IEEE 802.11
Wireless Access Method and Physical Specification

Title: FH Interoperability Addition to Harris HS PHYProposal

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FH Backward Interoperability

Backward interoperability with 1/2 Mbps DS PHY is provided for within the Harris High Speed (HS) DS PHY proposal

- Important for maximum range, robustness in severe multipath, minimum collisions (CCA), variety of cost vs performance tradeoff options, and preservation of customer investments

We propose an FH PHY backward interoperability mode as an option for the Harris HS proposal

- This proposal does not modify the basic modulation format, but it assumes the addition of the HS preamble; wraps around the Harris proposal
- Two fundamental changes required for FH interoperability are
  1) hopping of the wideband DS signal synchronized to the FH hop sequences
  2) using the FH preamble in front of the HS preamble and data

Resulting system is not a hybrid system with regard to FCC rules, but a dual mode radio: an FH mode and a DS mode that also hops

Why is FH interoperability important?

The same reasons that applied to the DS PHY plus improved reliability, or survivability, in interference limited environments

- Hopping of the wideband HS signal will provide a level of protection against a variety of fixed frequency intereference.
- As a last line of defense, backing down to 1/2 Mbps FH with 79 1 MHz channels will provide the best chance of operating through interference.

Symbol's experiences in the 900 MHz band since 1990 have shown

- Fixed frequency system will fail in the presence of interference
- Changing channels is slow and often does not work
- Our proprietary format 900 MHz DS system has evolved into a hopping DS system to provide reliable connection in the presence of interference

The 2.4 GHz band may eventually be worse than the 900 MHz band since it is the only unlicensed band available worldwide

- Also, non-802.11 systems in this band are already and will continue to be a significant portion of the usage of this band

Efficiency of Frequency Plan

Most efficient use of the band would be achieved by frequency planning in a cellular arrangement such as used by DS

- Sharing possible with other 802.11 DS systems
- However, that requires exclusive use of the band which cannot be guaranteed in the unlicensed ISM band

1 MHz FH can perform quite well without control of the band

- Allows more overlapping BSS's (essentially non interfering) than DS
- More tolerant to non-802.11 devices

The FH interoperability mode achieves a compromise of the best of both formats, achieving both 11 Mbps peak data rates and falling back to 1 MHz FH for maximum reliability in dense environments

- It trades off the efficiency of the cell planning approach for the reliability of frequency hopping and the flexibility of scaling down to a 1 MHz narrow FH signal

Hop Sequences, Synchronization, and Frequency Plan

Hopping of the HS PHY will be defined and synchronized using the mechanisms contained in the existing 802.11 FH PHY

- The particular 1 MHz channel selected will be associated with a HS PHY channel center frequency

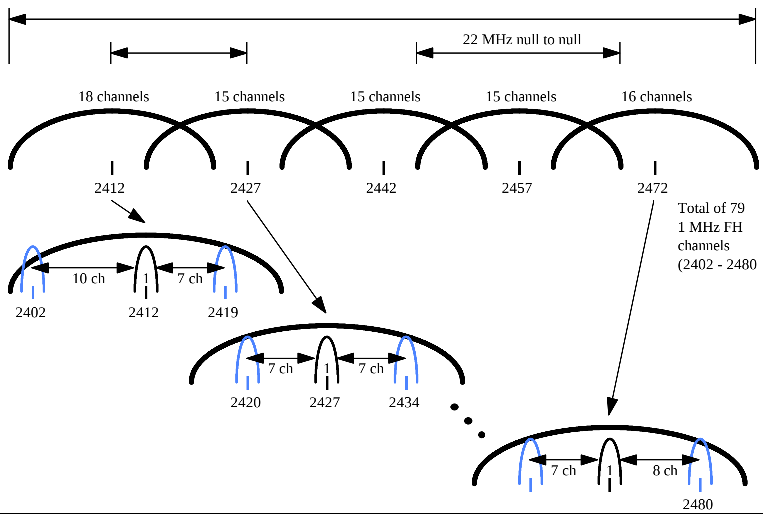
5 HS PHY channels about 22 MHz null to null bandwidth, partially overlapped with a channel spacing of 15 MHz

- Subset of the center frequencies defined in the DS PHY section
- A number of 1 MHz FH channels are assigned to each HS channel

The HS channel that has its center frequency closest to the selected 1 MHz channel is used to transmit and receive HS data

- Maximum offset in center frequency between 1 MHz FH and HS channel is generally +/- 7 MHz except at band edge (-10 to +8 MHz).
- Power and sensitivity would be reduced by several dB at the -10 MHz offset due to filter rejection

Frequency Plan of HS PHY and FH PHY channels



Other Frequency Consideration

Consider option of adding new FH hop sequences which improves performance in the mixed HS and FH environments.

1) By hopping a minimum of 15 MHz instead of 6 would guarantee that the next hop will also hop the wideband channel.

- 2a) Reducing the number of channels to 77 by chopping off the bottom 2 channels would limit the frequency offset of the 1 MHz FH channel to +/- 8 MHz from the HS channel center; use 2404 to 2480 MHz
- 2b) The minimum number of FH channels specified by the FCC is 75. Chopping off 1 more channel on each end of the band from (2a) would limit the FH to HS channel offsets to +/- 7 MHz; use 2405 to 2479 MHz

Backward interoperability with the DS PHY necessitates turning off the hopping feature since hopping is not part of existing DS PHY

- Turning off the HS hopping of course loses the interference mitigation capabilities of the hopping

FH Backward Interoperability Header

Proposal uses an FH 1 Mbps preamble and headerprior to the short HS preamble and header

- Provides for 1/2 Mbps FH operation when range, multipath, or backwards interoperability required
- Units that are operating in 1/2 Mbps FH mode only will be able to see the length of the frame and defer for the duration of the frame.

FH Backward Interoperability Frame Format

1 Mbps FH Preamble	1 Mbps FH PLCP	Gap	HS Preamble & Header	
96 usec	32 usec	8 usec	~50 usec	Variable

DS Backward Interoperability Frame Format

1 Mbps DS Preamble	1 Mbps DS PLCP Header	5.5/11 Mbps Data
144 usec	48 usec	Variable

Field

The 4 bit FH PLCP Signaling Field will be modified to utilize the reserved bit b0 to expand the data rates from 8 to 16 values

b0	b1	b2	b3	Indicated rate
0	X	X	X	Rates 1 - 4.5 Mbps per existing text
1	0	0	0	5.5 Mbps
1	0	0	1	11 Mbps
1	0	1	0	16.5 Mbps
1	0	1	1	22 Mbps
1	1	0	0	27.5 Mbps
1	1	0	1	33 Mbps
1	1	1	0	38.5 Mbps
1	1	1	1	44 Mbps

To maintain hopping without the FH PHY backward interoperability header, the base rate of the BSS could be set at the high speed rate

- However, to retain the 1/2 Mbps FH rate scaling capability, the 1 Mbps FH header must be added on whenever the rate scaling feature is needed.

1/11 Mbps Cross Interference and CCA

If there is only one BSS, there will not be excessive collisions with the mixed FH and HS operation

- Everyone will hear the FH interoperability header

When there are more than one BSS, there may be 1/2 Mbps FH traffic at other channels inside the wideband HS channel

- May not see the FH header, but could see the wideband HS header
- The probability of interference of this mixed mode case is in general better than that of two hopping HS BSS’s because adjacent HS channels are less of a problem

Implementation options available to perform CCA on all 1 MHz channels within the wideband HS channel

- These vary from simple RSSI techniques to more complex algorithms implemented mainly at the cost of additional gates

Rate Switching Algorithms

The algorithms and triggers for rate switching between the rates in the released standard are not specified by 802.11

- This will be the same in the case of 1/2 Mbps FH to HS operation

Implementation Considerations

Implementation issues need to be addressed in the standards process to validate the practicality of the proposal

The following discussion summarizes an implementation currently in a joint development process between Harris and Symbol

- The resulting chip set, when released, will be widely available from Harris to all interested companies at fair and reasonable terms

The discussion here assumes primarily digital implementation of the FH processing

- Most of the non-digital functions and components are common with that needed for HS processing

Two modes of FH processing

Wideband mode allows full interoperability with both HS and FH packets

- Use the same bandwidth SAW as the HS signal processing
- Switch instantaneously from narrow FH preamble to wideband HS packet
- However, selectivity will be less than specified in the FH section.

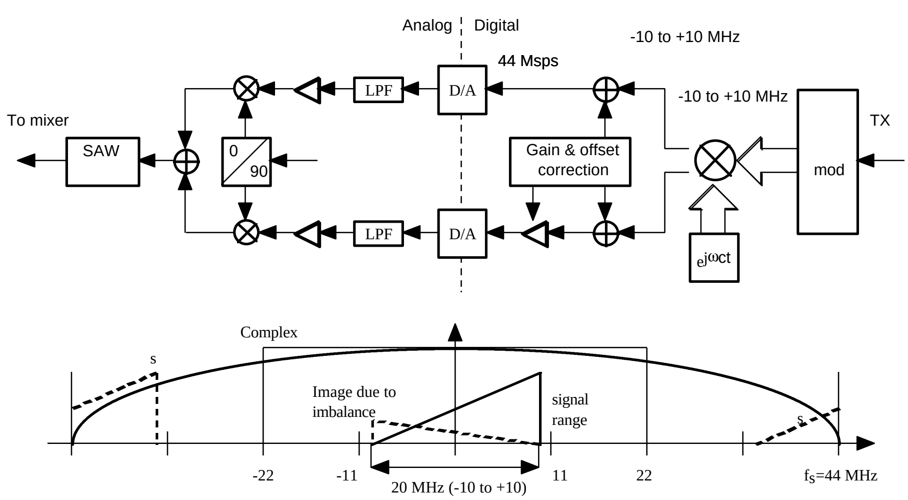
In narrowband mode, FH operation with maximum selectivity performance ensures best possible performance in interference limited environments.

- Use a 1 MHz SAW to achieve the selectivity of an FH compliant device

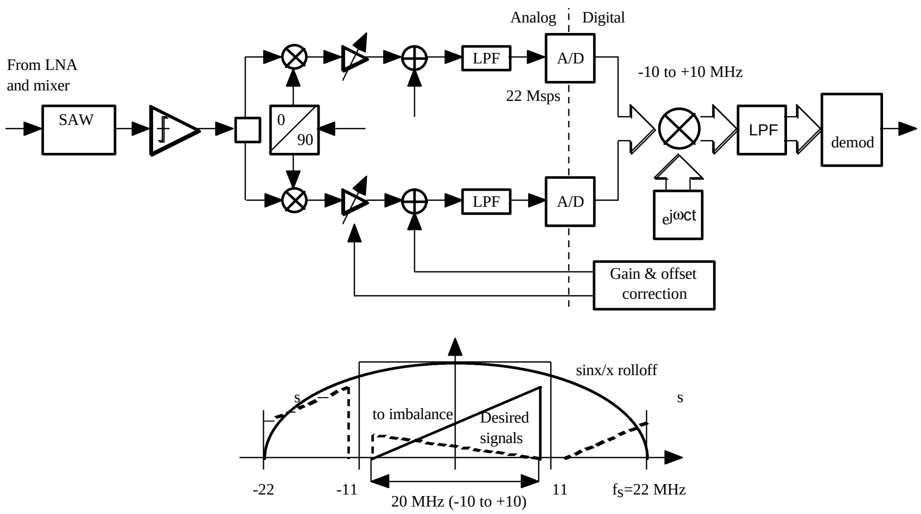
Both modes needed to achieve the full benefits of the FH interoperability

- Only wideband mode necessary if you only care about backward interoperability

Transmitter Block Diagram and Spectrum



Receiver Block Diagram and Signal Spectrum



Implementation Tradeoffs

The requirements, problems, and tradeoffs encountered in implementation bring up possible changes to the proposal

One example is the necessity to have a high degree of phase and amplitude balance and small DC offsets

- Phase and amplitude imbalance in the transmitter causes images on the other side of DC that will be unattenuated in the wideband mode
- DC offsets in the transmitter causes unmodulated carrier components which would also be unattenuated in the wideband mode
- In the receiver, phase and amplitude imbalance distorts the signal slightly and reduces the selectivity which would be achievable otherwise

One way to achieve receiver balancing is to estimate and correct the imbalances and offsets during the preamble of a receive packet

- When the FH channel is at the same center frequency as the HS channel, the preamble will vary in I/Q space about 60° on the unit circle
- Difficult to separate the I and Q imbalance and offset components

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Implementation Tradeoffs (cont.)

Three options to resolve this problem are:

1) Measure and correct between regular packets
2) Offset LO tuning and process signal at a small frequency offset
3) Select a different center frequency for the wideband signal, i.e., the channel center frequency 5 MHz away. This will increase the number of channels to 13 overlapping channels.

The first two options only affect the implementation, whereas the third one changes the protocol to simplify the implementation. In this particular case, the degree of change to the protocol is probably not warranted.