RFID Alliance Lab: Data Rates
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Who We Are

RFID Alliance Lab

- Evaluate RFID products in a *scientific* way
- Provide useful, timely, credible, and unbiased data to end users of RFID products
- Constituents
  - **University of Kansas / ITTC**: Primary research contributor
  - **RFID Journal**: Initial funding, distributor, advertisement
  - **Rush Tracking Systems**: Initiator, industry lesion
- Business model
  - Sell reports (~$1,000 / report) to finance future reports
  - Sponsorships

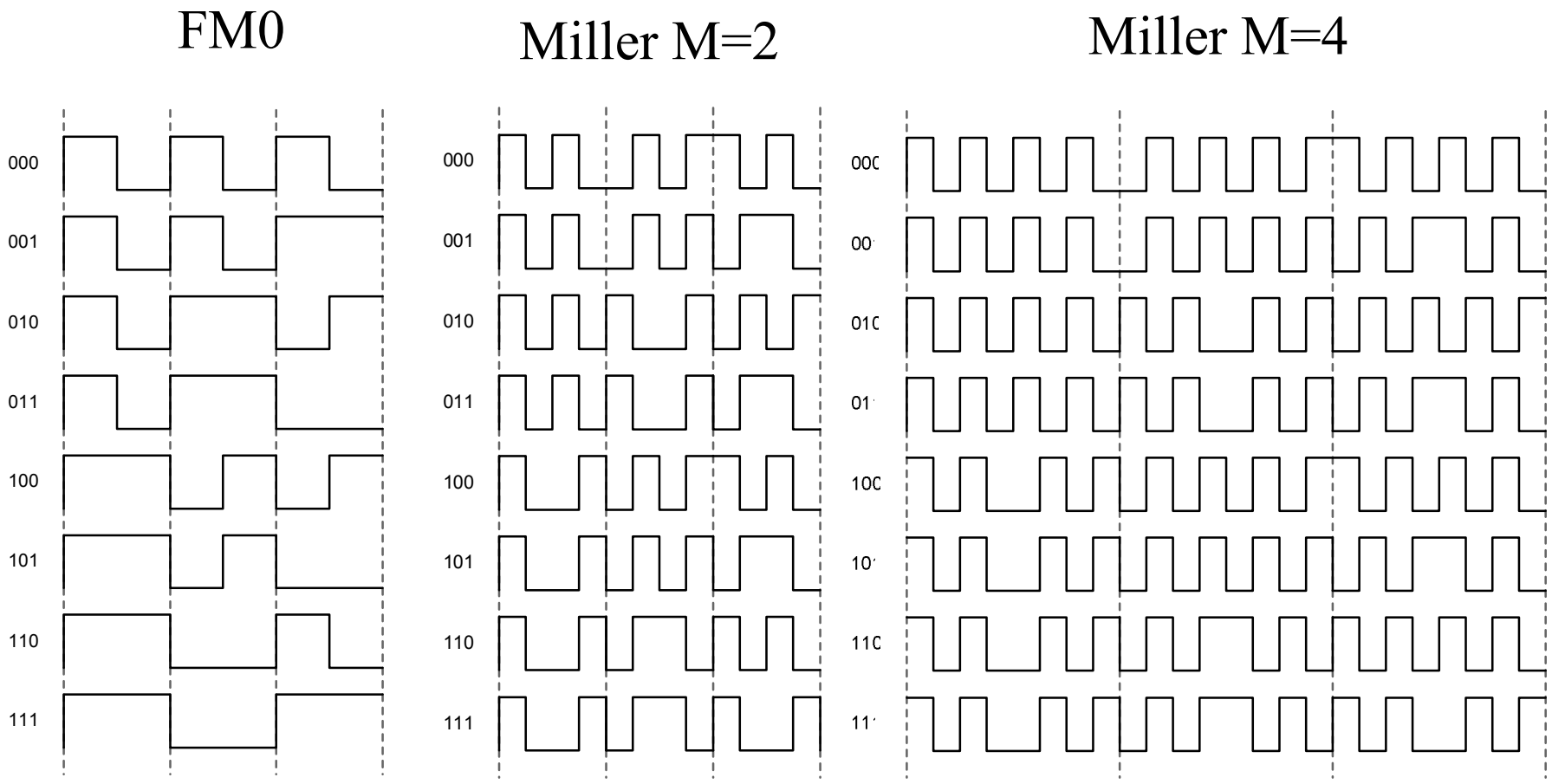
ITTC/KU Applied Research Labs

- Helping companies solve hard problems
  - Tagging small electronics devices
  - Seknion: direction of travel through portal
  - Tagging metal assets
- Adamas: high performance low profile metal tag
- Basic research
  - RFID privacy using CDMA
- We would like to talk with you about your hard problems

Gen 2 Options

- The Gen 2 standard makes *optional*:
  - T=>R data rates varying from 40–640 kbps
  - Codes: FM0, Miller M=2, M=4, M=8
- Effectively 5–640 kbps

Modulation



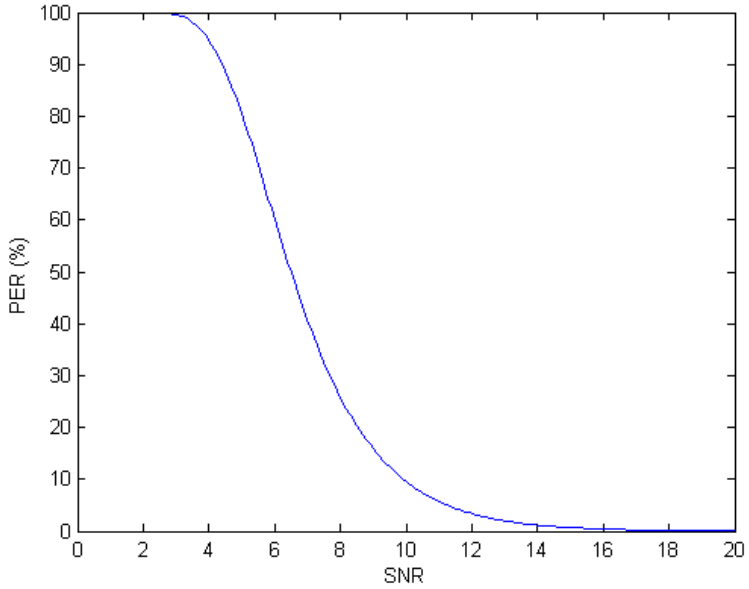
Tag Energy Equation

- $P_T \propto \frac{P_{R=>T}}{d^2}$
- $P_{T=>R} = P_T - 10\mu W$
- $P_{Rx} \propto \frac{P_{T=>R}}{d^2}$
- $\therefore P_{Rx} \propto \frac{P_{R=>t}}{d^4} - \frac{10\mu W}{d^2}$

Problem

- Let A be the difference between on and off in voltage received
- Let T be the symbol time
  - Signal energy $E_b = A^2T/2$
  - ½ for synchronization and estimation
- Let N_0 be the noise power level (watts / Hz)
- SNR: E_b/N_0
- $$\mathrm{BER} = Q\left(\sqrt{\frac{A^2T}{2N_0}}\right), \quad \mathrm{PER} = 1-(1-\mathrm{BER})^{128}$$

What That Means



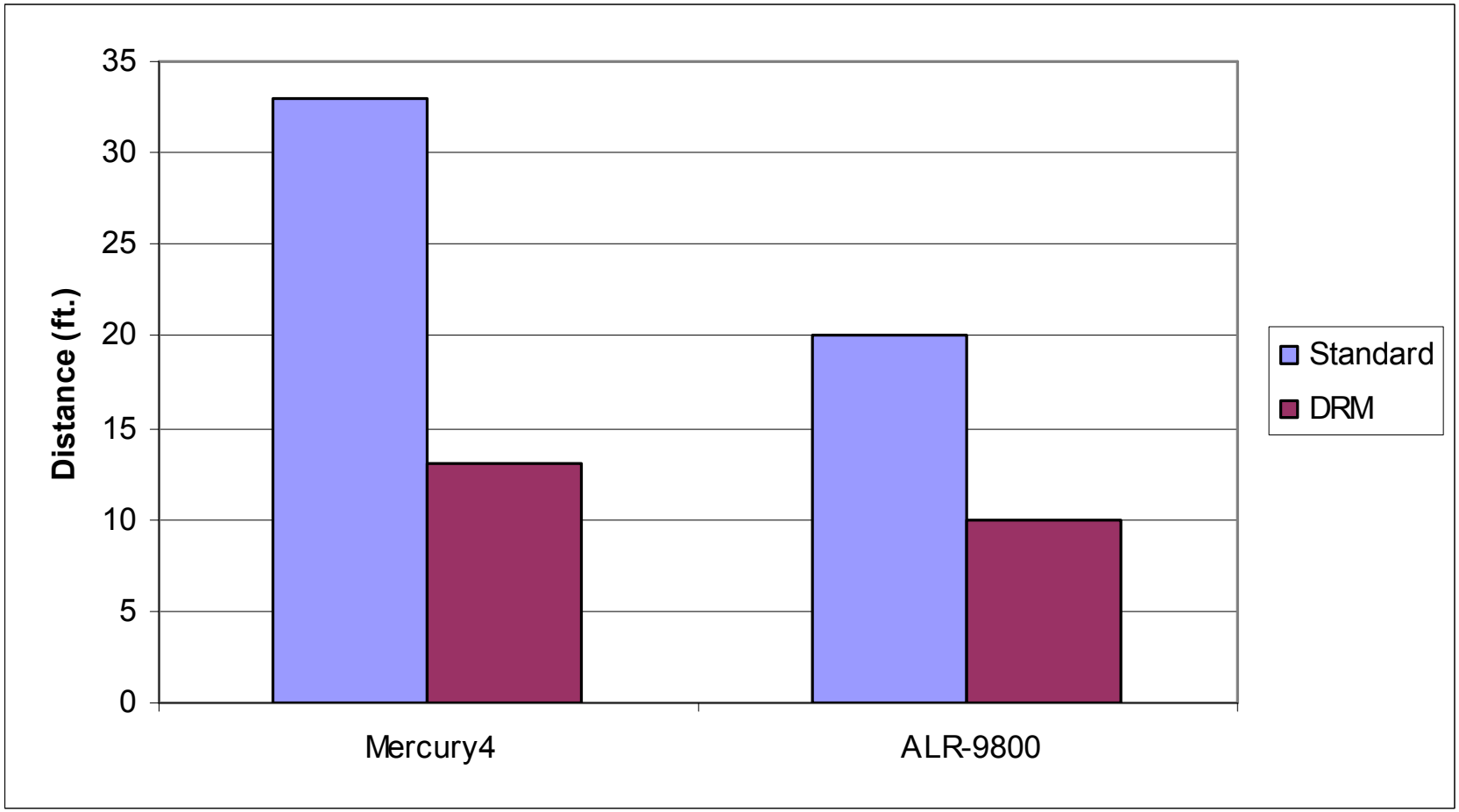
- SNR: **S**ignal to **N**oise **R**atio
- PER: **P**acket **E**rror **R**ate

- Signal should be >10× noise level for reliable communications
- More signal yields diminishing returns

What You Can Do

- Currently, with most readers — nothing.
- In Dense Interrogator Mode — almost nothing.
- Hopefully in the near future:
  - Set Data Rate (40-640 kbps)
  - Set Modulation (FM0, M=2, M=4, M=8)
- Ideally, in Single Interrogator Mode:
  - Let the reader “sniff” the RF environment
  - Estimate N_0
  - Set data rate, modulation appropriately
  - Incorporate data rates, Q into single algorithm

Lab Test Results



Experiment

- SAMSys v2.8 allows data rates to be set between 40/40 and 80/160 kbps (relatively slow)

Results in Laboratory Conditions

SAMSys 9320 v2.8		
Forward Channel	Reverse Channel Rate	Reads / second
80 kbps	160 kbps	~600
40 kbps	40 kpbs	~160

Conclusions

- Gen 2 offers variable data rates
- Can theoretically tune signal strength by 128×
  - Dense Interrogator Mode gives little flexibility
  - Different tags, distances, orientations make signal strength between two tags highly variable
- Current implementations show *worse* distances
  - Likely “growing pains” of Gen 2
- Look for future readers to incorporate dynamic data rates into inventory algorithm