IEEE P802.15 Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)		
Title	**PHY Proposal Using Dual Independent Single Sideband, Non-coherent AM and Defined Unit Pulse**		
Date Submit	March 3, 2003		
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Re:	**15.3a CFP Response presentation**		
Abstract	This proposal is a combination of: 1) a baseband waveform with desirable properties for a bandpass medium, and 2) where the unit pulse period is several bit durations and overlapped to double the information transfer rate by creating three amplitude levels, and 3) linear translation of the data bearing waveform to a single radio sideband, and 4) two instances of that translation such that the homodyne image of one sideband falls inverted in the passband of the other. This contribution contains: a) mathematical simulations of the baseband data waveform properties, and b) implementation description in support of asserted execution simplicity, and c) results available from recent work on system simulation (continuing).		
Purpose	To show evidence of advantage of analog-intensive approach to high speed data transmission with particular emphasis on optimization criteria and definition of propagation environment.		
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Proposal–SSB and DSB AM Modulation for High-rate Data Microwave Radio Systems

About Modulation and Microwave Propagation

Multipath propagation substantially degrades the orthogonality of the I and Q phases increasing crosstalk interference as the points in the constellation are increased.

The phase of a vector sum of several rays is a constantly changing value which makes difficult receivers which can successfully decode data.

A better means of data encoding is amplitude modulation using a detection means that is independent of RF phase.

For better spectral efficiency with AM, it is desirable to use single sideband transmission with a small number of amplitude coding levels.

Technology Proposed

There are two primary technology selections:

- Use of three-level sym-pulse baseband data shaping (later described), and
- Use of AM with ISSB SC (independent dual single sideband—suppressed carrier) radio modulation

The SSB signal consists of two independent data streams about a virtual carrier, and provides twice the bits/Hz as the DSB. The SSB is arranged so that ***the suppressed image of one data channel is in the passband of the other.*** The phasing cancellation employed provides at least 23 dB suppression of the image relative to the desired signal.

The method employed uses two (vector) I-Q mixers, and two narrow band phase shifters.

The receiver uses phase-independent amplitude detection for both SSB and DSB. The operating principal is based on the identity: $\cos^2\theta + \sin^2\theta = 1$ with a pair of quadrature phased mixers.

Frequency conversion plan

At the input a video signal with a power spectrum symbolized by a trapezoid (T1) is applied to a video mixer with a 25 MHz LO for a 2 x 30 Mbps data transport. The output of this mixer, shown in mid-figure (T2), is double sideband replica extending from 2-48 MHz. The lower sideband is desired, and the upper sideband is to be stopped by the 25 MHz low pass filters preceding the microwave mixer. Failure of this stop function causes an undesired product (shown dotted) to appear at the 5 GHz output at 25-50 MHz from the microwave mixer LO frequency.

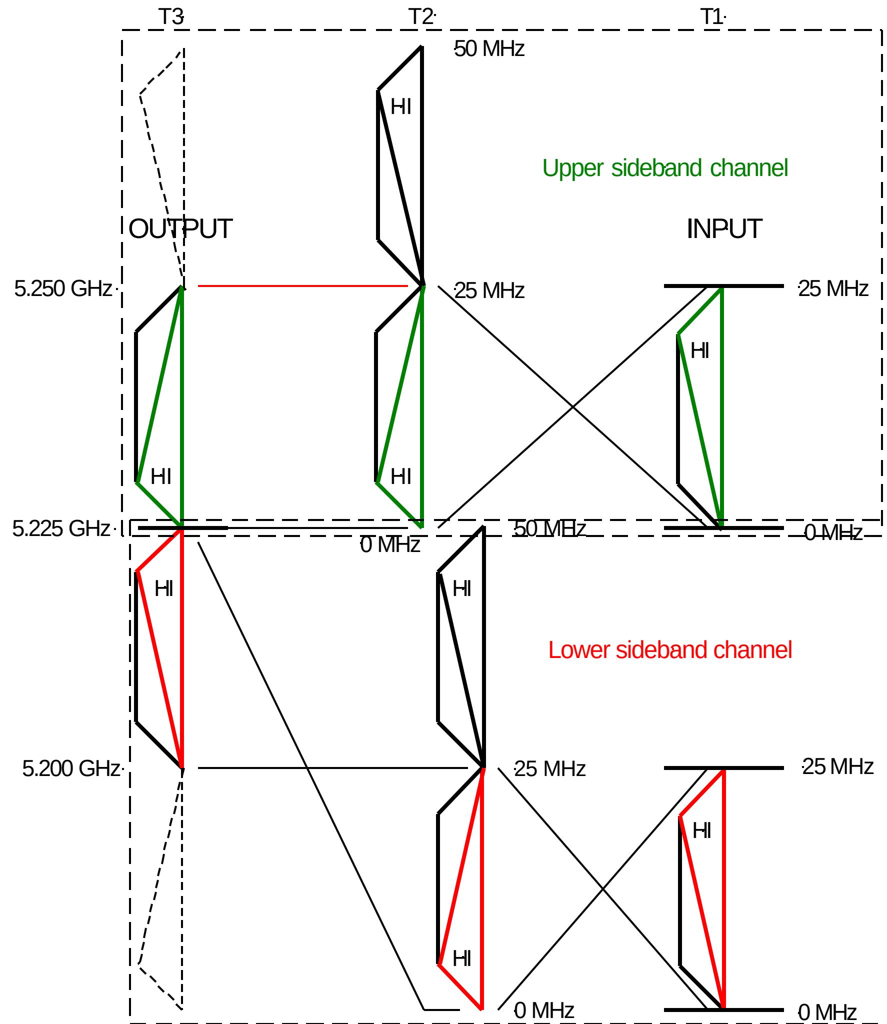


Figure A-1 Frequency relationship diagram for transmit conversion steps

Properties of the Video Waveform

The advantages of the sym-pulse three-level random data stream is the combination of the following characteristics:

- First null near 80 % of the bit rate (rather than 100%)
- All sidelobes beyond the first null are more an 30 dB down—worst case
- Low energy content at frequencies below 10% of the first null frequency
- SSB spectral utilization of more than 1.3 bits/Hz

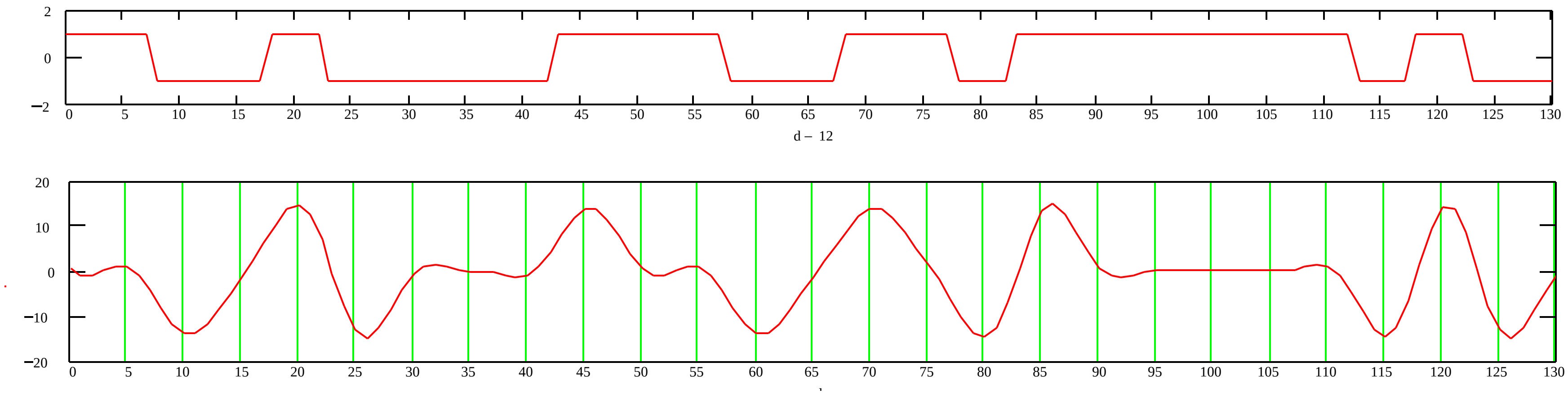
Because there are only three amplitude levels and no crosstalk from a quadrature phase, this modulation will be more robust than 4-QAM/QPSK and much more robust than higher order constellation modulations.

This is a baseband data waveform which has the following properties:

a) an acceptable relationship between bit rate-carried and occupied bandwidth, and
b) sufficient suppression of side-lobes so that additional filtering is not required.

The Baseband Data Waveform

Figure 1 Data stream and associated 3-level analog waveform



Shown below is a simulation binary data pattern and the resulting video waveform. At sampling time, the amplitude is either +1 or –1 for data 1 or approximately zero (several dB) lower for data zero.

Data Waveform Power Spectral Density

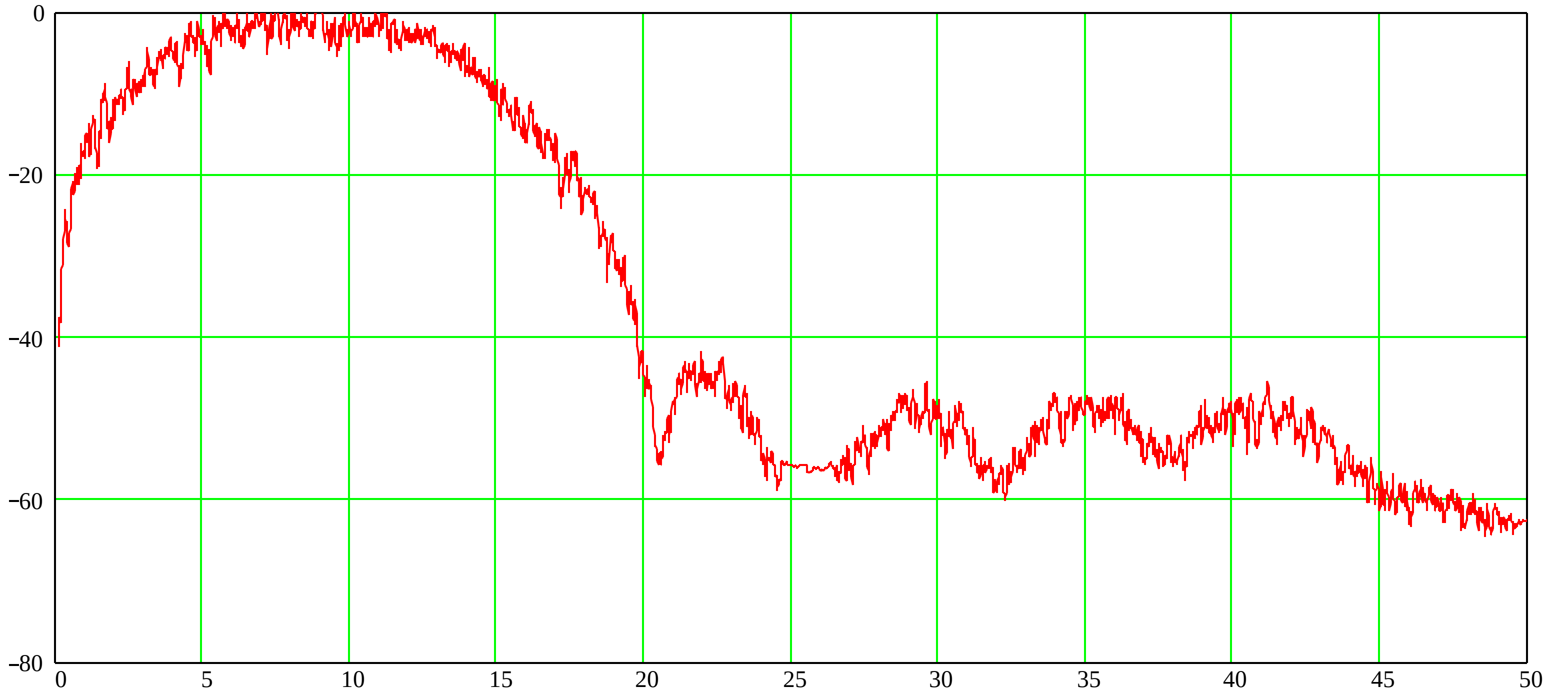


Figure 3 Calculated and smoothed spectrum for waveform of previous Fig. 1

This is the power density spectrum at baseband (video) that results from this signal. The first null is at 20.5 MHz at a 25 Mbps data rate. The transform is performed for a sequence of 4095 pseudo-random bits. The normal null at the bit rate also appears at 25 MHz. The out-of-band level is more than 40 dB down.

Recommendations to 802.15.3

Recognize as a class modulations that have the following properties

a) use a single virtual or actual radio frequency carrier, and
b) use amplitude coding to carry data information, and
c) use radio frequency phase-independent means of detecting the data carried, and
d) use a small number of levels for information coding, and
e) achieve the desired rate within a bandwidth of one set of regulatory constraints

For modulations of this class use a virtual or physical interface between video data waveform bearing information and the radio translation from baseband.

This class is believed to offer the superior prospects for a combination of simplicity of implementation and quality of provided communication.

Need for Collaboration

In 802, a one-person or one-Company proposal rarely gets as far as the short list of candidates. Provided that this work is seen as sufficiently attractive for possible adoption in whole or in part, this Contributor (and partner) would like to see this technology absorbed within the effort of a stronger sponsorship.

Acknowledgments

This work is the result of the combined efforts of Bob Ritter (partner), John Arminini and the Author. All had an indispensable and highly valuable part in this work.

5.25 GHz dual ISSB AM data radio transmitter block diagram

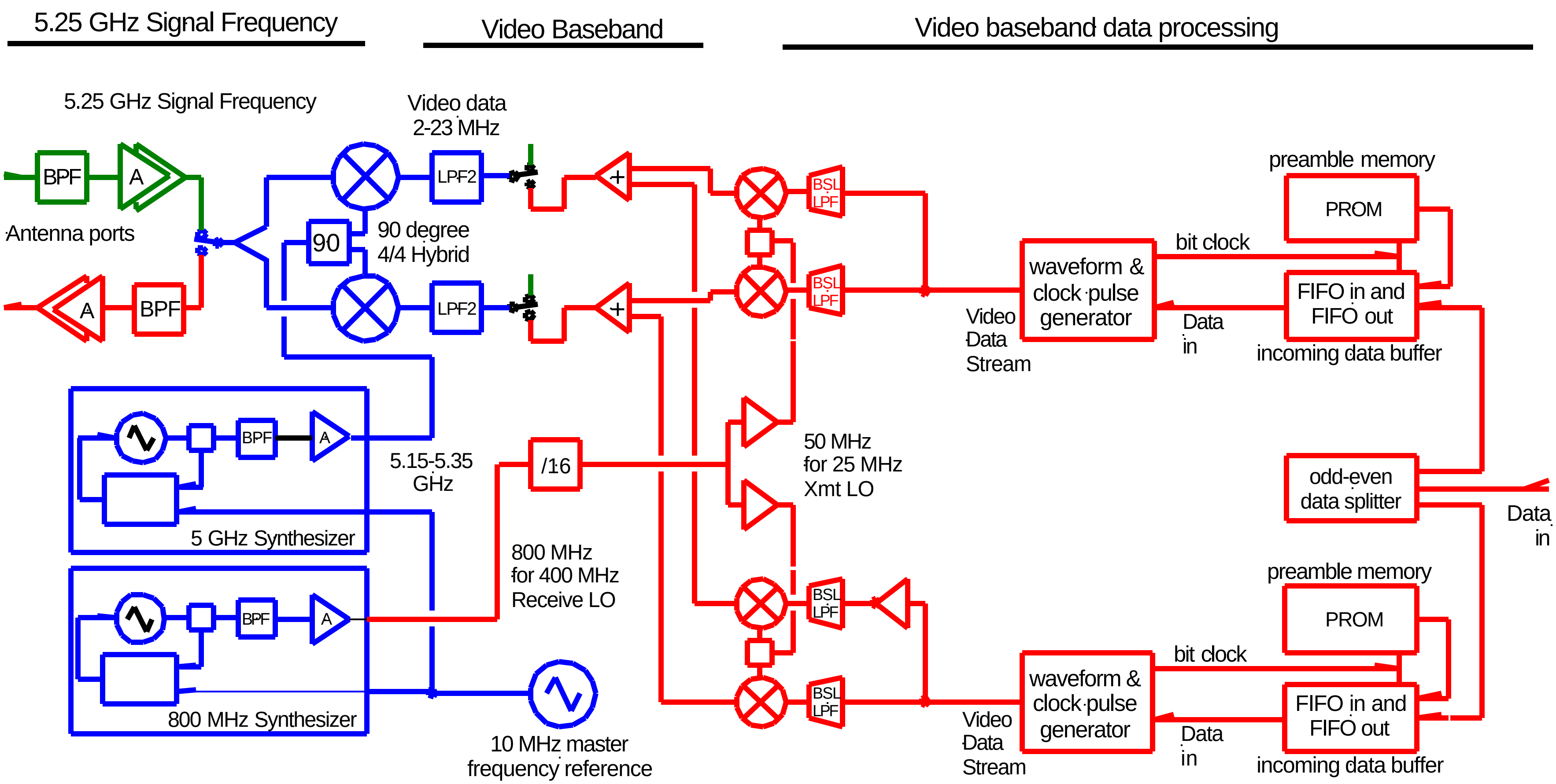


Figure A-2 5.25 GHz dual ISSB AM data radio transmitter block diagram (60 Mbps in 48 MHz bandwidth)

5.25 GHz dual ISSB AM radio receiver block diagram

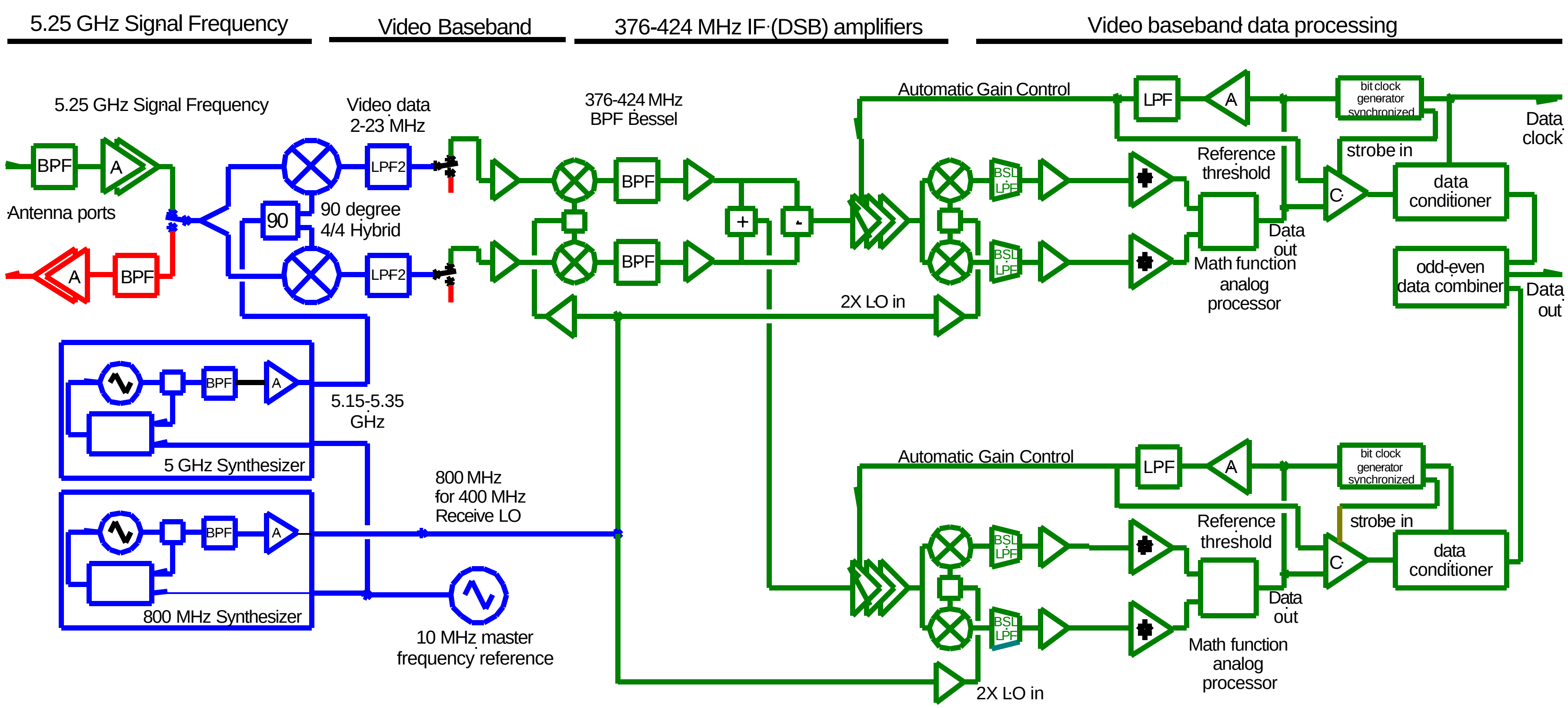


Figure A-3 5.25 GHz dual ISSB AM radio receiver block diagram

Implementation of a DSBSC Data Radio

The is a very simple radio and data detection will provide 30-32 Mbps in 24-25 MHz or any other rate at linearly scaled bandwidth.

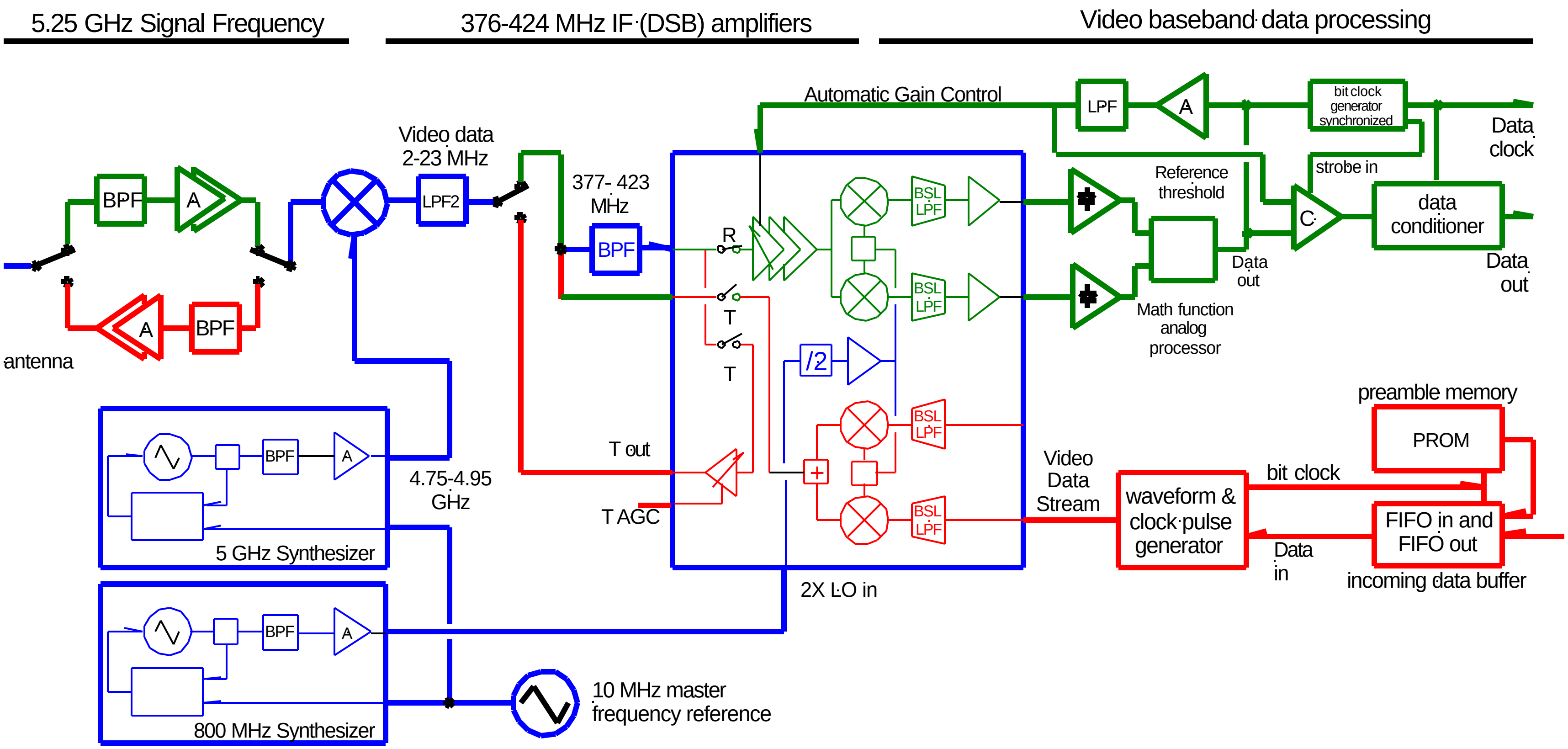


Figure B-1 AM DSBSC Radio Modem Transceiver Block Diagram