Expanding ALERT2 System Capacity with Configurable Forward Error Correction

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Introduction

- David and Adam acquired Blue Water Design last year.
- We proposed Configurable Forward Error Correction last year.
- Configurable FEC adds new modes to ALERT2, allowing sites to send data more quickly.
    - Allows transmitter sites to use a 250ms time slot, instead of 500ms, **doubling system capacity, or halving latency!**
    - Allows repeater sites to transmit more information, expanding backbone capacity and/or reducing reporting latency.
- Configurable FEC is available now on Blue Water Design's A2X and A2M INDs. We expect to see these features available from other vendors soon.

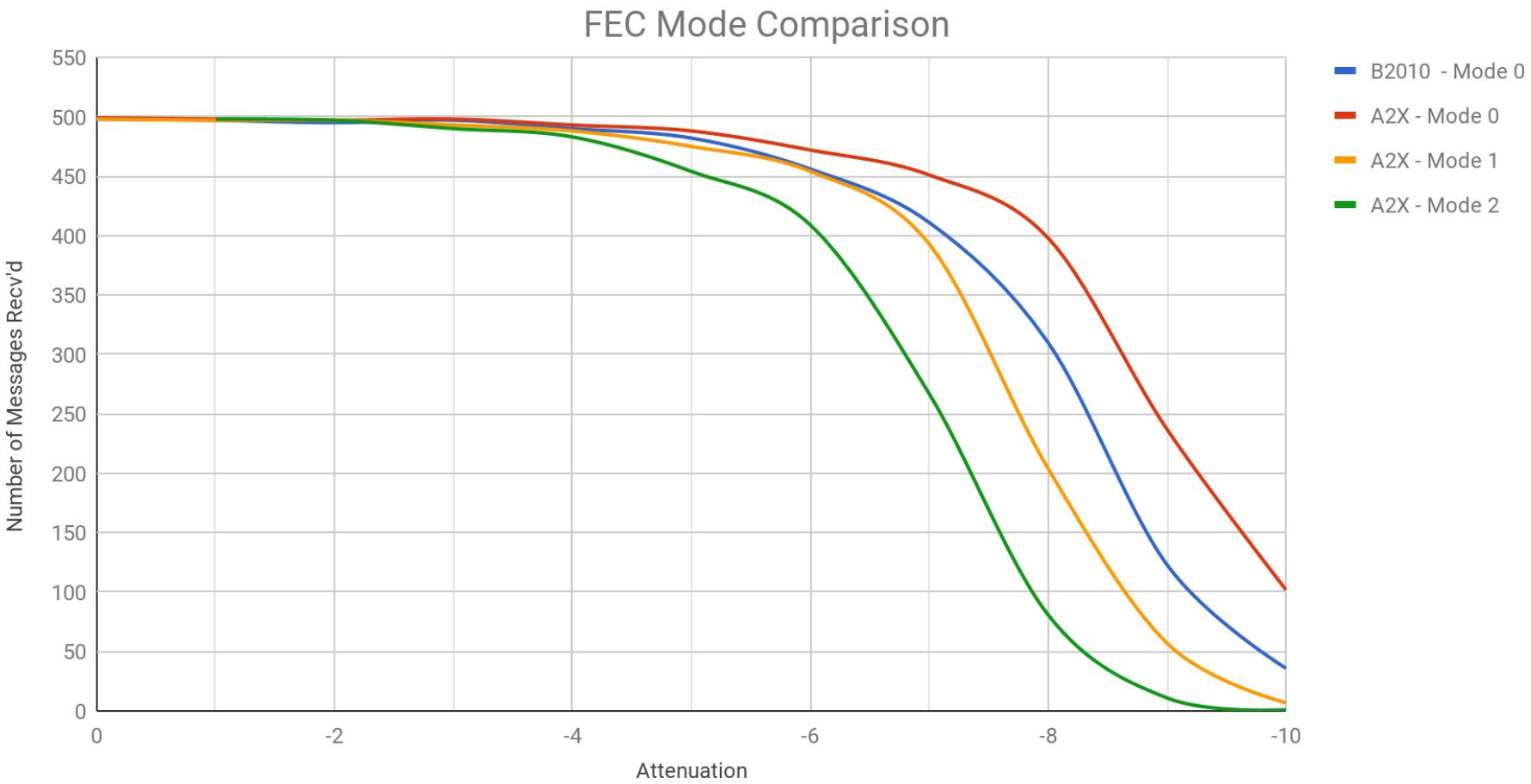
What is Forward Error Correction, and what does it have to do with ALERT2?

- ALERT2, unlike ALERT, can detect and correct errors introduced by noisy radio channels.
- The transmitter uses a *redundant encoding* to send the message with some duplication, allowing the decoder to correct a limited number of errors in the message.
- The more error correction information we add, the more errors we can correct but the longer it takes to send the same message.
- Configurable FEC allows users to adjust the amount of error correction information included to optimize transmission for differing circumstances.

New Modes and Throughputs

- Configurable FEC specifies three levels of error correction:
  - Mode 0 is the existing ALERT2 FEC scheme
  - Mode 1 is suitable for moving most transmit sites to a 250ms timeslot
  - Mode 2 is primarily intended to reduce the amount of airtime used by busy repeater sites with good radio paths
- The demodulator identifies the new FEC modes by use of new frame sync values

FEC Mode	**Max MANT data in 250ms slot**		**Max MANT data in 2s slot**		**RX Sensitivity**
0	22 bytes	100%	353 bytes	100%	0dB
1	42 bytes	190%	531 bytes	150%	-1.5dB
2	52 bytes	236%	646 bytes	183%	-2.5dB


FEC Mode Comparison
Number of Messages Recv'd
550
500
450
400
350
300
250
200
150
100
50
0
0
-2
-4
-6
-8
-10
Attenuation
B2010 - Mode 0
A2X - Mode 0
A2X - Mode 1
A2X - Mode 2

Considerations for Shorter TDMA Slots

- Understand and minimize message overhead time
- Be aware of the requirements imposed by different VHF radio models
- Optimize application data encoding
- Evaluate and understand impacts on repeater capacity

AirLink Message Overhead

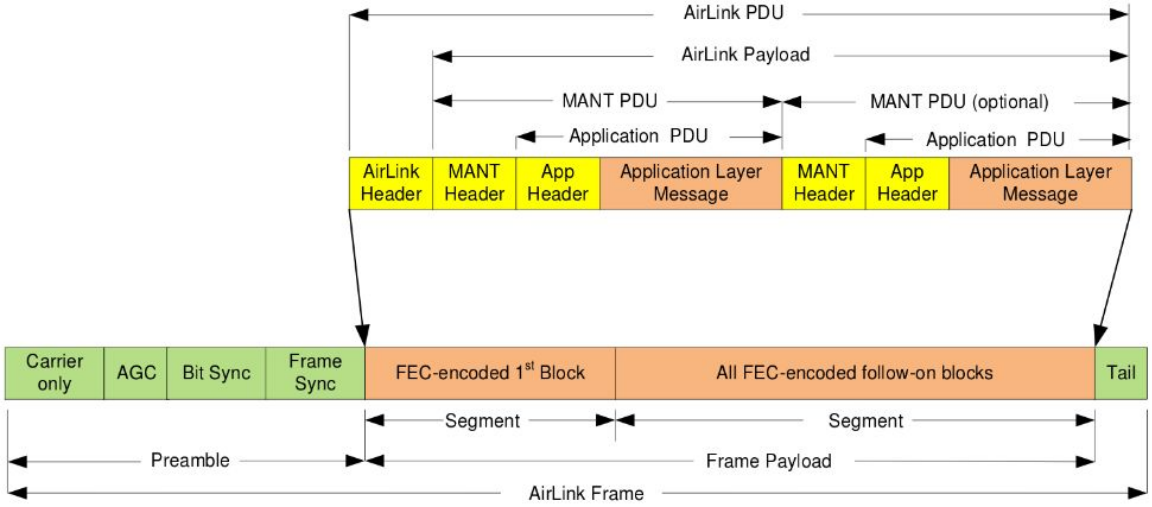


Figure 2-1 AirLink Terminology

Component	Duration
TDMA Padding	25 ms
Carrier Only	5 ms
AGC	30 ms
Bit Sync	10 ms
Frame Sync	6.67 ms
Tail	5 ms
Total	**81.67 ms**

- Overhead: Carrier only, AGC, Bit Sync, Tail, TDMA Slot Padding (Not Shown), AirLink Header

Moving to Higher Data Rates: Manage Overhead

- 25ms of TDMA slot padding is recommended to allow for clock drift, IND latency, etc.
- Minimize carrier only time; add padding to AGC instead
- AGC time required depends on radios and may need to be determined experimentally.
    - Ritron DTX-Ls transmitters respond to PTT faster than Maxon SD-125E V2
    - Suggest AGC time of 15-30ms for Ritron, 25-50ms for Maxon
- Limit RF Tail time to 5ms for Ritron & Maxon
- Other radios will require values to be set experimentally
- Power amplifiers may require extra warmup time

Moving to Higher Data Rates: Application Data

Application data format has a large impact on system efficiency. Imagine a weather station wishing to report the data in the following table, along with three tips from a tipping bucket rain gauge.

Sensor	**Value**
Air Temperature	82.1 deg F
Relative Humidity	32 %
Wind Speed	19 mph
Wind Direction	271 deg
Stage	12.7 ft
Rain Accumulator	325

Message Format	**Size (bytes)**
MSR + TBR in 1 MANT packet	31
MSR + TBR in 2 MANT packets	41
GSR + TBR in 1 MANT packet	39
GSR + TBR in 2 MANT packets	49
GSR + TBR in 6 MANT packets	95

This is a typical report, **not** a worst case. Sites with more sensors will require more time to send that data!

Moving to Higher Data Rates: MANT Details

Msg Type	MANT Header	App Header	Msg Type Header	Air Temperature	Relative Humidity	Wind Speed	Wind Direction	Stage	Total Bytes
MSR	06:00:10:0E:30:39:00	04:12:05	03:09:5B	03:35	20	13	01:0F	04:F6	**22**
GSR	06:00:10:17:30:39:00	04:12:05	01:12	01:22:03:35	02:11:20	04:11:13	05:12:01:0F	07:22:04:F6	**30**
Msg Type	MANT Header	App Header	Msg Type Header	Sensor ID	Accumulator	Time Stamps			Total Bytes
TBR	06:00:10:0C:30:39:00	04:12:05	02:07	01	12:01:45	18:10:06			**19**

Configurable FEC and Repeaters

- Repeaters using FEC Mode 2 can send nearly twice as much data compared with FEC Mode 0.
- However, repeaters listening to sites using FEC Mode 1 and 250ms slots may receive double the amount of data.
- Finally, real world data doesn’t change. If the TDMA frame length is shorter, less data will need to be sent each frame.
- Practically speaking, existing repeater TDMA configurations should continue to work.
- BWD’s A2X repeaters will buffer messages if the TDMA slot is too short for the amount of data needing to be transmitted, and send them out in LIFO order.

The Benefits of Configurable FEC

- Reduce TDMA Frame length (and, therefore, reporting latency) by 50% without changing system capacity.
- **Or**, add more sites to an existing system, without needing to licence additional frequencies and add additional repeaters and complexity.
- **Or**, extend the number and type of sensors used at gauging sites without requiring excessively long slot times.
- **Or**, transport data from a larger region over the same backbone network, without exceeding its capacity.

Future Possibilities

- Over-The-Air configuration
    - By increasing the throughput of the protocol and reducing TDMA latency, FEC Modes 1 and 2 make OTA configuration changes more practical -- especially for larger configurations like pass-lists.
- EERDS and Two-Way communication
    - TDMA Frame Length is the main cause of latency in two-way communication using ALERT2. The Configurable FEC protocol should allow most systems to reduce frame length substantially, resulting in a significant decrease in two-way communication latency.

Future Possibilities - Images

Original 4320x3240
JPG
3,438,974 bytes
(3.4MB)

160 x 120 JPG
986 bytes
(~3s Mode 2)

160 x 120 JPG
793 bytes
(2.5s Mode 2)

Parting Thoughts

- Configurable FEC can nearly double your system capacity, or halve it’s latency
- Useful timeslots of 250mS are possible starting with Mode 1
- Some care must be taken in determining which sites are suitable for the new modes
- Demodulators supporting the new modes are currently available, and need no additional configuration

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