POLYPHASE UP CONVERTER CHANNELIZERS FOR FULLY DIGITAL FREQUENCY HOPPING MODULATOR

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SPREAD SPECTRUM TRANSMISSIONS

Spread spectrum (SS) techniques were, at the beginning, investigated for military applications because of their characteristic of being highly jamming resistant

APPLICATIONS

- Communication
- Navigation
- Test systems
- .....

- **The name, spread spectrum, derives from the fact that the modulated signal is spread over a wider bandwidth before being transmitted. i.e. the bandwidth employed for transmission is much larger than the minimum bandwidth required to transmit the information**

SPREAD SPECTRUM TRANSMISSIONS

ADVANTAGES

- Low probability of detection (energy density reduction)
- Interference suppression
- Fine time resolution
- Communication resource sharing (multiple access transmission techniques)

FREQUENCY HOPPING

Frequency hopping is one of the most common spread spectrum techniques in which the carrier frequency of the signal is periodically changed before transmission

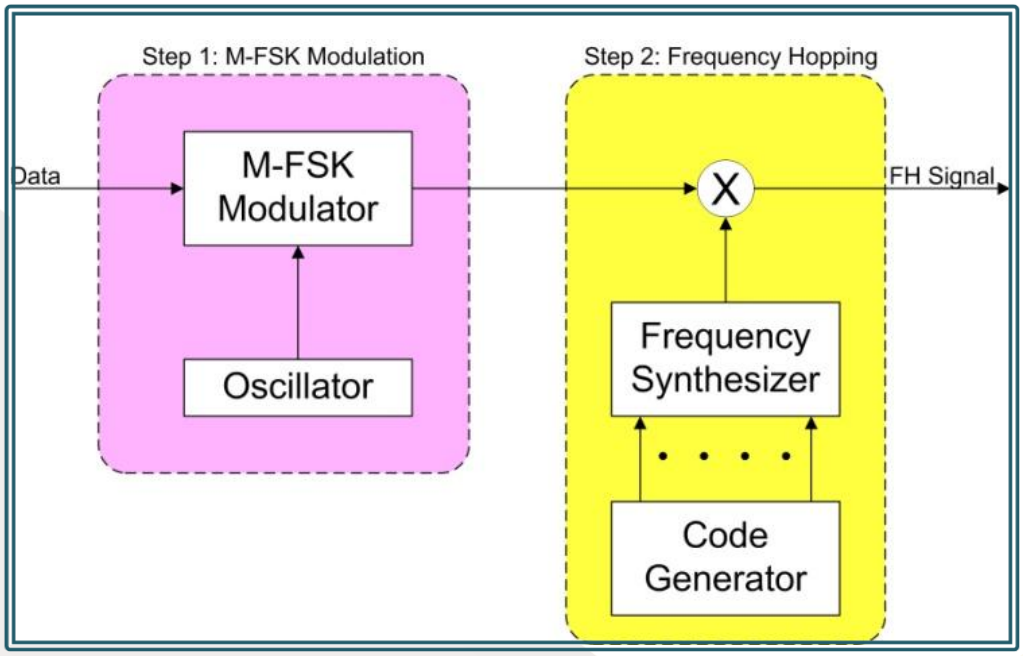
In frequency hopping spread spectrum (FHSS) transmissions, a frequency band, called hopping band, that includes M channels, is accessed by a controlled pseudorandom sequence, called frequency hopping pattern, that shifts it to a different center frequency which is selected from N possible center frequencies

The receiver knows the pseudorandom sequence

FREQUENCY HOPPING

In the frequency hopping transmitters, the modulation process occurs in two steps:

1. The input signal is baseband modulated (generally by using an analog or a digital M-FSK modulator)
2. The complete hopping band is hopped over one of the N possible hopping frequencies by a second tier up converter

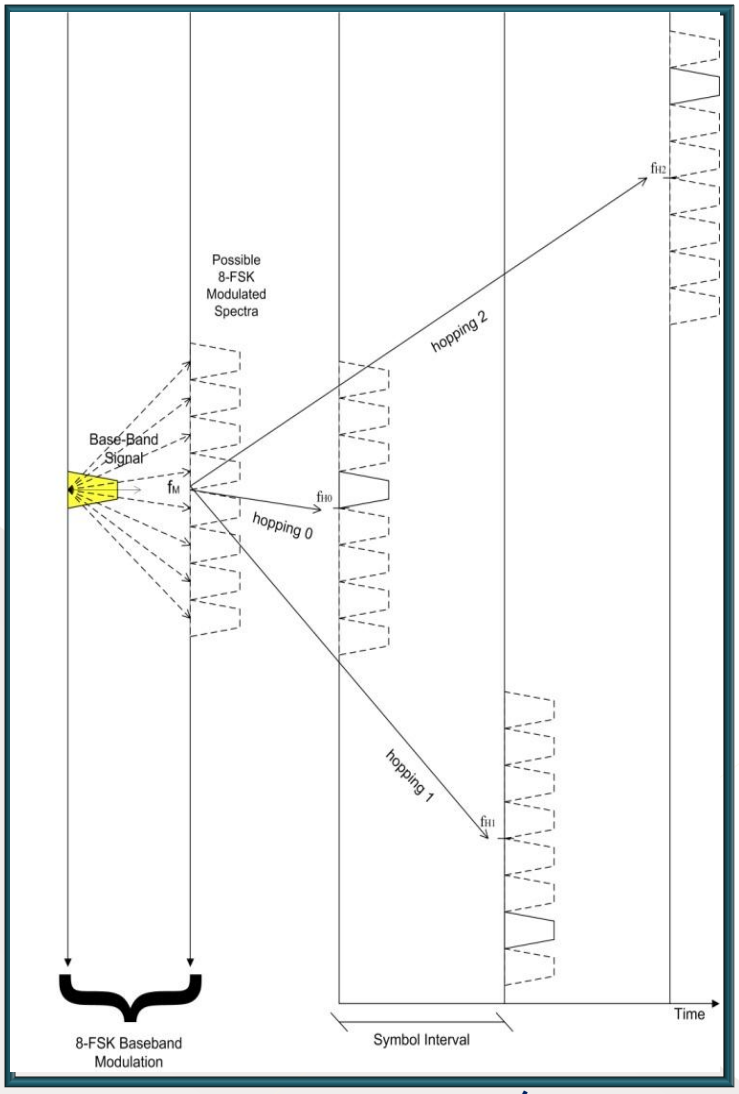


FREQUENCY HOPPING

The frequency synthesizer produces frequency hopping patterns determined by the time-varying multilevel sequence specified by the output bits of the code generator

At each hop time the pseudorandom code generator feeds a frequency synthesizer a frequency word which dictates one of the possible center frequencies from the *hopset*

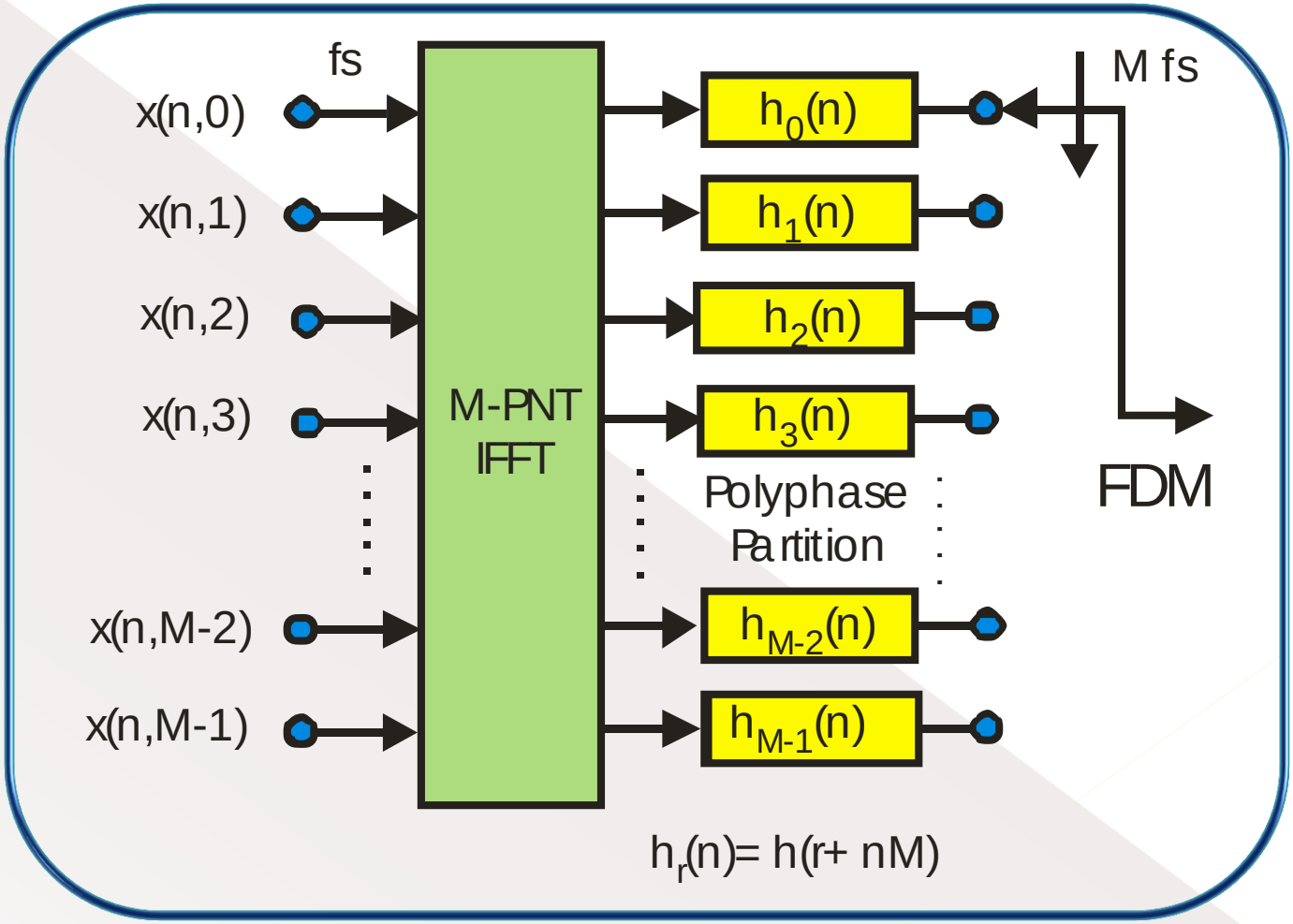
The M-FSK data modulated signal is then mixed with the synthesizer output pattern to produce the frequency hopped signal



NOW LET'S MAKE IT COMPLETELY DIGITAL!

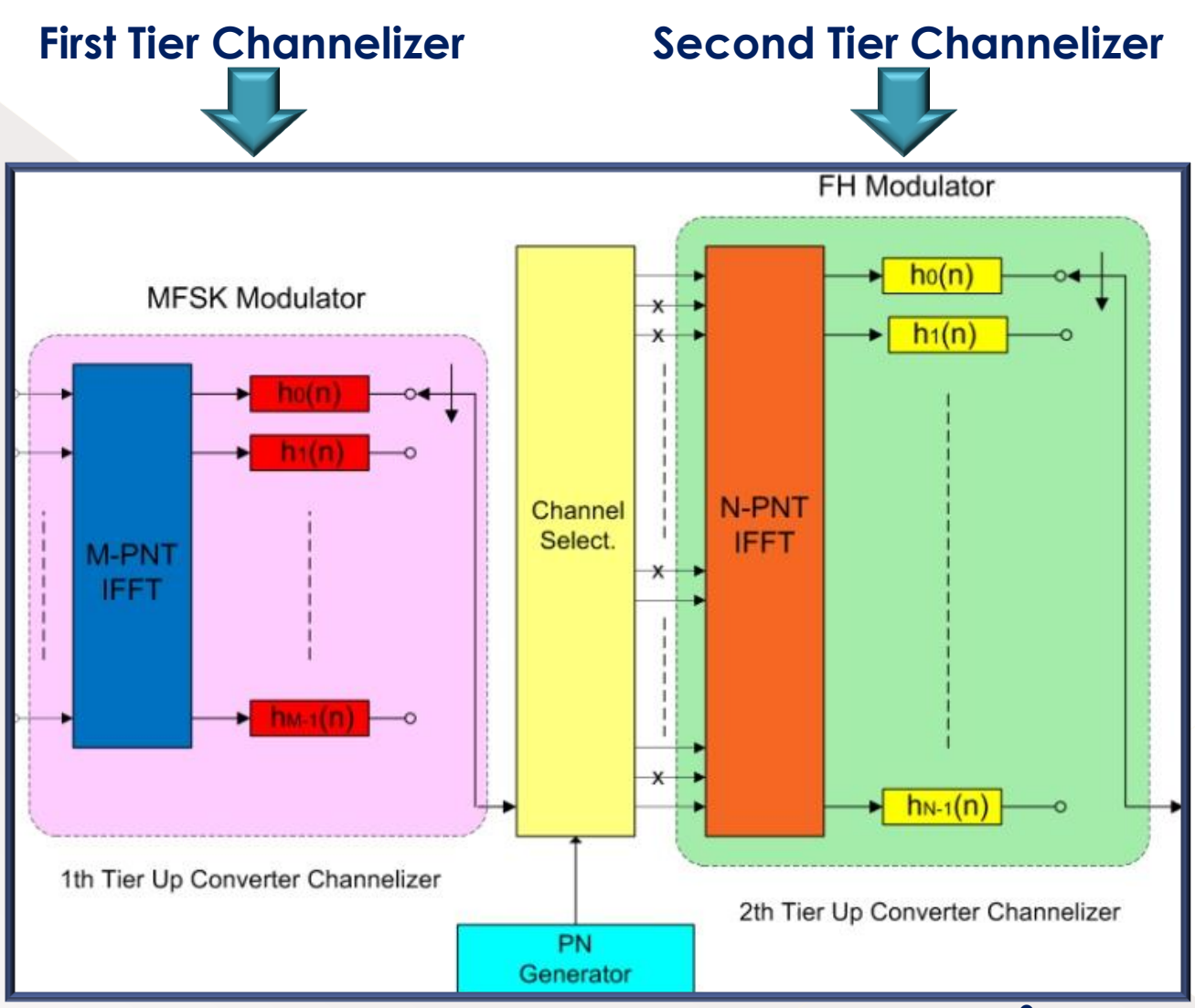
POLYPHASE UP CONVERTER CHANNELIZER

- Digital up conversion to higher Nyquist zones by the IFFT
- Spectral shaping and filtering by the M-path partitioned filter weights
- Sample rate change by the M-port output commutator

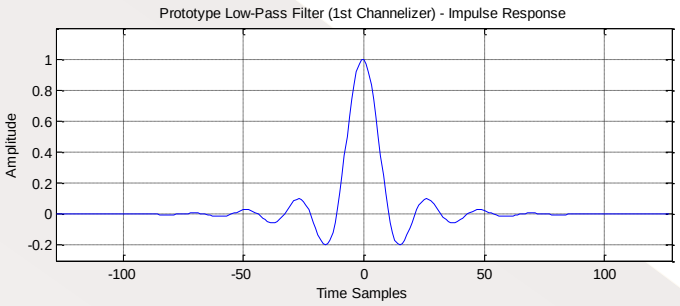


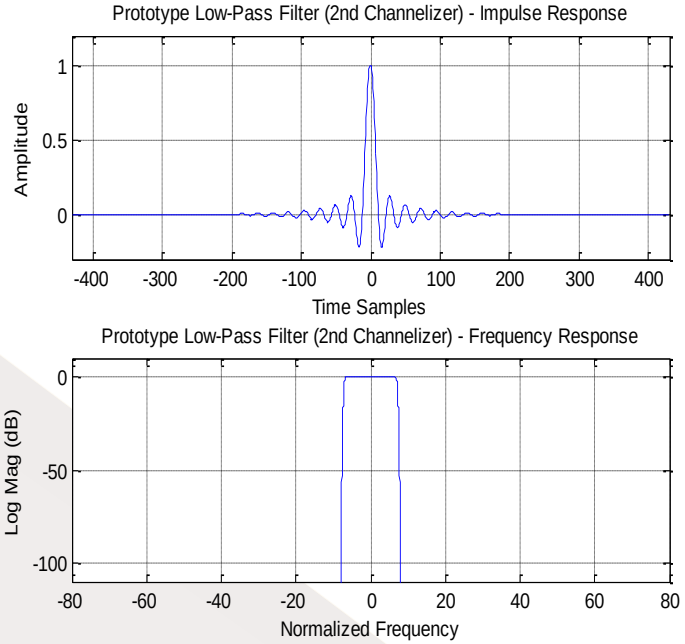
PROPOSED ARCHITECTURE

The channel selector, controlled by a pseudo noise sequence generator, and placed between the two engines, delivers the input signals to the proper input port of the second up converter channelizer for performing the desired hops



CHANNELIZERS' IMPULSE RESPONSE

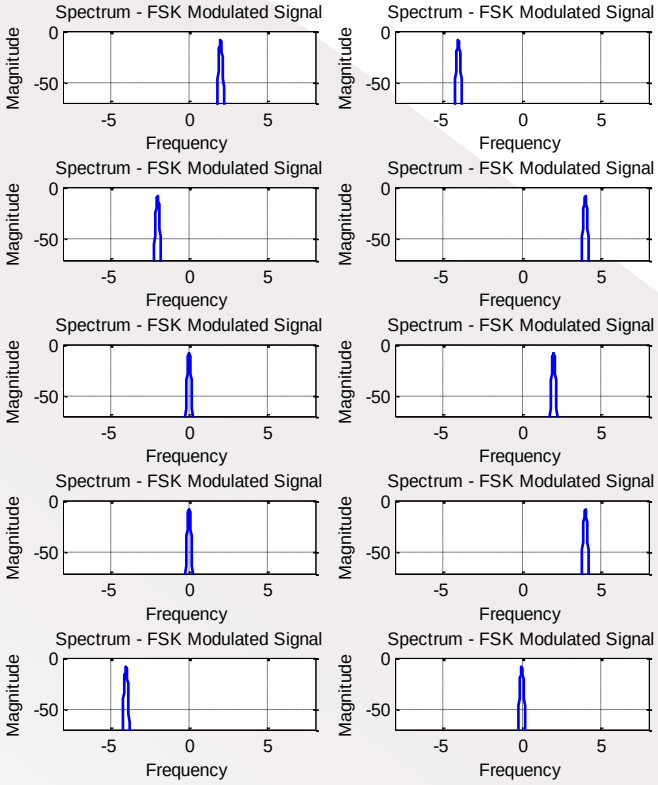




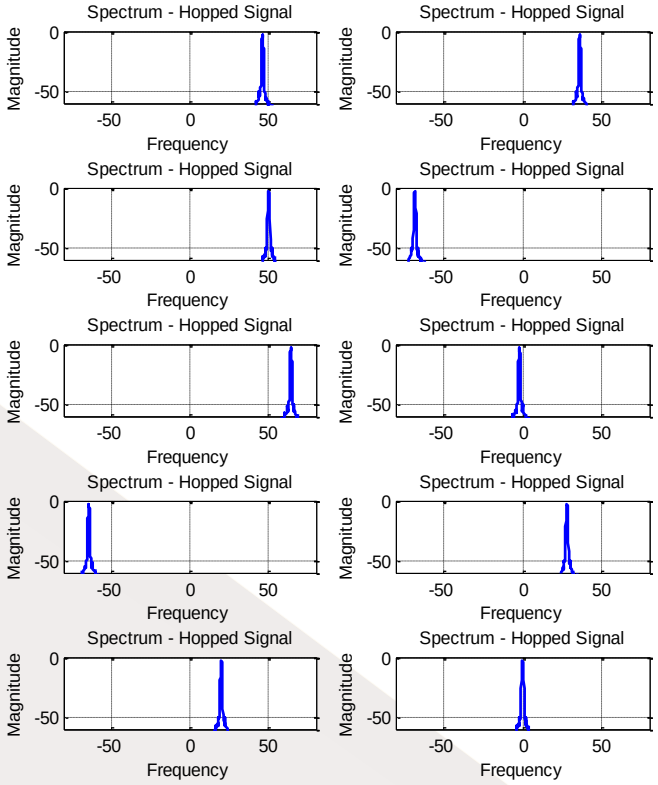
First Tier Channelizer -Impulse and Frequency Response-

Second Tier Channelizer -Impulse and Frequency Response-

SIMULATION RESULTS

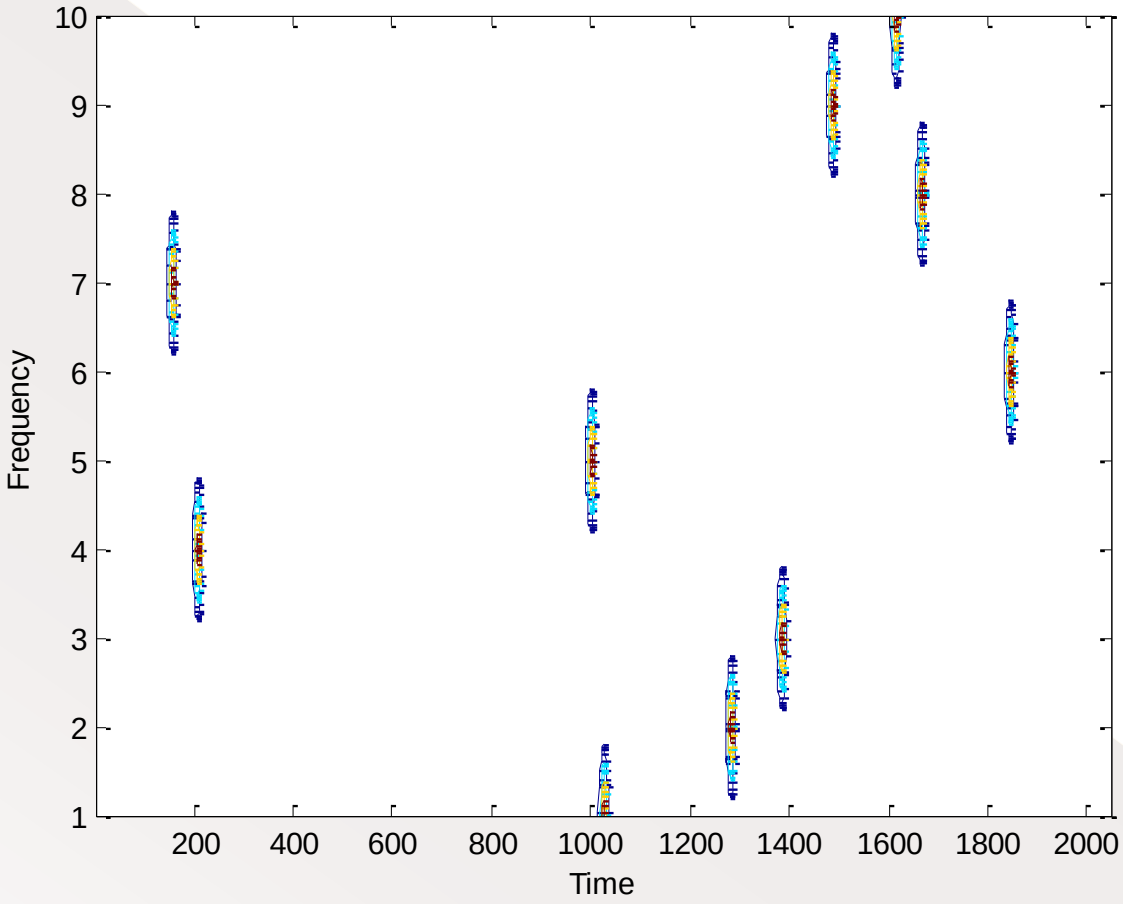


First Tier Channelizer Outputs



Second Tier Channelizer Outputs

SIMULATION RESULTS - CONTOUR PLOT -



Contour plot, for ten symbols, of the hopped 8-FSK signals

BENEFITS OF THE PROPOSED FH MODULATOR

The up converter channelizer provides the digital frequency hopping modulator with the unique capability of performing multiple simultaneous hopping without adding complexity to the design (Multiple simultaneous hops can be performed in the analog FH modulator at the cost of including multiple up converters in the design)

Dual and multiple code hopping sequences can be easily performed

Increase the frequency diversity capability of the FH transmitter

CONCLUDING REMARKS

We proposed a fully digital frequency hopping modulator architecture. Two polyphase up converter channelizers, in cascade, compose its core.

The first channelizer performs the M-FSK modulation of the baseband spectrum while the second one hops the modulated spectra over N possible center frequencies.

The novel architecture inherits the flexibility of these engines that allows us to select the levels of the M-FSK modulation, as well as the dimensionality of the *hopset* and the hopping bandwidth while, due to the efficiency of the IFFT algorithm, the total workload of the structure is kept low which makes feasible the realization of the proposed fully digital frequency hopping modulator.

NOW WE ARE OPEN FOR QUESTIONS
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….Thanks for your attention