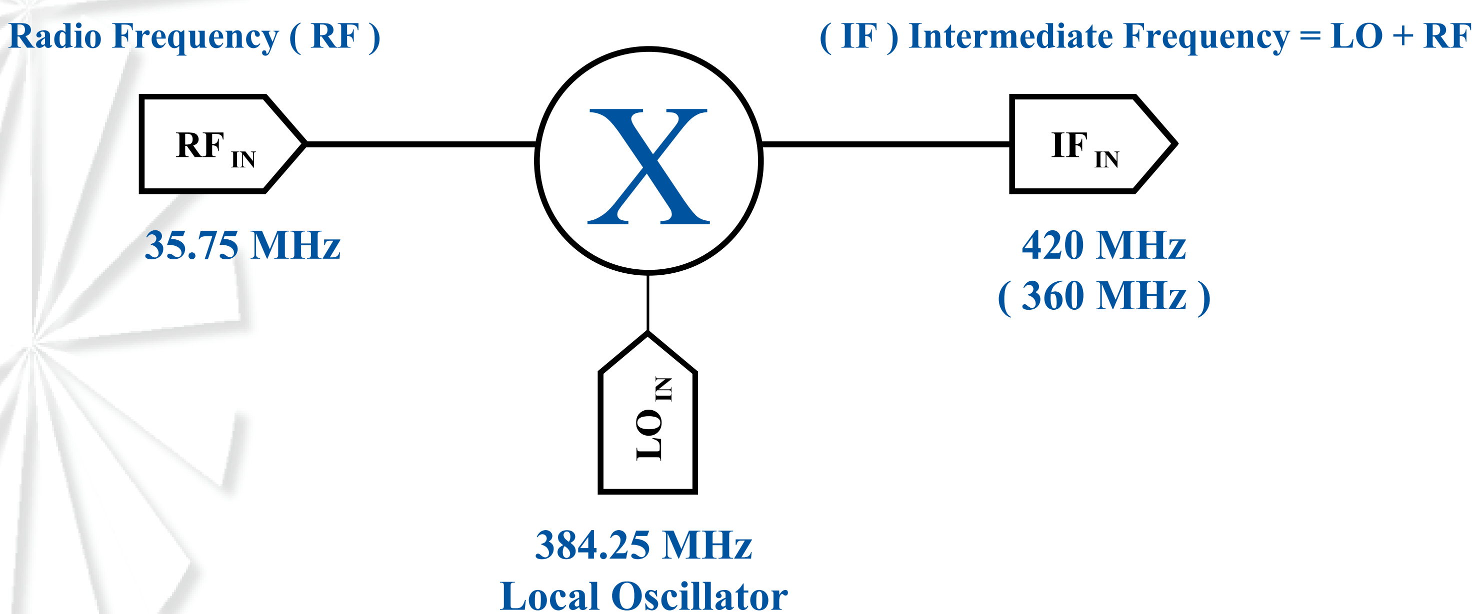


Actual Amplifier Performance



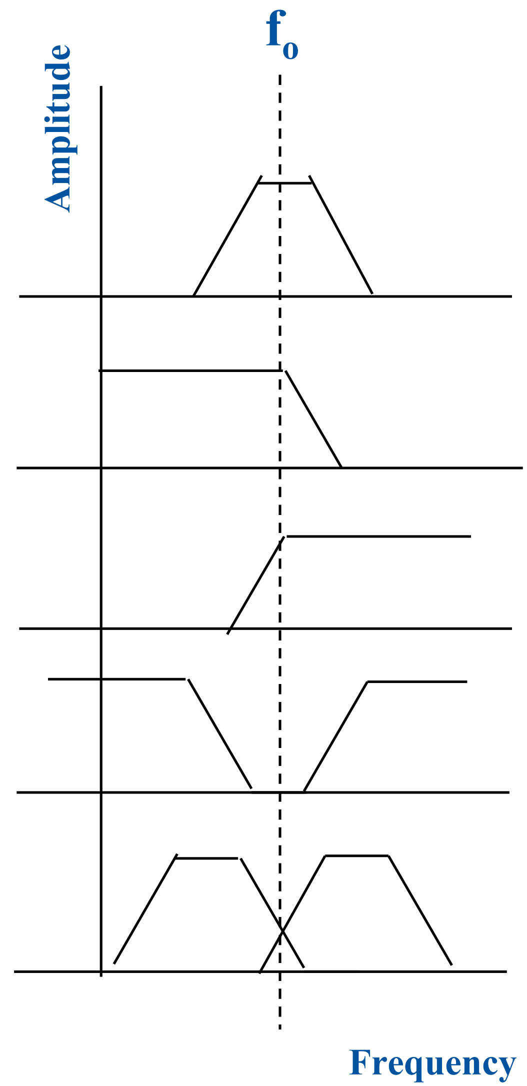
Mixers

- Mixers are the key component for Frequency Conversion
- Can be used for either Up or Down Conversion
- The output response is actually: N LO + M RF



Filter Types

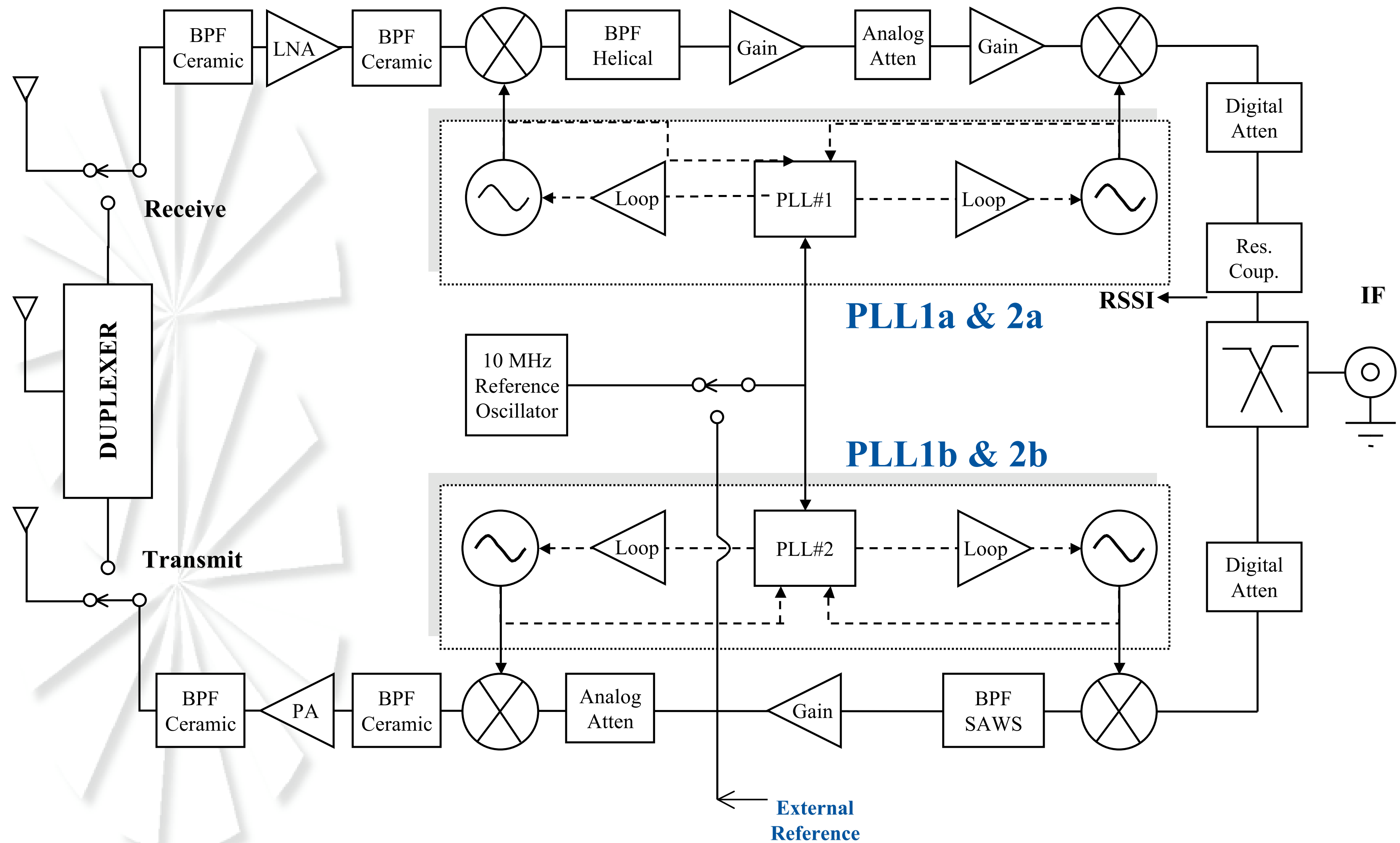
- ❑ Band Pass
- ❑ Low Pass
- ❑ High Pass
- ❑ Band Stop
- ❑ Diplexer



Filter Technologies

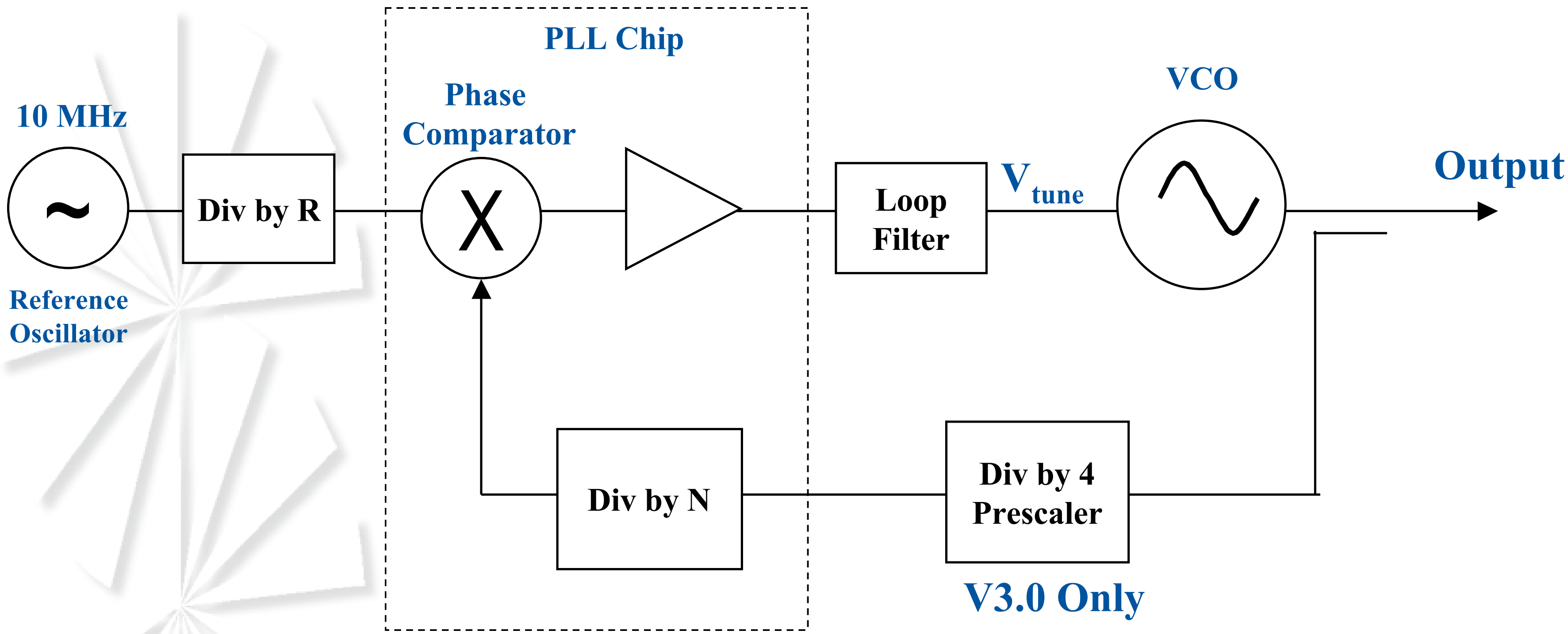
Type	Advantages	Disadvantages
- Lumped Element	Small size, Low cost	Low Freq Limit
- Microstrip/Stripline	Planar, High Repeatability	Large in Size
- Ceramic	Small size, Low Cost	Low Freq Limit
- Cavity	High Q	High Cost, Large
- SAW (Surface Acoustic Wave)	High Rejection "in Close"	High Loss

Transceiver Block Diagram

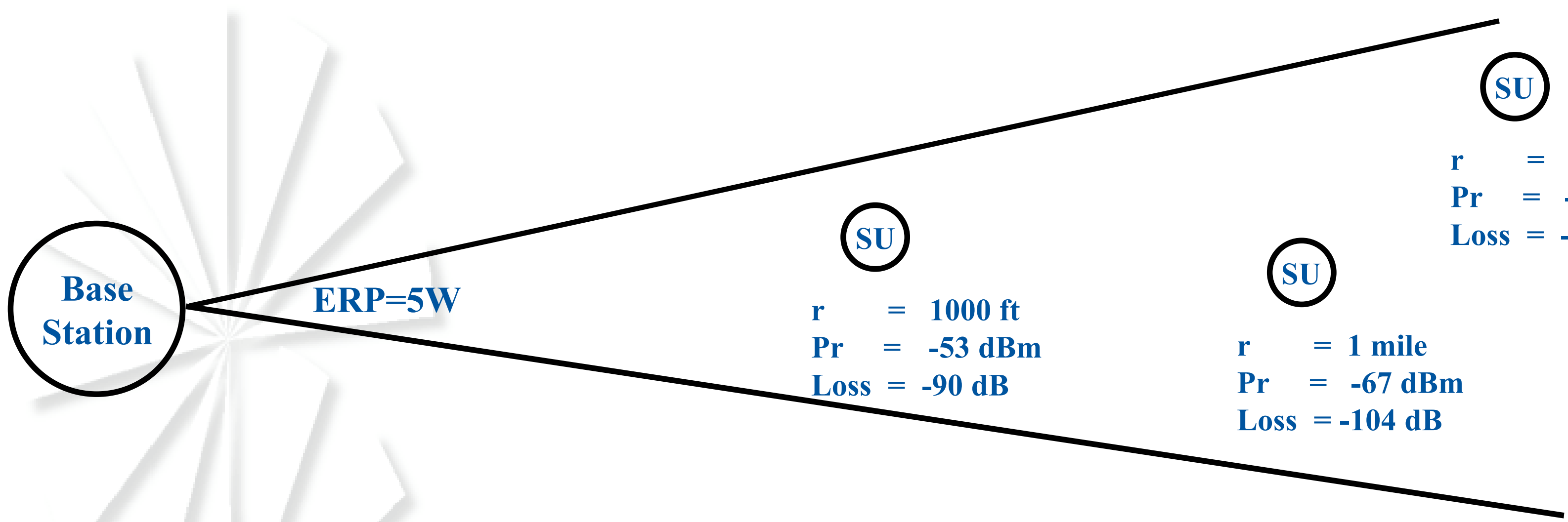


•Phase Locked Loops (PLLs) -Stabilize the VCOs to a Reference Oscillator

Basic Phase Locked Loop



System Power Control



- **Subscriber Receive power estimated and measured at installation**
- **Modem Power Control will compensate for approx ±15 dB of signal variation**
- **Same attenuator setting used on Transmit side**
- **Base Station will receive power at same level from all Subscribers**

Variable Attenuators

- Digital Attenuators
  - Coarse gain selection
  - Step Size / 2dB
- Analog Attenuators
  - Fine Step Size / < .1 dB
  - Fine gain selection and temperature compensation