IEEE 802.11
Wireless Access Method and Physical Layer Specification

Title: Low Power IR-4 Mb/s and 10 Mb/s FQPSK and 1 Mb/s and 2 Mb/s PPM Components and Systems.

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Abstract:
Based on joint UPM, ULPGC system and Siemens IR components investigation and in-depth studies, as well as confirmed by UC Berkeley diagrams supported by IBM, DEC and AT&T, it has been concluded and it is shown that FQPSK operated at bit rates of 4 Mb/s and 10 Mb/s is more power (DC power) efficient than comparable PPM systems. It is shown thet the carrier modulated higher bit rate FQPSK components require significantly lower power than 4PPM at 2 Mb/s. The FQPSK system is also 6 times more spectrally efficient than the corresponding PPM systems, which is also a significant advantage from a transmission speed and capacity point of view. Based on the extensive data it is demonstrated that from all previous proposal of the IR-PHY WG, only FQPSK is a viable option for the 4 and 10 Mb/s rates.

Introduction

It is usually assumed that PPM is the most power saving technique, in this submission we demonstrate that this is not quite true, at least for the schemes accepted by the IR-PHY working group. These modulation and codification schemes are:

1. 16 PPM at 1 Mb/s
2. 4 PPM at 2 Mb/s
3. FQPSK at 4 Mb/s
4. FQPSK at 10 Mb/s

A realistic approach to the energy problem should be based on frame energy, i.e. the energy needed to send a frame of data, not on the power needed to send a single bit. The most important factor to be taken into account is the electrical current demanded by the optical emitter (LED), other consumptions can be neglected because they represent less than 10% of the total.

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Energy Calculation

Due to different rates, we calculated the energy needed to send 20 data bits.

From the figure 1, it is easily seen that the time while the LED is in the ON state represents the energy used to send the 20 bits. The actual value can be obtained multiplying this time by the current amplitude (A) and the direct voltage across the LED (V_d) being this in the range 1.8 - 2.1 Volts..

The values calculated are:

PPM at 1 Mb/s	1.25 μs
PPM at 2 Mb/s	2.5 μs
FQPSK at 4 Mb/s	2.5 μs
FQPSK at 10 Mb/s	1.0 μs

System Considerations:

Based in the previous results and the data from (1) the total consumption can be resumed in the table 2:

Notes for Table 2:

0. Spectral efficiency, in b/s/Hz, of 4PPM is 0.4, that is 2Mb/s needs 5 MHZ, for 20 dBr spectral attenuation. For FQPSK it is more than 1 b/s/Hz.
1. Receiver bandwidth: For same bit rate, 4PPM requires more than 2.5 times FQPSK's bandwidth.
2. Based on [1], the IR-transmitter power requirement is defined for achieving the same S/N of the compared systems for assumed same receiver bandwidth and BER. Increased (2.5 times) bandwidth of 4PPM relative to FQPSK is not taken into account. (See figure 9 on pg. 22 of reference 1)
3. Battery DC power consumption will be smaller if message is transmitted in shorter time.
4. Battery processing power of receiver is reduced in high rate systems, assuming the same message length.[2]
5. A positive number represent an increase in power consumption.

Power Budget	4PPM @ 2 Mb/s	FQPSK @ 4Mb/s	4PPM @ 2 Mb/s	FQPSK @ 10Mb/s	4PPM @ 10Mb/s	FQPSK @ 10Mb/s
0.Spectral efficiency. (20dBr), in b/s/Hz	0.4	1	0.4	1	0.4	1
1.Relative Rx bandwidth	0	-4.5	0	-0.5	7	-0.5
2.Increase of Tx power for achieving the same S/N and BER performance, with the same bandwidth	0	+4.5	0	+4.5	0	+4.5
3.Battery DC Tx-power increment due to transmission time.	0	0	0	-4	0	+3
4. Power reduction by lower processing time, at the receiver	0	-1	0	-1	0	0
5. Subtotal.	0	-1	0	-1	7	7
6. FQPSK vs. 4PPM	+1		+1		0	
7. Increase due to multipath induced ISI.	0	0	0	+1	+15	+1
8. Increase due to syncronization errors	0	0	0	0	+2	0
9. Total (5+7+8)	0	-1	0	0	+24	1
10. Net **total** difference	**+1**		**0**		**23**	

Table 2: Power efficiency comparison of 2 and 10 Mb/s rate baseband 4PPM and 4 and 10 Mb/s modulated FQPSK systems. Proposed draft specifications approved by IR-PHY working group are 1 Mb/s 16PPM and 2 Mb/s 4PPM, and 4 and 10 Mb/s FQPSK. This table is partly based on experimental results of IBM, DEC and AT&T supported programs and University of Callifornia, Berkeley (ref.1) extensive studies, as well as our system investigations.

6. Advantage (in dB)in a idealized system (without delay spread, full syncronized clock, etc.). This is a very optimistic situation.

7. Dispersion causes ISI and BER performance degradation. This can be mitigated by increased power. These values are for a 30 ns delay spread, but it can be much larger.

8. Syncronization errors cause more degradation for PPM systems. This is because in PPM the pulse is defined in 250 ns, while in FQPSK, at 4 Mb/s the definition time for a symbol is 500 ns.

9. Total increase of power to be emitted in a more realistic case.

10. Advantage of FQPSK over 4PPM, in dB. This power difference represents the ratio between PPM and FFQPSK amplitudes

Conclussions:

It has been demonstrated that modulation scheme needs less energy to work than PPM, which is important for battery powered portable systems. The extra benefit is that the lower consumption is got at higher data rates with an improvement on system performance.

As table 2 shows, FQPSK outperforms or equal 4PPM (requires less power) and offers much higher bit rates.

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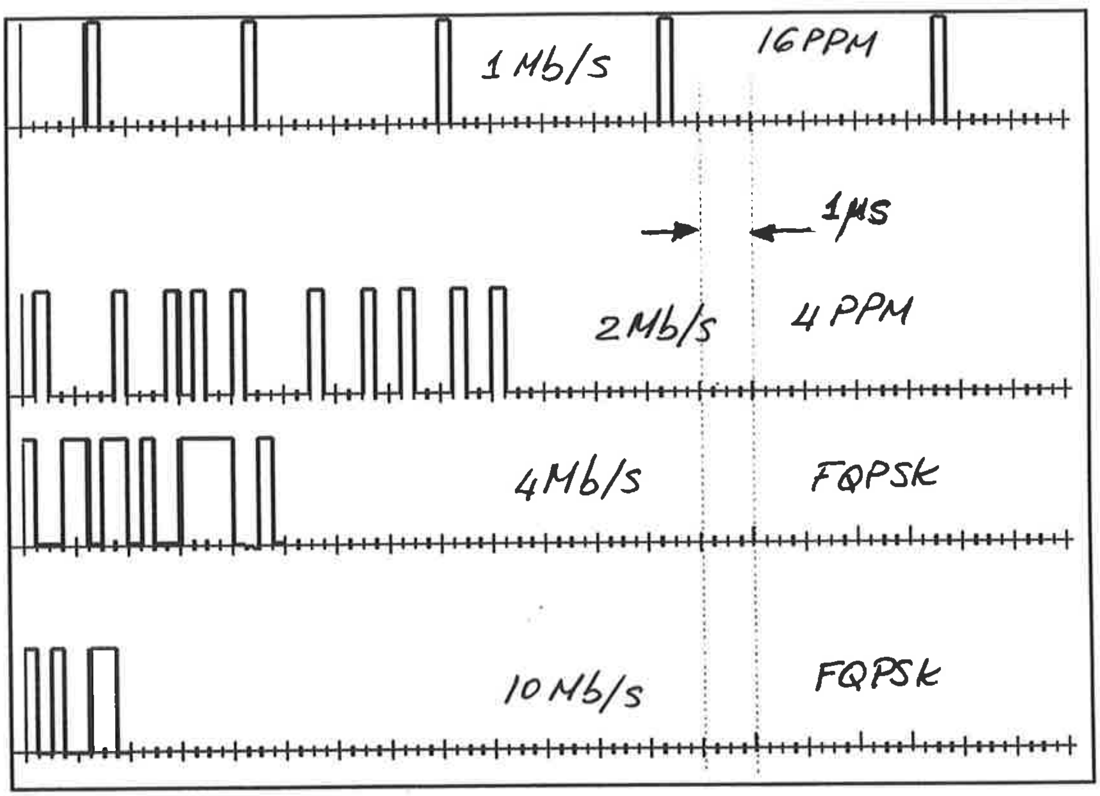

Figure 1.