

gr4-packet-modem

a QPSK packet modem for GNU Radio 4.0

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- A packet-based QPSK modem implemented from scratch in GNU Radio 4.0
- Funded by GNU Radio with an ARDC grant. Project runs May to September.
- Goals:
 - Test GNU Radio 4.0 in a digital communications application
 - Produce an example of a complete system and documentation



- Modular implementation with many “small” blocks
- Suitable for IP communications (TUN device)
- Should have good latency
- Flexible packet size \Rightarrow no payload FEC
- Use good signal processing techniques (e.g., FFT-based preamble correlation for synchronization)
- Production ready (besides the lack of payload FEC)
- Only QPSK. Provision to support additional MODCODs (user customization)
- If a payload FEC is added, should work at low SNR
- Burst mode and stream mode (continuous transmission with idle packet insertion)

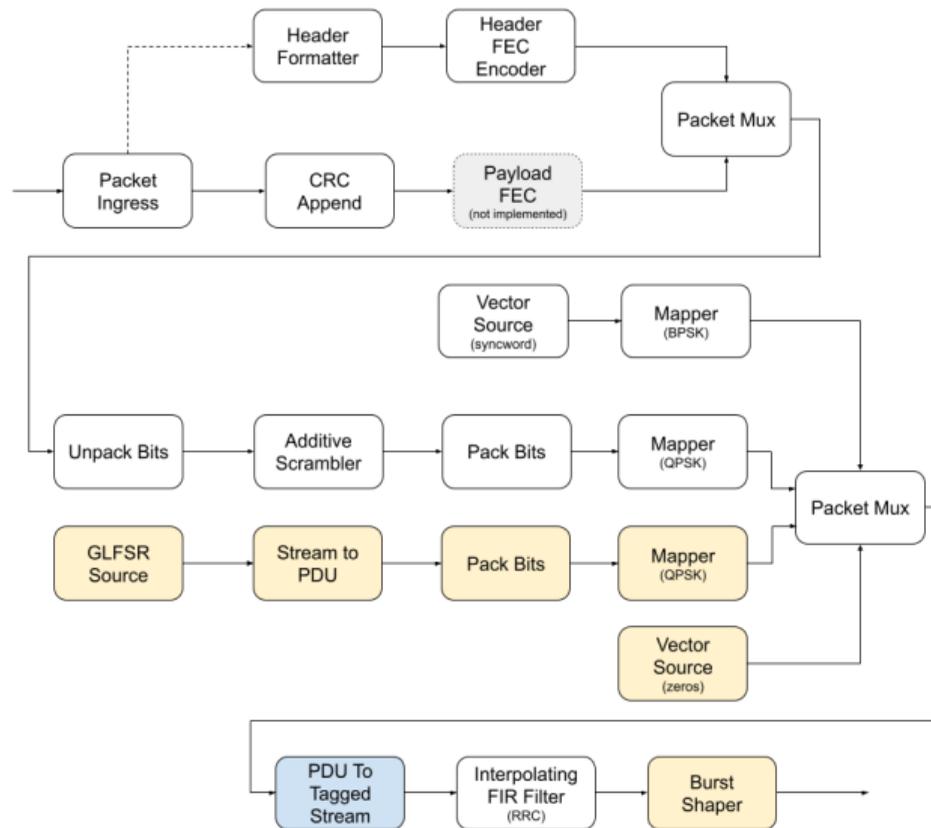
Waveform design

- Single-carrier root-raised cosine QPSK waveform
- Packet structure:

| | Symbols | Constellation | Notes |
|------------------|----------------|----------------------|---|
| Syncword | 64 | BPSK | CCSDS 64-bit ASM |
| Header | 128 | QPSK | 32 bit with $r=1/4$ LDPC and $r=1/2$ repetition |
| Payload | Variable | QPSK/other | |
| CRC-32 | 32 bits | QPSK/other | CRC-32 of payload |
| Ramp down | 9 | QPSK | Only burst mode; pseudorandom |

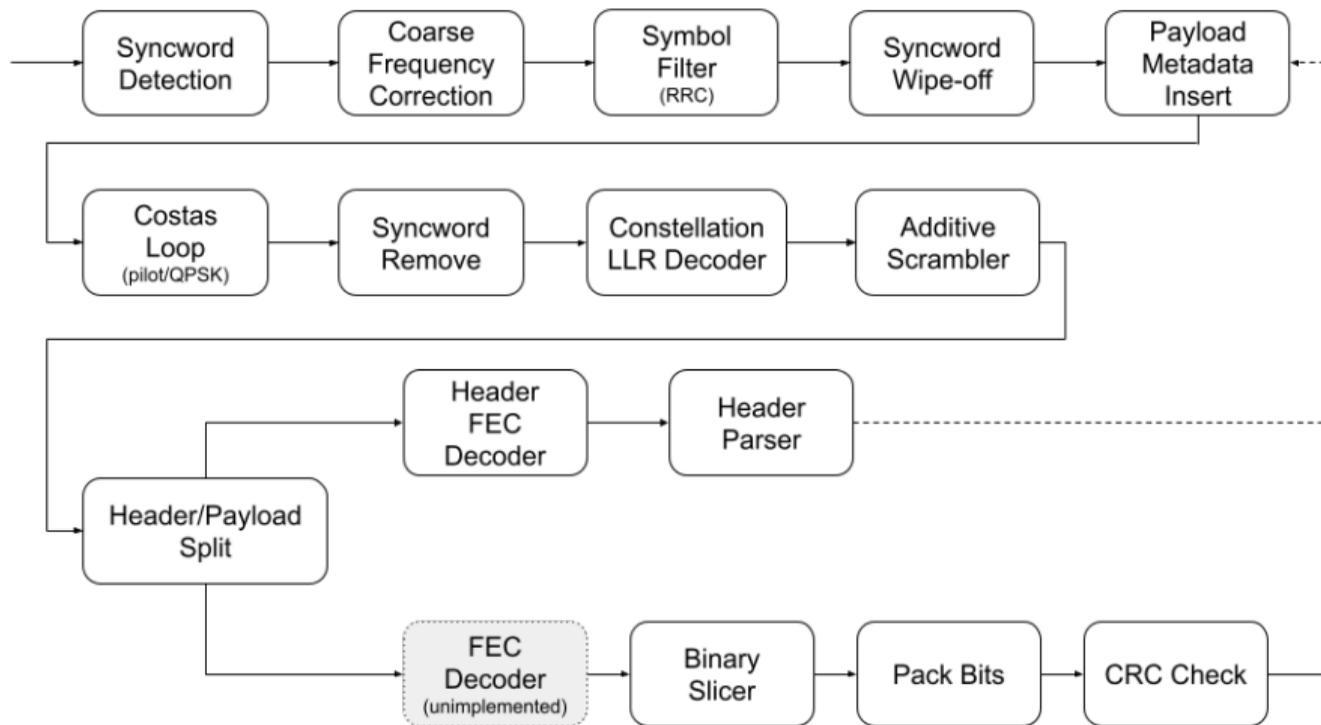
- Header, payload and CRC-32 are scrambled with 17-bit CCSDS scrambler
- Header contains payload length, packet type (idle, MODCOD, etc.), with room for user extensions
- Burst mode has amplitude ramp up and ramp down

Packet transmitter



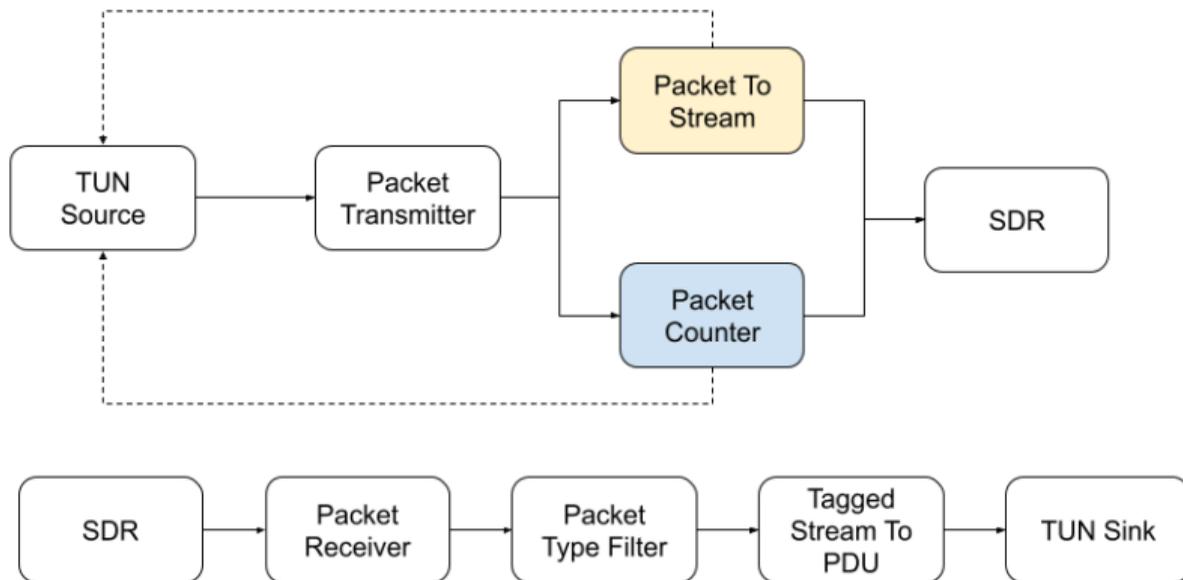
- Use FFT-based correlation to detect packet and estimate amplitude, phase, frequency and timing (several frequency offsets tested)
- Correct all the packet for the estimated frequency error and amplitude
- RRC filter and downsample to 1 sample/symbol using estimated timing
- Closed-loop phase recovery with Costas loop, seeded with estimated phase and frequency (use syncword as known pilots)

Packet receiver



Complete modem

The transmitter uses packet counting for latency management.



Demo

Some feedback about GNU Radio 4.0

Disclaimer: feedback is subjective and prone to change!

Nice features:

- `processBulk()` calls are chunked using tags: a tag can only appear in the first item. Caveat: too much overhead when not needed. Perhaps should be opt-in.
- Messages can be treated as regular connections: `PortIn<Message>`, `PortOut<Message>`. Caveats: not compatible with `MsgPortIn`, `MsgPortOut`. Probably single-producer.
- Rational-ratio resampling blocks are a first class citizen: `Resampling<inputChunkSize, outputChunkSize>`
- `HistoryBuffer<T>` quite good replacement for history (also useful in other contexts)

Shortcomings:

- Tags are too expensive. Packet transmitter using `packet_len` tags didn't work properly.
- Can use `std::vector<T>` to delimit packets (on the receiver not really), but:
 - Buffers are 65536 elements by default
 - Lack of effective backpressure (buffer only fills up with 65K packets)
 - Memory management (who deallocates unused packets? does this constantly allocate and deallocate?...)
- “General blocks” perhaps too simplified. No `forecast()`, just `Async port` annotation. Might not be enough in some cases (e.g., when to call a block? how to know if a block can produce output without any input?)
- `scheduler::Simple<scheduler::ExecutionPolicy::multiThreaded>` doesn't really work at the moment
- Some buffer management bugs (fixes in progress)

A fun experiment: test over a GEO transponder

From Frank Zeppenfeldt <Frank.Zeppenfeldt@esa.int> 

To Daniel Estévez <daniel@destevez.net> 

Subject **gr4-packet-modem - test over GEO C-band**

 Reply

 Forward

 Archive

 Junk



Hi Daniel,

Possible interest at your side to test the your new packet modem over a C-band uplink over GEO? I have 1 MHz capacity over Intelsat at 18W. Uplink only.

IQ data can be picked up via ZMQ at the teleport in Germany.

24 dBi 5 GHz WiFi flat panel and 2W power amplifier



125 syms/s gave an SNR of 9-10 dB

