

**IEEE P802.11
Wireless LANs**

Draft text for the Higher Speed Extension of the standard

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Abstract

Draft text is provided for the high speed extension of the 2.4 GHz standard. The text specifies additional data rates to the Direct Sequence standard of 5, 8 and optional 10 Mbit/s. The specified modulation method is Barker Code Position Modulation (BCPM).
In revision 1 the optional short preamble and header is defined.

1. Extension of the Direct Sequence Spread Spectrum Physical Layer Specification for the 2.4 GHz ISM Band

1.1 Introduction

This clause describes the high speed extension of the physical layer for the Direct Sequence Spread Spectrum (DSSS) system (clause 15 in the standard). The Radio Frequency LAN system is initially aimed for the 2.4 GHz ISM band as provided in the USA according to Document FCC 15.247, in Europe by ETS 300-328 and other countries according to clause **Error! Reference source not found.**

Above the 1 Mbit/s and a 2 Mbit/s data payload as described in clause 15 the extension of the DSSS system provides a 5 and 8 Mbit/s payload and an optional 10 Mbit/s. According to the FCC regulations, the DSSS system shall provide a processing gain of at least 10 dB. This shall be accomplished by chipping the baseband signal at 11 MHz with an 11-chip PN code. To provide the higher rates Barker Code Position Modulation (BCPM) will be employed. The DSSS system uses baseband modulations of Differential Binary Phase Shift Keying (DBPSK) and Differential Quadrature Phase Shift Keying (DQPSK) to provide the 1 and 2 Mbit/s data rates, respectively.

The higher speed system is fully coexistent and interoperable with the 1 and 2 Mbit/s systems. It can use the same PLCP preamble and PLCP header as the 1 and 2 Mbit/s system and thus can make use of the rate switching capabilities as provided in the standard. To optimize data throughput at the higher rates an optional short PLCP preamble is provided.

1.1.1 Scope

This clause describes the extension of the physical layer services provided to the 802.11 wireless LAN MAC by the 2.4 GHz Direct Sequence Spread Spectrum system. The clause will only describe deviations from the 802.11 spec for DSSS.

To be conformant to the higher speed standard the 5 and 8 Mbit/s datarates (in addition to the 1 and 2 Mbit/s ,in this document referred to as current standard) are mandatory. The 10 Mbit/s datarate is optional.

The specification also provides an optional short preamble and header for the higher rates.

1.2 5, 8 and 10 Mbit/s DSSS Physical Layer Convergence Procedure Sublayer

1.2.1 Introduction

This clause provides a convergence procedure for the 5 and 8 Mbit/s mandatory specification and the 10 Mbit/s optional specification in which MPDUs are converted to and from PPDU. During transmission, the MPDU shall be prepended with a PLCP preamble and header to create the PPDU. Two different preambles and headers are defined: the mandatory supported long preamble and header as defined in the current 1 and 2 Mbit/s DSSS specification and an optional short preamble and header. At the receiver, the PLCP preamble and header are processed to aid in demodulation and delivery of the MPDU.

1.2.2 Physical Layer Convergence Procedure Frame Format

The format for the PPDU including the long DSSS PLCP preamble, the long DSSS PLCP header and the MPDU do not differ from the current standard.

The extended DSSS PHY supports one optional modulation service. The actual datarate of the 10 Mbit/s optional mode is 9.77 Mbit/s and is established by increasing the symbolrate with a factor 11/9. Two signal field values are defined for this service:

- | | | | |
|----|-----|---------------|------------|
| e) | 61h | 9.7Mbit/s PPM | (optional) |
| f) | 62h | 9.8Mbit/s PPM | (optional) |

The values 61h and 62h are used depending on the number of bytes in the MPDU. While converting the number of bytes into a value for the LENGTH field (see next paragraph) two byte boundaries can fall within a microsecond.

- | | |
|--|--------------|
| If the remainder of (#bytes * 9/11) is between 0 and 3/11: | Signal = 61h |
| else: | Signal = 62h |

The DSSS PHY rate change capability is described in clause 1.2.3.2. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause **Error! Reference source not found.**

1.2.3.2 Long PLCP Length Field (LENGTH)

The PLCP length field shall be an unsigned 16 bit integer which indicates the number of microseconds (16 to $2^{16}-1$ as defined by aMPDUMaxLngth) required to transmit the MPDU. The transmitted value shall be determined from the LENGTH parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause **Error! Reference source not found.** The length field provided in the TXVECTOR is in bytes and is converted to microseconds for inclusion in the PLCP LENGTH field. The Length field is calculated as follows:

- | | | |
|----|----------------|---|
| a) | 1Mbit/s DBPSK: | Length = #bytes * 8. |
| b) | 2Mbit/s DQPSK | Length = #bytes * 4. |
| c) | 5Mbit/s PPM | Length = #bytes * 8/5, rounded to the next integer. |
| d) | 8Mbit/s PPM | Length = #bytes. |
| e) | 10Mbit/s PPM | Length = #bytes *9/11, rounded to the next integer. |

At the receiver, the number of bytes in the MPDU is calculated as follows:

- | | | |
|----|----------------|---|
| a) | 1Mbit/s DBPSK: | #bytes = Length / 8. |
| b) | 2Mbit/s DQPSK | #bytes = Length / 4. |
| c) | 5Mbit/s PPM | #bytes = Length * 5/8, truncated to the last integer. |
| d) | 8Mbit/s PPM | #bytes = Length. |
| e) | 10Mbit/s PPM | #bytes = Length *9/11-1, truncated, if Signal = 61h. |
| f) | 10Mbit/s PPM | #bytes = Length *9/11 , truncated, if Signal = 62h. |

The LSB (least significant bit) shall be transmitted first in time. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause **Error! Reference source not found.**

1.2.3.3 Long PLCP Data Modulation and Modulation Rate Change

The PLCP preamble shall be transmitted using the 1 Mbit/s DBPSK modulation. The 802.11 SIGNAL field shall indicate the modulation which shall be used to transmit the MPDU. The transmitter and receiver shall initiate the modulation indicated by the 802.11 SIGNAL field starting with the first symbol (1bit for DBPSK , 2 bits for DQPSK, 5 bits for 5 Mbit/s PPM, 8 bits for 8Mbit/s PPM or 8 bits for 10 Mbit/s (with the symbol rate increased with a factor 11/9)) of the MPDU. The MPDU transmission rate shall be set by the DATARATE parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause **Error! Reference source not found.**

1.2.4 Short PLCP Field Definitions

The entire short PLCP preamble shall be transmitted using the 1 Mbit/s DBPSK modulation described in clause **Error! Reference source not found.**. The short PLCP header shall be transmitted using 5 Mbit/s BCPM modulation as described in clause 1.4.1.2.

All transmitted bits shall be scrambled using the feedthrough scrambler described in clause **Error! Reference source not found.**

1.2.4.1 Short PLCP Synchronization (shortSYNC)

The short PLCP synchronization field shall consist of 54 scrambled all zeros. The preamble is used for energy or carrier detection (CCA as described in clause ..), antenna diversity (if desirable) and receiver synchronization.

1.2.4.2 Short PLCP Start Frame Delimiter Field (shortSFD)

The shortSFD shall be 16 bit field and be the bit reverse of the field of the SFD in the long PLCP preamble (clause 15.2.3.1). The field is 05CFh (MSB to LSB). The LSB shall be transmitted first in time.

1.2.4.3 Short PLCP Signal Field (shortSignal)

The 3 bit 802.11 Signal Field indicates to the PHY the modulation which shall be used for transmission (and reception) of the MPDU. The extended DSSS PHY operating with a short preamble and header supports two mandatory modulation services given by the following 3 bit words, where the LSB shall be transmitted first in time:

- | | |
|---------|-------------|
| a) 000b | 5Mbit/s PPM |
| b) 001b | 8Mbit/s PPM |

The extended DSSS PHY supports one optional modulation service. The actual datarate of the 10 Mbit/s optional mode is 9.77 Mbit/s and is established by increasing the symbolrate with a factor 11/9. Two signal field values are defined for this service:

- | | | |
|---------|---------------|------------|
| c) 010b | 9.7Mbit/s PPM | (optional) |
| d) 011b | 9.8Mbit/s PPM | (optional) |

The values 010b and 011b are used depending on the number of bytes in the MPDU. While converting the number of bytes into a value for the shortLENGTH field (see next paragraph) two byte boundaries can fall within a microsecond.

- | | |
|--|--------------------|
| If the remainder of (#bytes * 9/11) is between 0 and 3/11: | shortSignal = 010b |
| else: | shortSignal = 011b |

1.2.4.4 Short PLCP Length Field (shortLENGTH)

The short PLCP length field shall be an unsigned 16 bit integer which indicates the number of microseconds (16 to $2^{16}-1$ as defined by aMPDUMaxLngh) required to transmit the MPDU. The transmitted value shall be determined from the LENGTH parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause **Error! Reference source not found.**. The length field provided in the TXVECTOR is in bytes and is converted to microseconds for inclusion in the PLCP shortLENGTH field. The shortLength field is calculated as follows:

- | | |
|-----------------|---|
| a) 5Mbit/s PPM | Length = #bytes * 8/5, rounded to the next integer. |
| b) 8Mbit/s PPM | Length = #bytes. |
| c) 10Mbit/s PPM | Length = #bytes *9/11, rounded to the next integer. |

At the receiver, the number of bytes in the MPDU is calculated as follows:

- | | | |
|----|--------------|---|
| a) | 5Mbit/s PPM | #bytes = Length * 5/8, truncated to the last integer. |
| b) | 8Mbit/s PPM | #bytes = Length. |
| c) | 10Mbit/s PPM | #bytes = Length * 9/11-1, truncated, if shortSignal = 010b. |
| d) | 10Mbit/s PPM | #bytes = Length * 9/11, truncated, if shortSignal = 011b. |

The LSB (least significant bit) shall be transmitted first in time. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause **Error! Reference source not found.**

1.2.4.5 Short CCITT CRC-16 Field (shortCRC)

The shortCRC shall be the same as the CRCfield as defined for the long PLCP header. The CRC-16 is calculated over the shortSIGNAL and shortLENGTH fields.

1.2.4.6 Short PLCP Data Modulation and Modulation Rate Change

The PLCP preamble shall be transmitted using the 1 Mbit/s DBPSK modulation. The short PLCP header shall be transmitted using the 5Mbit/s BCPM modulation. The 802.11 SIGNAL field shall indicate the modulation which shall be used to transmit the MPDU. The transmitter and receiver shall initiate the modulation indicated by the 802.11 shortSIGNAL field starting with the first symbol (1bit for DBPSK, 2 bits for DQPSK, 5 bits for 5 Mbit/s PPM, 8 bits for 8Mbit/s PPM or 8 bits for 10 Mbit/s (with the symbol rate increased with a factor 11/9)) of the MPDU. The MPDU transmission rate shall be set by the DATARATE parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause **Error! Reference source not found.**

1.2.5 PLCP Transmit and Receive Procedure

1.2.5.1 PLCP Transmit Procedure

The transmit procedure for a transmitter not using the short PLCP preamble and header is described in the section 15.2.7. and will not change apart from the ability to transmit 5, 8 or optional 10 Mbit/s.

The transmit procedure for a transmitter employing the short PLCP preamble and header is in essence the same. The decision for using a long or short PLCP is not prescribed in this standard. The decision can be taken on a per frame basis by the Modem Management entity or can be set at network installation.

1.2.5.2 PLCP Receive Procedure

The receive procedure for a receiver configured to receive a long PLCP preamble and header is described in section 15.2.8. A receiver conformant to the extension of the standard is capable to receive 5 and 8 Mbit/s and optionally 10 Mbit/s. If a PPDU with a short preamble and header is being transmitted this receiver will also react as described in the section 15.2.8. The receiver will detect energy or a carrier conform the CCA procedure and defer. The short preamble is a DSSS signal. The shortSFD will normally not be detected and the receiver defers until the energy or carrier drops, thus providing coexistence capabilities between the systems

The receiver configured to receive a short PLCP preamble and header shall perform CCA and synchronize on the short preamble (54 microseconds) in order to be able to detect the shortSFD. After detection of the shortSFD the receiver shall be set to be able to receive 5Mbit/s, in order to process the rest of the header. After this the receive procedure is the same as described in section 15.2.8. The modulation rate change mechanism is described in clause 1.2.4.6.

The receiver configured to receive a shortPLCP shall also be capable of receiving a PPDU with a longPLCP preamble or header. The detection of the longPLCP preamble can be based on the data content

of the preamble (scrambled all 1's compared to scrambled all 0's) or on the absence of the shortSFD after 54 microseconds. Once detected the long PLCP the receiver can follow the receive procedure as described in section 15.2.8.

1.3 DSSS Physical Layer Management Entity (PLME)

1.3.1 PLME_SAP Sublayer Management primitives

Extension to Table 1 lists the MIB attributes which may be accessed by the PHY sublayer entities and intra layer of higher Layer Management Entities (LME). Only values to agPhyRateGroup are added for 5, 8 and 10 Mbit/s. The values 02h upto 10h are mandatory to be conformant to this extended specification. The value 14 is optional.

agPhyRateGroup		
aSupportedDataRatesTx	02h, 04h, 0Ah, 10h, 14h	Static
aSupportedDataRatesRx	02h, 04h, 0Ah, 10h, 14h	Static

Extension to Table 1, MIB Attribute Default Values / Ranges

Notes: The column titled Operational Semantics contains two types: static and dynamic. Static MIB attributes are fixed and cannot be modified for a given PHY implementation. MIB Attributes defined as dynamic can be modified by some management entity.

1.4 DSSS Physical Medium Dependent Sublayer

1.4.1 General

The modulation scheme for 5, 8 and 10Mbit/s is BCPM, a pulse position modulation scheme based on the Barker sequence. The power spectrum is not different from the 1 and 2 Mbit/s schemes. As a result of this most Phy Medium Dependent specifications are not changed. 5, 8 and 10 Mbit/s BCPM uses the same spectrum mask, operating channels, powerlevels, turnaround times, slot time and CCA mechanism. Different is (of course) the specification of the modulation scheme and the parameters associated with it.

1.4.1.1 Extension of PMD_SAP Service Primitive Parameters

Parameter	Associate Primitive	Value
TXD_UNIT	PMD_DATA.request	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK 00h-1Fh : joint BCPM (5Mbit/s) 00h-FFh : disjoint BCPM (8 and 10Mbit/s)

RXD_UNIT	PMD_DATA.indicate	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK 00h-1Fh : joint BCPM (5Mbit/s) 00h-FFh : disjoint BCPM (8 and 10Mbit/s)
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Table 2, Extension to the List of Parameters for the PMD Primitives

1.4.1.2 Modulation and Mandatory Channel Data Rates of 5 and 8 Mbit/s

The extended Direct Sequence specification defines two mandatory additional datarates. The modulation scheme for 5 Mbit/s is joined Barker Code Position Modulation (joined BCPM), the modulation scheme for 8 Mbit/s is disjoint BCPM.

At 5 Mbit/s 5 bits (d0 to d4; d0 first in time) are transmitted per symbol. The first two bits define in the same way as in the 2 Mbit/s DQPSK encoder the phase change of a DQPSK signal (see section 15.4.6.4, Table 67). The in-phase and quadrature components I and Q are spreaded with the 11 chip Barker sequence as defined in section 15.4.6.3. Contrary to 2 Mbit/s the first chip is not aligned at the start of a transmitted symbol but the start is dependent on the value of the third, fourth and fifth bit. The symbol duration is 11 chips long. The chips in the symbol define the starting points (position) of the Barker sequence. Only the first 8 positions (P0 to P7) are used. For 5 Mbit/s the Barker sequences for the I and Q component start at the same time (joined BCPM). The Table X defines the positions.

d4	d3	d2	position
0	0	0	p0
1	0	0	p1
1	1	0	p2
0	1	0	p3
0	1	1	p4
1	1	1	p5
1	0	1	p6
0	0	1	p7

Table X: joined BCPM position encoding table

At 8 Mbit/s 8 bits (d0 to d7) are transmitted per symbol. In BCPM scheme d2 to d4 define the position of the start of the Barker sequence for the I component, d5 to d8 define the position for the Q component (disjoint BCPM). d5 to d8 are defined in the same way as d2 to d4. See Table Y.

d4	d3	d2	position of I	d7	d6	d5	position of Q
0	0	0	p0	0	0	0	p0
1	0	0	p1	1	0	0	p1
1	1	0	p2	1	1	0	p2
0	1	0	p3	0	1	0	p3
0	1	1	p4	0	1	1	p4
1	1	1	p5	1	1	1	p5
1	0	1	p6	1	0	1	p6
0	0	1	p7	0	0	1	p7

Table Y: disjointed BCPM encoding table

The next figure shows a modulation example for three 8 Mbit/s symbols. Data-in is the output of the scrambler, I-n and Q-n are the contribution of the n-th symbol to the final I and Q signals at the D/A output. Assume I-0 has been transmitted at $\pi/4$ ($I'=1$ and $Q'=1$).

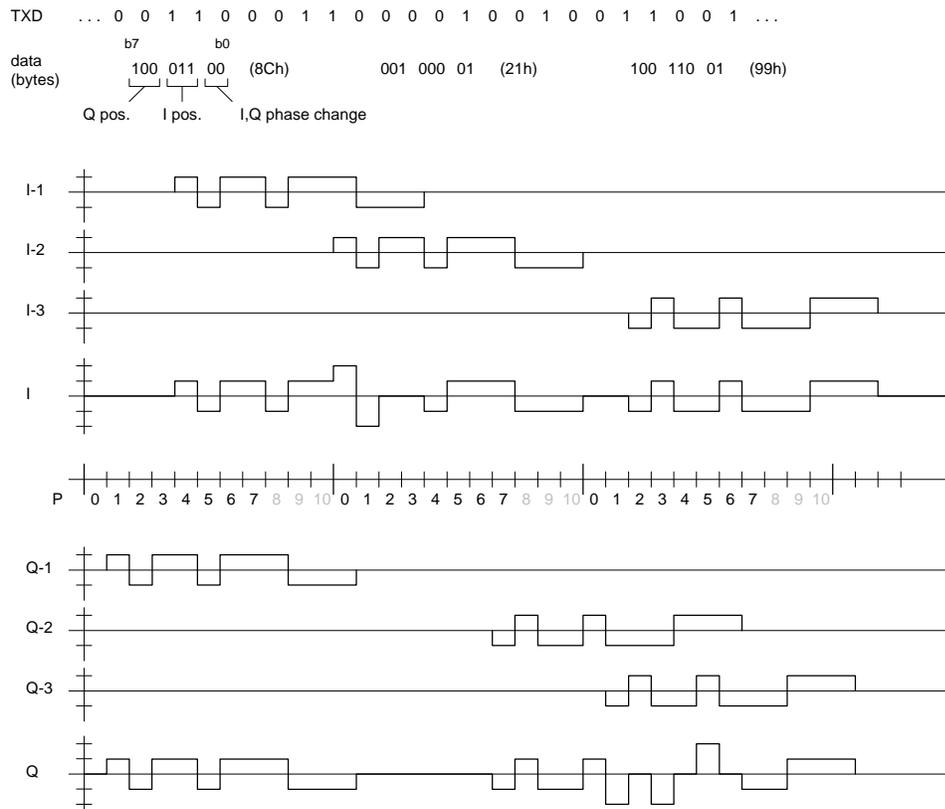


Figure xx, Example of 8 Mbit/s Modulation

1.4.1.3 Modulation and Optional Channel Data Rates of 10 Mbit/s

The extended Direct Sequence specification defines one optional additional datarate of 10 Mbit/s. The modulation is in essence similar to the modulation method of 8Mbit/s. The only difference is that the symbol duration is reduced from 11 to 9 chips. The duration of a chip is not changed. The first 8 chips again define the possible positions (P0 to P7) for the starting points of the Barker sequence. The ninth chip is not used. The next figure illustrates the modulation method for 10 Mbit/s. The same datastream and assumption are used as in figure xx for 8 Mbit/s.

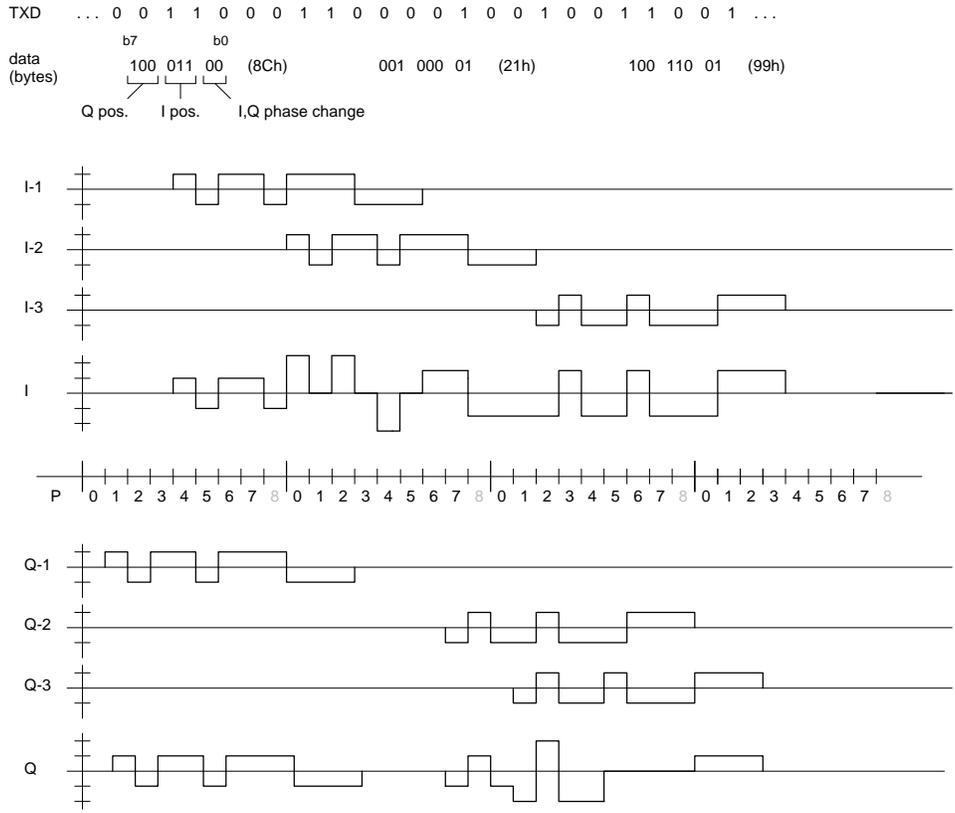


Figure xxx. Example of 10 Mbit/s modulation.

1.4.1.4 Amplitude Levels

As can be seen in the figures xx and xxx BCPM has five amplitude levels. This paragraph specifies the levels and the accuracy of these levels relative to the levels of the 1 Mbit/s signal. The 1 Mbit/s signal has two levels defined as -A and A.

The BCPM amplitude levels are specified as follows:

- $(4/3 \pm x) * A$:the high positive level, sum of two positive Barker pulses
- $(2/3 \pm y) * A$:the low positive level, only one Barker pulse adds to the BCPM signal
- $\pm z * A$:zero level, sum of a positive and negative Barker pulse
- $-(2/3 \pm y) * A$:the low negative level, only one Barker pulse adds to the BCPM signal
- $-(4/3 \pm x) * A$:the high negative level, sum of two negative Barker pulses

The accuracy x,y and z have to be defined.

Implementation note: setting the levels to these values means that the power level of the BCPM signal is ≈ 3.5 dB lower than the 1 Mbit/s DPSK signal (preamble and header). More back-off of the Power Amplifier compared to the back-off required for the 1 and 2 Mbit/s signals is not necessary. Some linear distortion of the peaks (high levels) does not significantly add to the sidelobes of the power spectrum, because the frequency of appearance of the high peaks is relatively low. The performance degradation as a result will not be more than 1 dB.

1.4.1.5 Transmit Center Frequency and Chip Clock Frequency coupling

The tolerance of both the Transmit Center Frequency and the Chip Clock Frequency shall be ± 25 ppm maximum. The clocks of the Transmit Center Frequency and the Chip Clock Frequency are coupled.