QUALCOMM RepeaterOne Technologies 2006 Briefing

80-W0836-1 Rev A

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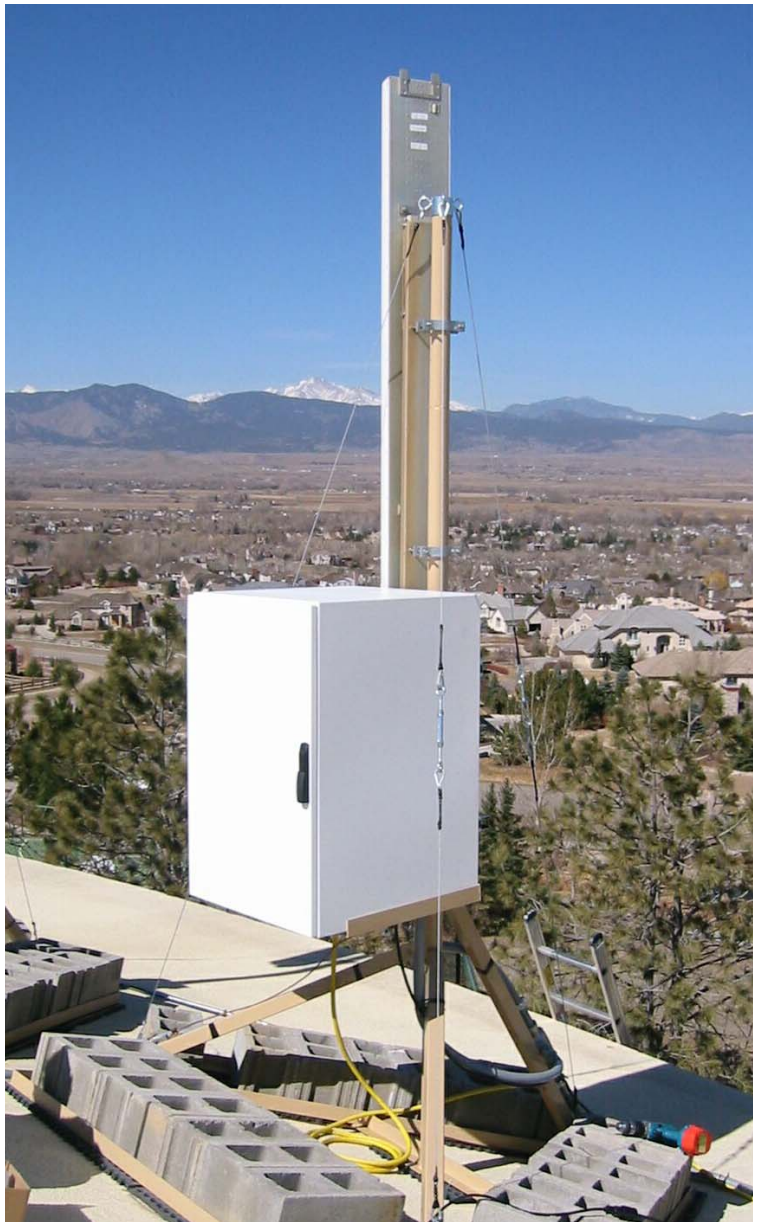
80-W0836-1 Rev A

Outline

- Gain Controlled Repeaters
- Modems
- Traffic Measurement
- Economic Benefits
- Conclusion



Repeater Challenges

- **Problems to solve to make the "Perfect CDMA" repeater**
  - Setting the RF gain correctly
    - Make Phone happy …balanced Uplink / Downlink gains
    - Make Base Station happy … minimize Uplink noise contribution
    - Make it automatic to install and maintain correct gain
  - Status and Telemetry from the repeater
    - Need reporting from the repeater to indicate good health
  - Measure the Traffic through the repeater
    - Enough traffic to justify repeater ?
    - Enough traffic to justify new Base Station ?
  - Insure stability of the repeater
    - During installation
    - During operation

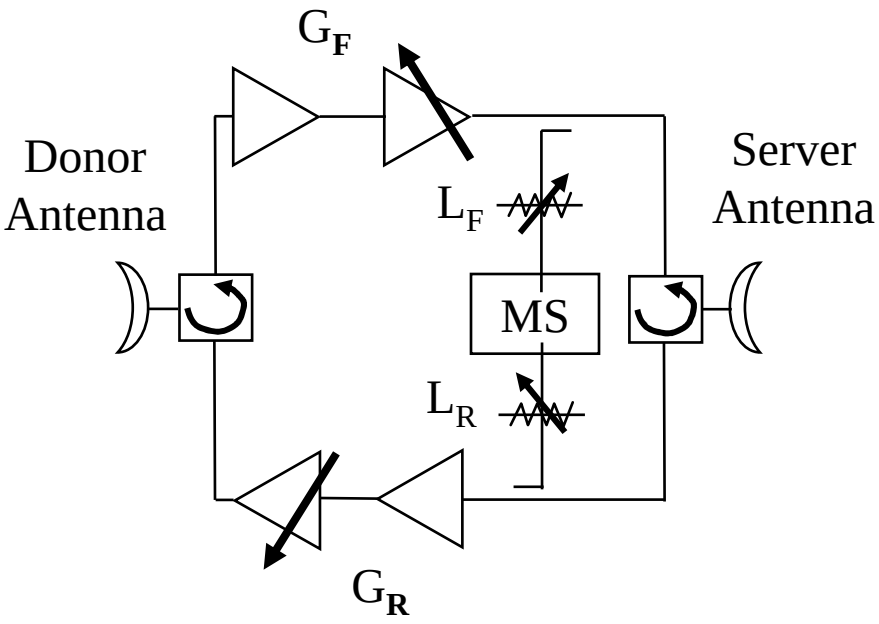
Repeater Power Issues

- **Excess gain on Reverse Link causes BS Interference**
  - Excess Rvs Link gain increases interference at BS reducing coverage
  - Repeaters have large RF gain which can vary with temp, age, frequency
  - Path loss between base station and repeater can vary with season, new construction
  - Correct deployment requires experienced engineers
  - Repeater can measure Path Loss and set correct gain
- **Forward Link gain adjust for constant Pilot power**
  - Change in Path Loss, or repeater gain can change output power
  - Constant Pilot power = constant service area
  - Repeater measures Path Loss and Repeater Gain
- **RepeaterOne Power Controlled Repeater technology**
  - Solves the gain control issue on Forward and Reverse links
  - Works for CDMA2000, EV-DO and UMTS

Power Control Repeater Solution

- **Embed a phone/modem card in the repeater and measure Ec/Io of Pilot and Total Power (RSSI)**
  - Pilot Power = RSSI + Ec/Io
  - Maintain constant Pilot Power at output of Repeater
  - Maintains consistent operating point as temperature, frequency, and surrounding environment changes with the seasons and new construction
  - Utilizes as much of the repeater forward link gain chain as possible
  - Reverse Link gain = Forward Link gain + calibration factors
- **Requires no special software or hardware in BS**
- **Simplifies Repeater deployment**
  - Smarter Repeater reduces the need for experienced engineers
  - Downlink / Uplink Gain is automatically set to correct value
- **Maintains a constant repeater coverage area**

Block Diagram



LF is used to compensate for gain G_F

LR is used to attenuate the phone output to a lower level since phone Tx now goes through repeater gain

Phone measures Ec/Io and RSSI

Processor sets G_F for correct Pilot power

Knowing G_F , set G_R = G_F + repeater calibration factors

Repeater Compensation

- **Ec/Io method of gain compensation does not require repeater to be in a call**
  - Repeater performs gain compensation on a schedule
  - Path loss and repeater gain change slowly
  - Every 15 minutes… 1 hour … perform gain compensation
- **Normal Modem operation is possible**
  - Gain setting uses DM information from the modem
  - Modem is standard modem hardware, standard software

Installation

RepeaterOne advantages

RepeaterOne

- Use GUI to point antenna at correct PN donor
- Use GUI to start automatic installation at desired Pilot power
- Use GUI to verify
  - Antenna isolation
  - Pilot power
  - Forward Gain
  - Reverse Gain
  - Repeater health
- Go to lunch

Manual repeater

- Use DM in repeater coverage area to help point donor antenna
- Measure antenna isolation with signal generator and spectrum analyzer
- Connect power meter and set gain for correct power
  - Must know loading of cell
- Set reverse gain = forward gain?
  - Difficult to optimize rev gain
- Gain less than isolation?
- Make test calls in repeater coverage to test link balance
- Go to Dinner

New GUI developed

- **New GUI (Graphical User Interface)**
  - Control all modem functions
  - Allows user to configure and install repeater
    - Set alarm values
  - Allows user to perform status and check errors
  - Status for
    - Gain
    - Attenuators
    - Power, VSWR, Temp, Current
- **Runs on a Laptop**
  - Serial interface
- **Easily Customized**
  - Written in industry standard Labview

Gain Compensation Summary

- Constant Pilot power = constant repeater coverage area
  - Many repeater ALC designs force constant power and ignore the fact that CDMA power changes with loading
- Simple, stable design
  - Measures path loss and repeater gain
- Modem available for data calls
- Demonstrated for
  - CDMA2000 1X
  - CDMA EV-DO
- Currently working on UMTS

Modem Issues

- **RepeaterOne needs design flexibility**
  - Need low cost mass produced modem
  - Many different band plans
  - Carriers certify phone/modems for carriers network
  - RepeaterOne volumes are small (compared to phones)
  - Modem vendor may not want to cooperate with repeater vendor and make special hardware / software
- **RepeaterOne needs to work for all waveforms**
  - 1X
  - EV-DO
  - UMTS

PC 104 Host

- **PCMCIA , CF data cards are available in every market**
- **Newest format is miniPCI card**
- **Need a host for the card to demonstrate reference design**
- **Single board computer standard - PC104** http://www.pc104.org/
- **Use the PC104 card to Host**
  - PCMCIA card
  - RepeaterOne software
- **Demonstrated**
  - Japan CMDA2000 1x Band Class 3
  - US PCS CDMA2000 1X Band Class 1
  - US PCS EV-DO Band Class 1
  - UMTS PCS in work

Design Flexibility

- **Time to market and repeater recurring cost need to be minimized**
- **Lots of variants to design**
  - 1x PCS / 800/ Japan BC3 / 450MHz / 2.1GHz
  - EV-DO PCS 1900 / 800 / 450MHz
  - UMTS 800 / 1.7GHz / 2.1GHz
- **PC104 Host design will help reduce engineering design costs**
  - PCMCIA and CF (camera flash memory card) modems available for all of these services and bands
  - Carriers do not need to certify new devices in their network
    - RepeaterOne will use standard device with no modifications
  - All RepeaterOne software resides on the host platform
    - Linux operating system is easy design environment for repeater vendors
    - All RepeaterOne unique software is C code running under Linux
    - Host hardware with Linux is low cost
    - PC104 is reference design, not a requirement

Repeater Status / Reporting

- **Repeater should use built in modem to report repeater status**
  - Some carriers are using SNMP reporting
  - Future requirements are for Web reporting
- **Current RepeaterOne I/O board monitors**
  - VSWR of Donor and Server antenna ports
  - Power of Donor and Server antenna ports
  - Voltage and Current of main DC power supply
  - Temperature
  - Synthesizer Lock status
  - Uplink / Reverse Link Channel Loading

Reference PC Status

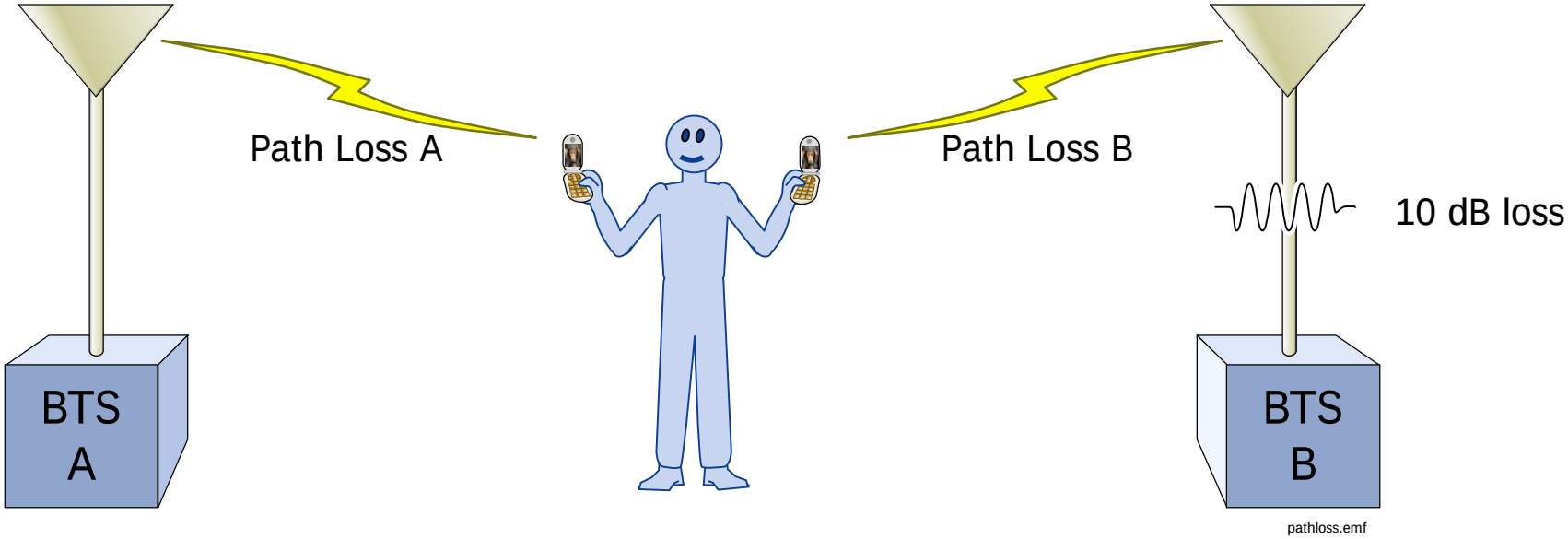
- Use off-the-shelf modems that are approved by carrier
- Standard interfaces
- Linux OS running C code
- Easy to transfer reference design to RepeaterOne Vendor
- New band plans and new technology designs are lower cost

Traffic Estimation

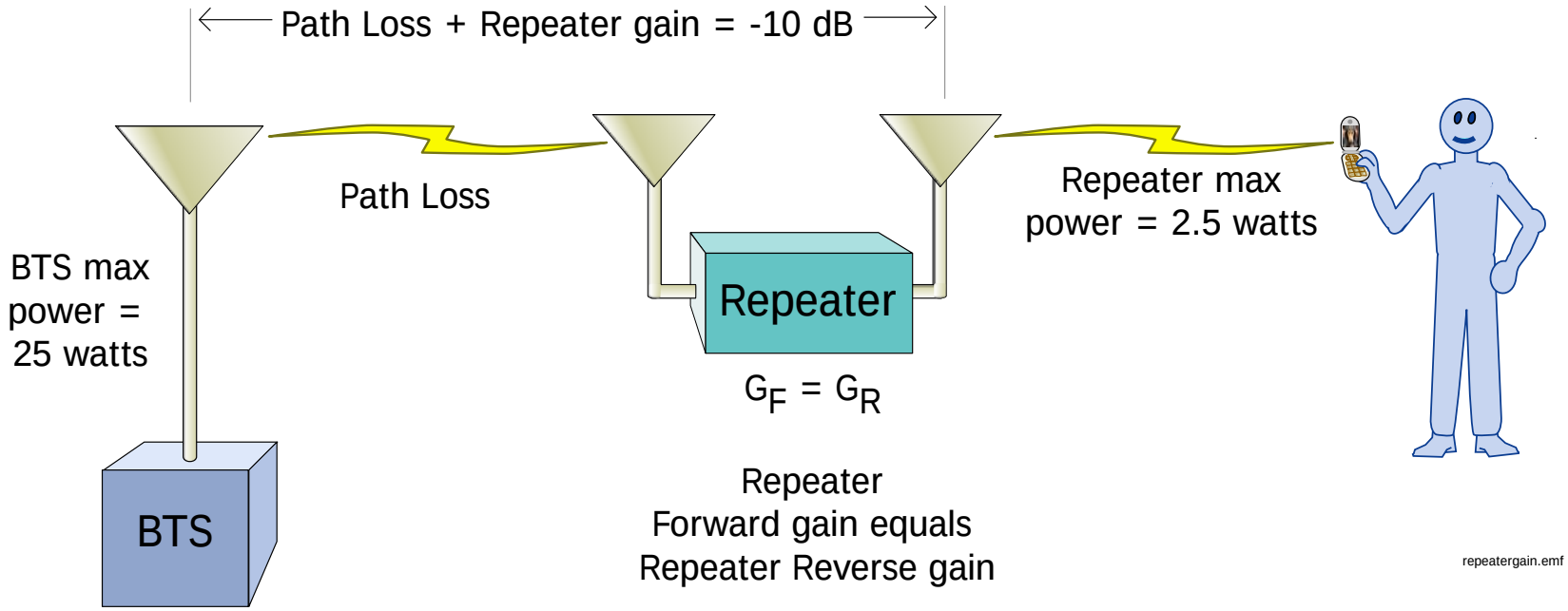
- **Desire to measure the traffic carried by the repeater**
- **Embed CSM chip in repeater and demod Reverse links**
  - Expensive
  - Would only “see” activity on R-ACH
    - Long code mask for R-ACH is public
    - Long code mask for Traffic is only known to Mobile and BTS, not repeater
  - Are Access Probes one call or multiple calls?
  - No traffic duration information
- **Measure Rise over Thermal in repeater Reverse Link**
  - Low Cost
  - Reasonable way to estimate traffic
  - RoT can provide a useful “minutes of load” metric

The Reverse Link Operating Point

If Path Loss A = Path Loss B, phone B has to transmit 10 dB more power for same FER



The Total Gain is less than 1



Path Loss + Repeater Gain has gain less than unity
Acts like BTS B in previous slide

RoT Comparison

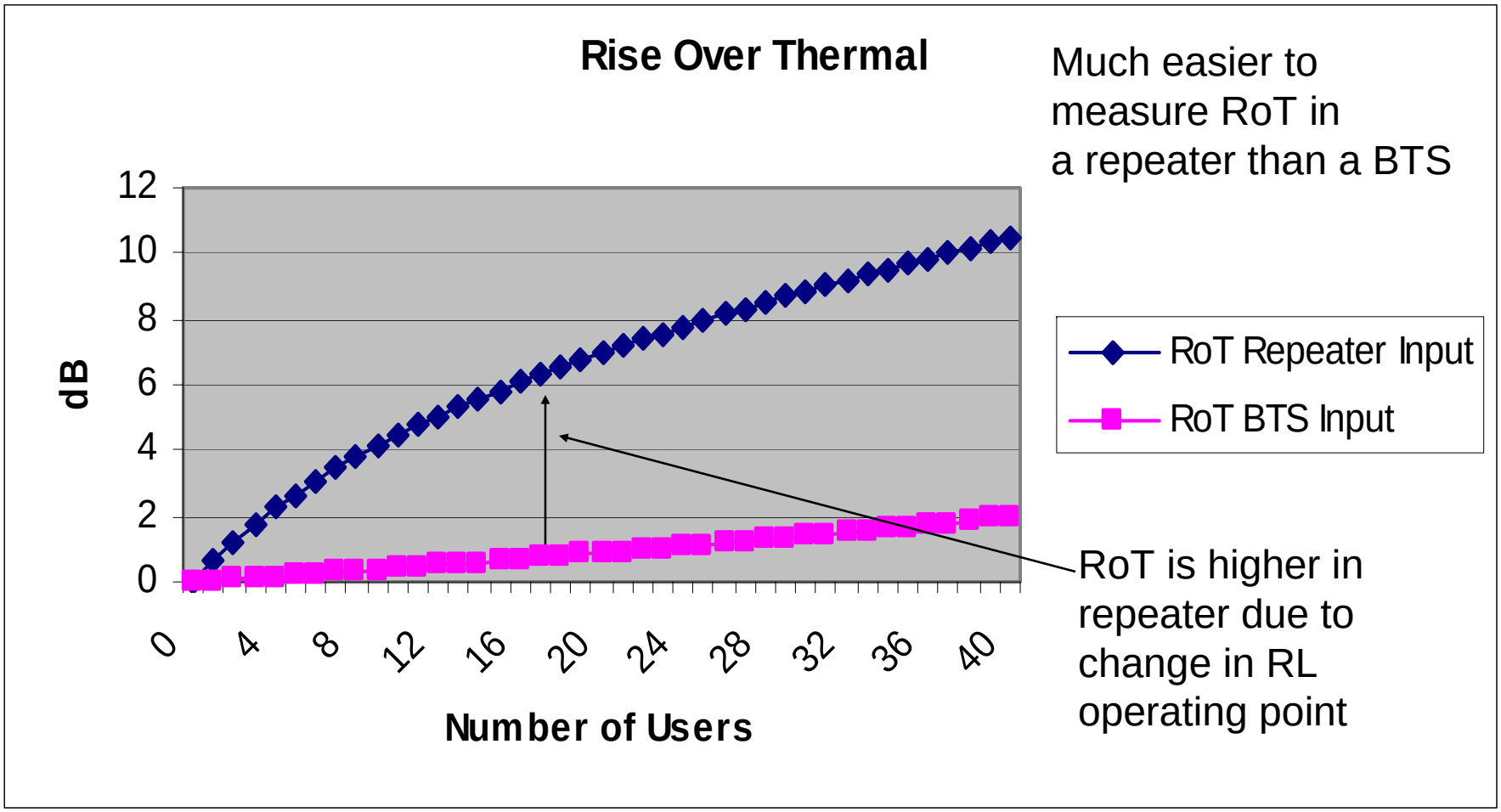


Chart Assumptions: AWGN, Isolated sector, 25Watt BTS, 2.5W Repeater, NF_{BTS}= NF_{R}= 4dB

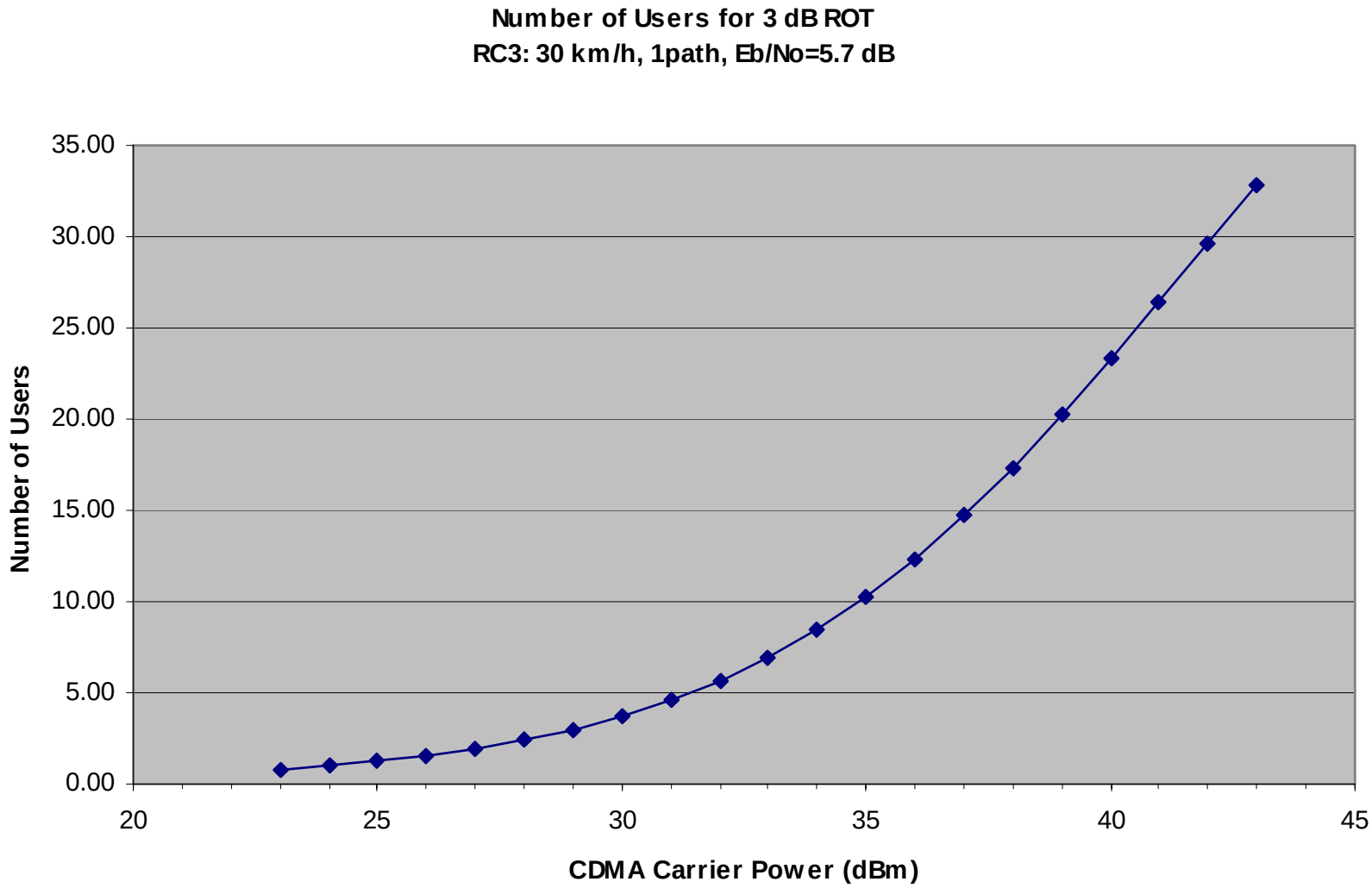
RULE Traffic Estimation

- RULE – Repeater Uplink Loading Estimate uses Rise over Thermal (RoT) to estimate the traffic
- The output power (gain) of the repeater effects the Reverse link operating point
  - Overall gain of Path Loss + Repeater Gain is < 1
  - Typical gain is -30dB to -10dB
- RULE really estimates channel load, not number of users
  - High speed data looks like a large number of users
  - Pedestrian users show less load than mobile users
- By assuming channel conditions and call type you can estimate traffic
  - Example – RC3 / 30km/hr Mobile users require Eb/No of 5.7dB

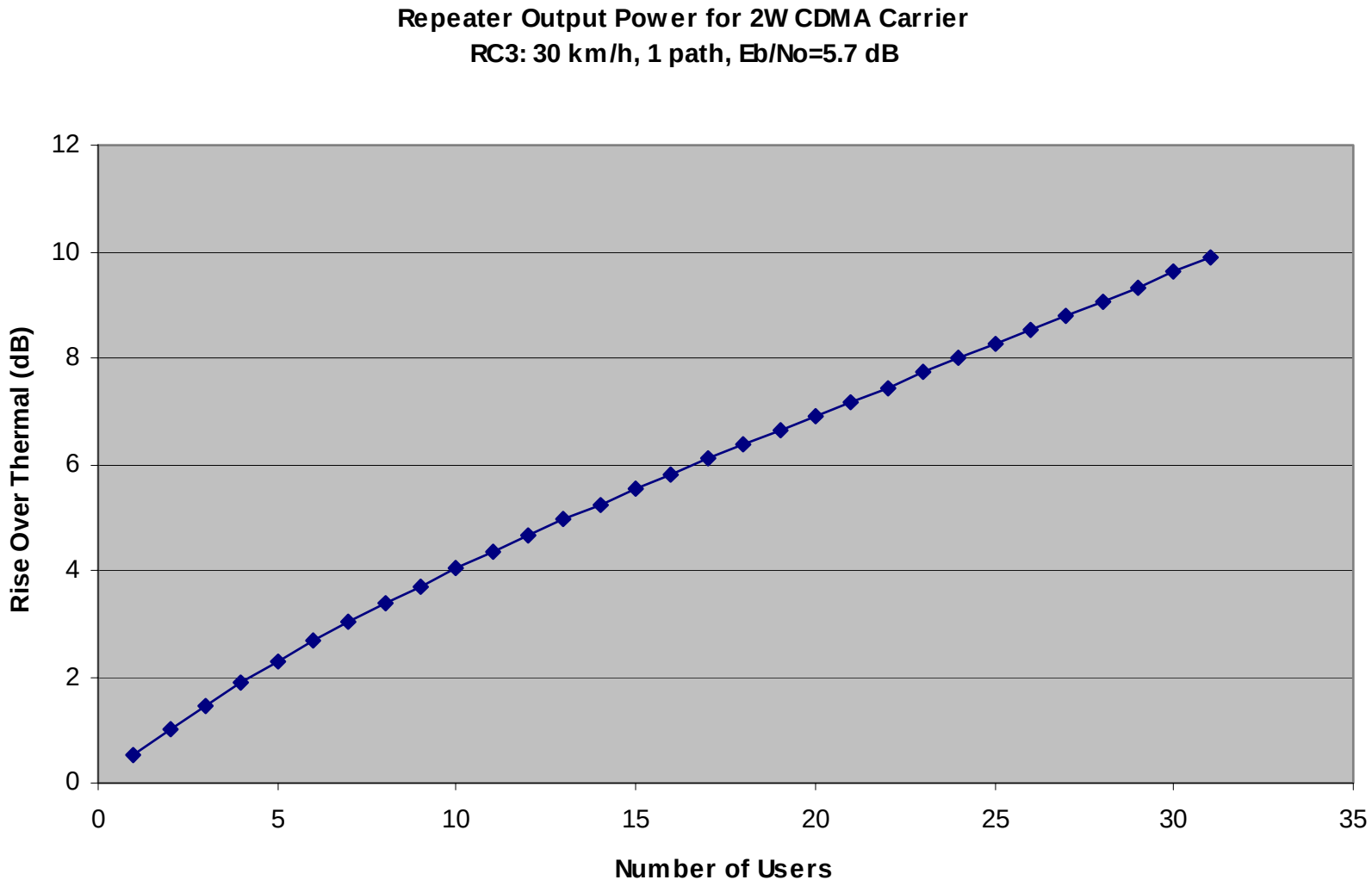
Thermal Floor

- Higher Power repeaters require more gain
  - More gain means thermal noise floor increases
  - Higher thermal noise floor “hides” the first few users of the sector
- Slide 22 shows the a 3dB rise for different power repeaters
  - Note that the power is per carrier, not the maximum total output power
  - Typical RepeaterOne circuit can detect a 1 to 2 dB rise
  - The slide assumes a RC3, 8K Voice, Mobile 30km/h environment
- Note that these slides talk about the power in one CDMA carrier
  - Most systems have more than one carrier
  - Example: 10 watt repeater with 5 carriers, then each carrier is 2 Watts
  - Most CDMA repeaters have a per channel power that is small and so RoT measurements are very useful

3dB RoT vs. CDMA Carrier Power



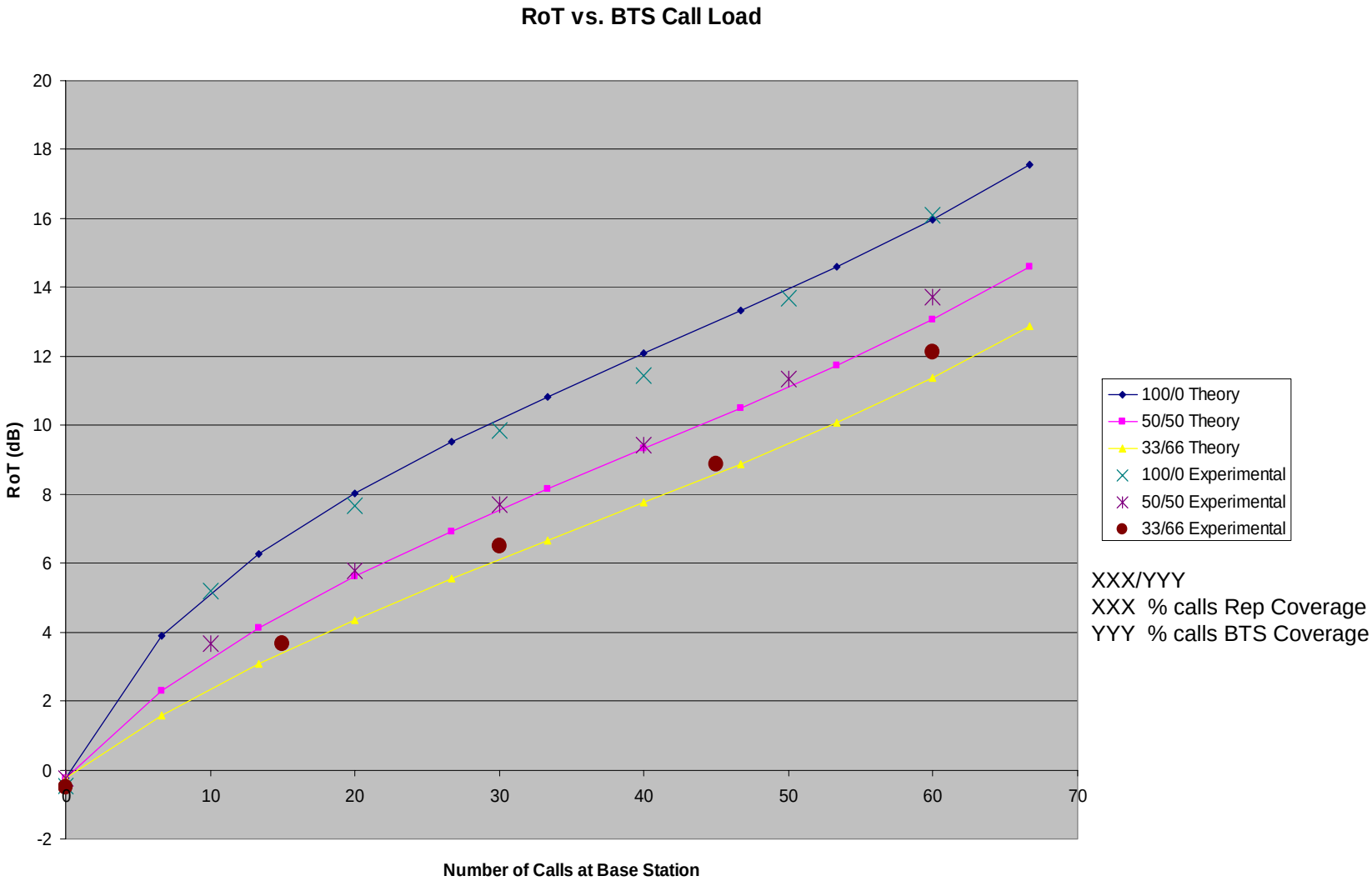
2 Watt per Carrier Example



Repeater/BTS Load Curves

- RoT changes slightly as a fraction of BTS load. Different curves are required for different BTS loads.
- For BTS loads up to 50% of call Blocking, little difference in RoT curves
- Knowing the Number of Calls at the BTS, you can back out the true repeater load.

RoT vs BTS Call Load



RULE Summary

- RULE measures Channel Loading , not individual users
  - Can infer number of users
  - How to count one high speed Data user?
  - Really better to understand the impact to channel loading and measure “call equivalents”
- RULE is low cost (requires RF detector chip, eg Linear Tech 5534)
- Simple to implement
- RULE calibration is simple and continuous
- RULE time history is reported back to carrier server via data call

Technology Status

- **Gain Controlled Repeater**
  - Makes repeaters easy to install and maintain
  - Working with dedicated Modem for 1X and UMTS
  - PC104 version working with 1X, EV-DO, UMTS soon
- **PC104 Reference Design is available**
- **RULE measurements**
  - Low Cost measurement for Reverse Link Traffic
  - Demonstrated in Lab tests and at Carrier demo
  - Upload call history to Carrier server daily

Carrier Economic Advantages

- Consistent Repeater Operation over Multiple Vendors
  - If all vendors employ RepeaterOne technology then
  - Less Training
  - Consistent Network performance
  - Less installation time
  - One less customer churning can equal royalty cost
- Use RULE to measure traffic
  - Justify CAPEX and OPEX
  - Electricity OPEX pays for RepeaterOne incremental cost in one year
  - Saving one CAPEX expenditure pays RepeaterOne incremental cost of 10 to 20 repeaters
    - USE RULE and determine little or no traffic at deployed site
    - Move unused repeater to new location, saving CAPEX
    - Save lease / real estate costs

CAPEX Increase

- Assume that high performance repeaters contain a modem for status monitoring
- BOM (Bill of Materials) Increase
  - Digital control of gain required
    - Many repeaters already have digital step attenuators
  - Processor required
    - Reference design uses 386 plus small Linux OS
  - RULE detector
    - Based on low cost chip from Linear Tech (LT5534) or Analog Devices (AD8317)
- Royalty
  - Standard infrastructure royalty rates
- Bottom Line
  - Total incremental costs are typically a few hundred dollars

Vendor Economic Advantages

- Optimizing CDMA performance is difficult and expensive
  - RepeaterOne removes this problem
  - System engineering performed by Qualcomm
  - 1X, EV-DO, UMTS all supported
  - Reference design available for RF, Processor + control interface, software
- Vendor can compete in area of expertise
  - Size
  - Power
  - Cost
  - Packaging
  - Filtering
  - Easy to adapt to new band plans, new CDMA technologies
    - Change Modem card
    - Reconfigure software

Conclusion

- **RepeaterOne technology**:
  - Controlled Performance of Forward and Reverse Link
  - Automated deployment
  - Use PCMCIA modem for simple deployment
  - Repeater can measure Reverse Link traffic
  - Repeater is able to detect oscillation
  - Increased repeater cost easily justified by reduced CAPEX, OPEX or Churn
- All IPR available under RepeaterOne license to repeater vendors

WWW.RepeaterOne.com