MEASUREMENT AND TECHNICAL REPORT

WIDCOMM, INC.
9645 Scranton Road, Suite 205
San Diego, CA 92121

DATE: 16 May 2001

This Report Concerns:	Original Grant: X	Class II Change:
Equipment Type:	Blue Connect, Model Blue Connect	
Deferred grant requested per 47 CFR 0.457(d)(1)(ii)?	Yes: **Defer until:**	No: X
Company Name **agrees to notify the Commission by:**	N/A	

of the intended date of announcement of the product so that the grant can be issued on that date.

Transition Rules Request per 15.37?	Yes:	No: X*

(*) FCC Part 15, Paragraphs 15.205; 15.209; 15.209(a); 15.247; 15.247(a)(1)(ii)

Report Prepared by:

TÜV PRODUCT SERVICE
10040 Mesa Rim Road
San Diego, CA 92121-2912
Phone: 858 546 3999
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TÜV PRODUCT SERVICE

TABLE OF CONTENTS

TÜV PRODUCT SERVICE 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone 858 546 3999 FAX 858 546 0364

1 GENERAL INFORMATION

1.1 Product Description

EUT Description: Wireless PDA Data Transmitter and Receiver
EUT Name: Blue Connect
Model No.: Blue Connect

Typical Installation and/or Operating Environment

Home/office

EUT Power Cable

X Not Applicable

EUT Interface Ports and Cables

Interface				Shielding								
Type	Analog	Digital	Qty	Yes	No	Type	Termination	Connector Type	Port Termination	Length (In meters)	Removable	Permanent
USB		X	1	X		Foil	Twisted	USB	100 ohm	1 m	X	
Or RS232		X	1	X			Twisted	9-pin D-sub	100 ohm	1 m	X	

EUT System Components

Description	Model #	Serial #	FCC ID #
Handspring Visor	Deluxe		
Ericsson Bluetooth Module			

Support Equipment

Description	*Model #*	*Serial #*	*FCC ID #*
None			

Oscillator Frequencies

Frequency	*Derived Frequency*	*Component # / Location*	*Description of Use*
2.4 to 2.5 G		Ericsson module Xtal	TX output Vart

Power Supply

Manufacturer	*Model #*	*Serial #*	*Type*
N/A			

Power Line Filters

Manufacturer	*Model #*	*Location in EUT*
N/A		

Critical EMI Components (Capacitors, ferrites, etc.)

Description	*Manufacturer*	*Part # or Value*	*Qty*	*Component # / Location*
N/A				

EMC Critical Detail -- Describe other EMC Design details used to reduce high frequency noise.

N/A

1 GENERAL INFORMATION (continued)

1.2 Related Submittal/Grant

None

1.3 Tested System Details

The FCC IDs for all equipment, plus descriptions of all cables used in the tested system are:

None

1.4 Test Methodology

Purpose of Test: To demonstrate compliance with the ANSI C63.4 setup.

Test Performed:

X 1. Conducted Emissions, FCC Part 15, Paragraph 15.247(a)(1)(ii)
2. Radiated Emissions EN55022: 1992 Class B limit, 30 - 1,000 MHz, 10 meters
X 3. Radiated Emission per FCC Part 15, Paragraphs 15.205; 15.209(a); and 15.247
4. Engineering evaluations
5. Frequency Stability, Part 2, Paragraph 2.995, and Part 87, Paragraph 87.133
6. RF Output Power, Part 2, Paragraph 2.985, Part 22, Paragraph 22.917

Both Conducted and radiated testing were performed according to the procedures in FCC/ANSI C63.4 and CSA 108.8 - M1983. Radiated testing was performed at an antenna-to-EUT distance of 3 meters (1 - 10 GHz).

TÜV PRODUCT SERVICE 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone 858 546 3999 FAX 858 546 0364

1.5 Test Facility

The open area test site and conducted measurement data were tested by:

TÜV PRODUCT SERVICE
10040 Mesa Rim Road
San Diego, CA 92121-2912
Phone: 619 546 3999
Fax: 619 546 0364

The Test Site Data and performance comply with ANSI 63.4 and are registered with the FCC, 7435 Oakland Mills Rd, Columbia Maryland 21046. All Measurement Data is acquired according to the content of FCC Measurement Procedure and ANSI C63.4, unless supplemented with additional requirements as noted in the test report.

2. SYSTEM TEST CONFIGURATION

2.1 Justification

The EUT was initially tested for FCC emission in the following configuration:

See Block Diagram.

2.2 EUT Exercise Software

None

2.3 Special Accessories

None

2.4 Modification

None

2.5 Configuration of Tested System

See Block Diagram.

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3 RADIATED EMISSION EQUIPMENT/DATA

The following data lists the significant emission frequencies, measured levels, correction factor (which includes cable and antenna corrections), the corrected reading, and the limit.

See following page(s).

See test setup photos for radiated emissions test setup.

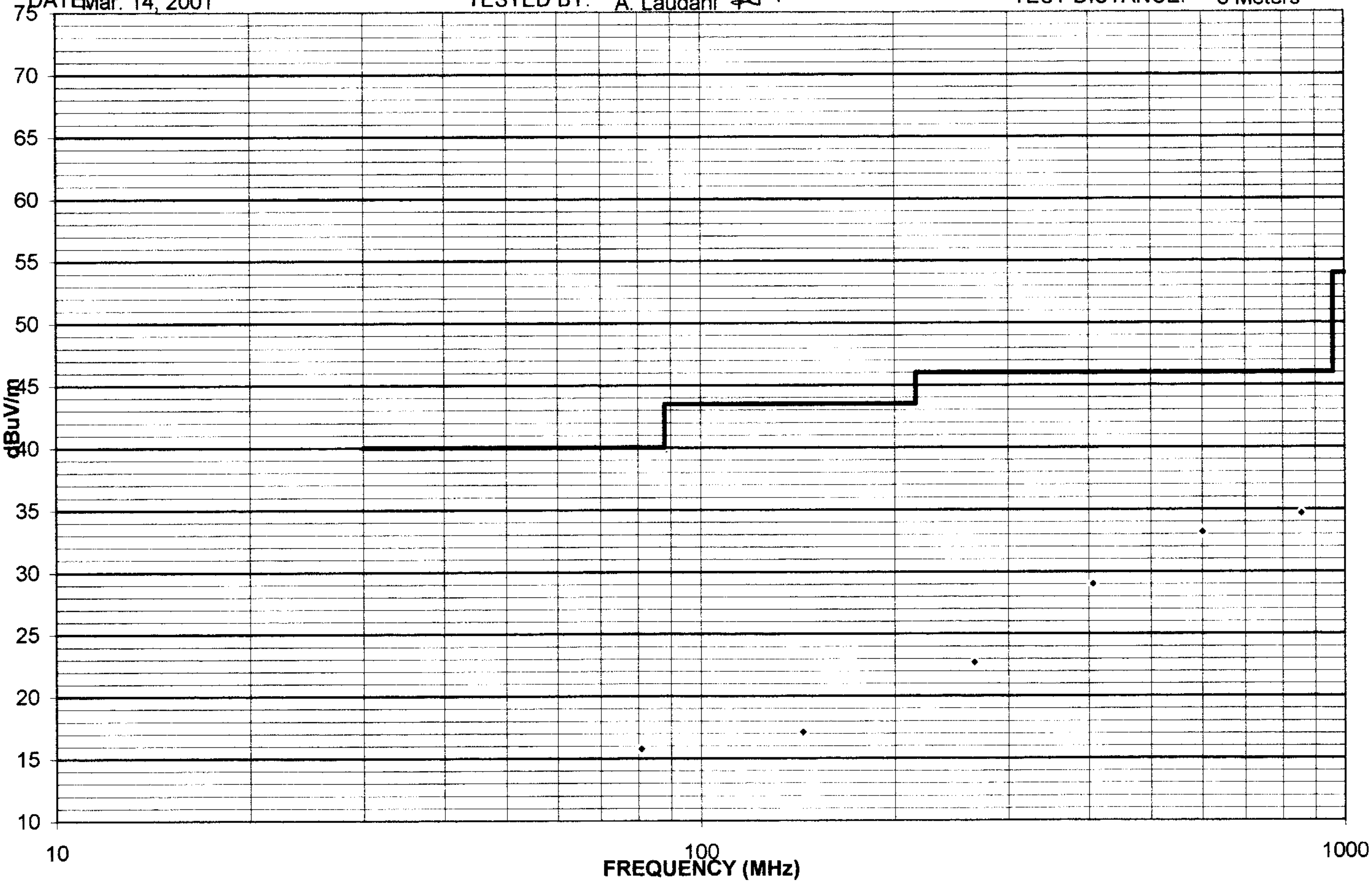
TÜV PRODUCT SERVICE 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone 858 546 3999 FAX 858 546 0364

REPORT NO.SC101740
COMPANY:A. Laudani
EUT:EA
EUT MODE:Receive
DATE:Mar. 14, 2001

SPEC: FCC Part 15 para 15.209(a)

TESTED BY: A. Laudani

TEST DISTANCE: 3 Meters



REPORT No: SC101740

SPEC: FCC Part 15 para 15.109(a)

CUSTOMER: A. Laudani

TEST DIST: 3 Meters

E U T: EA

TEST SITE: 1

EUT MODE: Receive

BICONICAL: 491

DATE: Mar. 14, 2001 TESTED BY: A. Laudani AAL

LOG PERIODIC: 243

NOTES: Quasi-Peak with 120 KHz measurement bandwidth.

RCVR: 466

Temperature: 16 Relative Humidity: 45

EUT MARGIN -11.3 dB at 855.8 MHz

ver 1.8

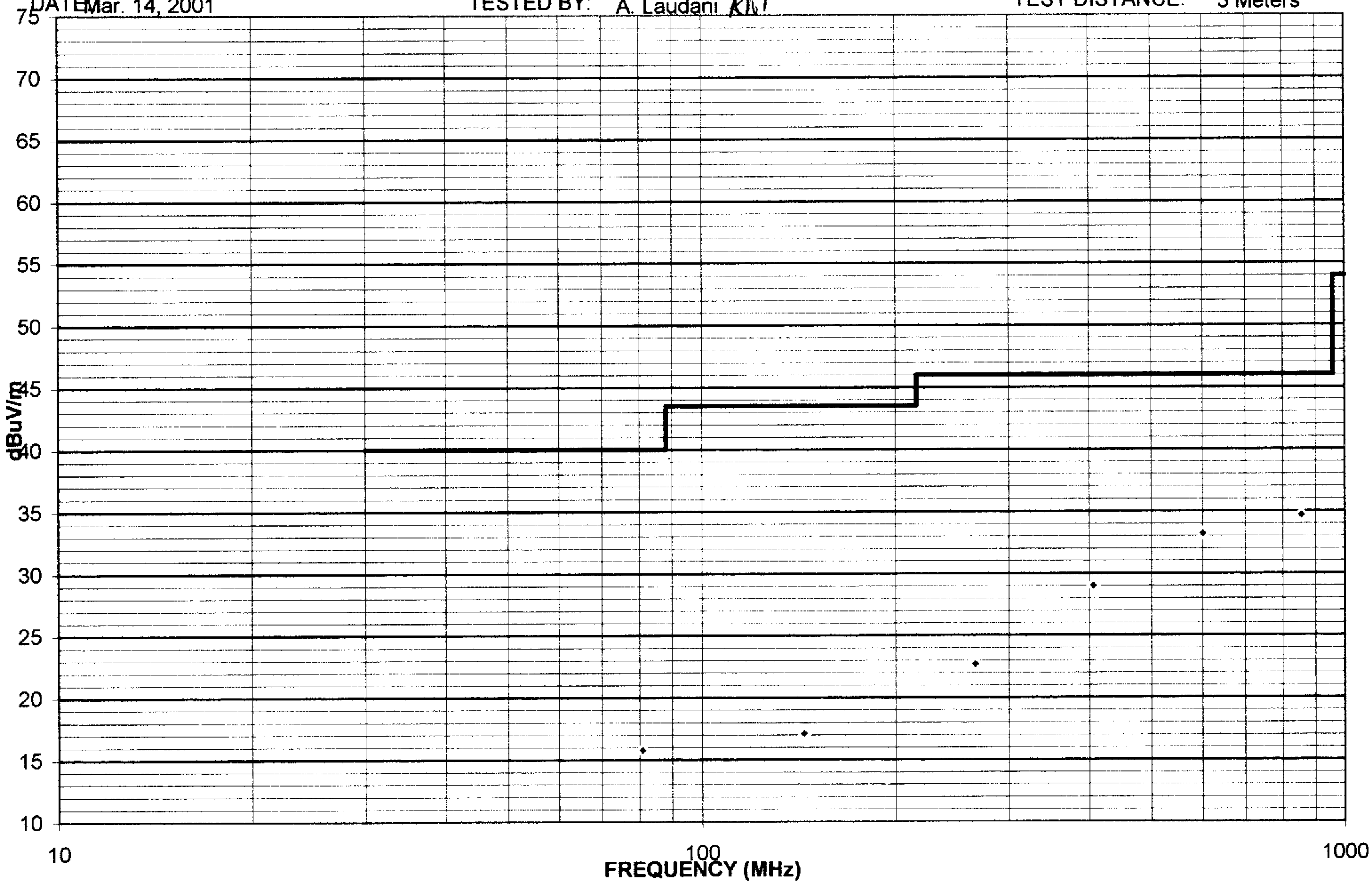
FREQUENCY (MHz)	VERTICAL measured (dBuv)	HORIZONTAL measured (dBuV)	CORRECTION FACTOR (dB/m)	MAXIMUM CORRECTED (dBuV/m)	SPECIFIED LIMIT (dBuV/m)	EUT MARGIN (dB)	EUT ROTATION (degrees)	ANTENNA HEIGHT (meters)
80.82	4.7	1.2	11.1	**15.8**	40	-24.2	0	1
144.00	0.8	2.4	14.7	**17.1**	43.5	-26.4	310	2
265.88	5.6	2.3	17.1	**22.7**	46	-23.3	335	1
406.55	8.3	5	20.7	**29.0**	46	-17.0	0	1
600.82	8	7	25.2	**33.2**	46	-12.8	335	1
855.80	4	0	30.7	**34.7**	46	-11.3	350	1

REPORT NO.SC101740
COMPANY:A. Laudani
EUT:EA
EUT MODE:Transmit
DATE:Mar. 14, 2001

SPEC: FCC Part 15 para 15.109(a)

TESTED BY: A. Laudani

TEST DISTANCE: 3 Meters



REPORT No: SC101740 | SPEC: FCC Part 15 para 15.109(a)

CUSTOMER: A. Laudani | TEST DIST: 3 Meters

E U T: EA | TEST SITE: 1

EUT MODE: Transmit | BICONICAL: 491

DATE: Mar. 14, 2001 TESTED BY: A. Laudani | LOG PERIODIC: 243

NOTES: Quasi-Peak with 120 KHz measurement bandwidth. | RCVR: 466

Temperature: 16 Relative Humidity: 45

EUT MARGIN -11.3 dB at 855.8 MHz

ver 1.8

FREQUENCY (MHz)	VERTICAL measured (dBuv)	HORIZONTAL measured (dBuV)	CORRECTION FACTOR (dB/m)	MAXIMUM CORRECTED (dBuV/m)	SPECIFIED LIMIT (dBuV/m)	EUT MARGIN (dB)	EUT ROTATION (degrees)	ANTENNA HEIGHT (meters)
80.82	4.7	1.2	11.1	**15.8**	40	-24.2	0	1
144.00	0.8	2.4	14.7	**17.1**	43.5	-26.4	310	2
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600.82	8	7	25.2	**33.2**	46	-12.8	335	1
855.80	4	0	30.7	**34.7**	46	-11.3	350	1

REPORT No: S101740 TESTED BY: Mary Washington SPEC: FCC Part 15, 15.247,15.209,15.205

CUSTOMER: Widcomm TEST DIST: 3 Meters

E U T: Blue Connect, Wireless PDA Data Tx and Rx TEST SITE: 3

EUT MODE: Transmit, Not hopping BICONICAL: N/A

DATE: 15-Mar-01 LOG: N/A

NOTES: OTHER: 251

Spectrum Anaylzer and Spectrum Analyzer Display, P/N 720 & 721

RBW and VBW = 1 MHz for peak and RBW = 1 MHz and VBW = 10 Hz for average.

Pre-Amp, P/N 367

v.beta2

FREQ (MHz)	VERTICAL (dBuv)		HORIZONTAL (dBuv)		CORRECTION FACTOR (dB/m)	MAX LEVEL (dBuV/m)		SPEC LIMIT (dBuV/m)		MARGIN (dB)		EUT Rotation	Antenna Height	Notes
	pk	av	pk	av		pk	av	pk	av	pk	av			
2402	55.2	39.5	59.9	40.9	31.0	**90.9**	**71.9**					231	1.7	low channel
4804	10.2		11.7		37.9	**49.6**	**37.9**	74	54	-24.4	-16	185	1.8	noise floor
7206	13.9	4.3	15.8	6.2	41.4	**57.2**	**47.6**	71.8	51.8	-14.6	-4.2	264	1.4	
2390	10.5		11.5		33.0	**44.5**	**33.0**	74	54	-29.5	-21	170	1.7	
2436	56.5	39.6	61.6	41.6	33.2	**94.8**	**74.8**					229	2.2	mid channel
4872	10.1	-0.8	14.8	3.6	38.0	**52.8**	**41.6**	74	54	-21.2	-12	3	2	
7308	14.8	4.3	15.1	4.2	41.6	**56.7**	**45.9**	74	54	-17.3	-8.1	160	1.9	noise floor
2480	56.4	39.5	61.8	42.1	33.4	**95.2**	**75.5**					16	1.8	high channel
4960	9	-0.7	11.7	1.6	38.2	**49.9**	**39.8**	74	54	-24.1	-14	236	1.9	noise floor
7440	14.5	4	14.9	4.5	41.9	**56.8**	**46.4**	74	54	-17.2	-7.6	156	1.9	noise floor
2483.5	21.1	7.6	25.9	9.4	33.4	**59.3**	**42.8**	74	54	-14.7	-11	35	2.2	

Emissions Test Conditions: RADIATED EMISSIONS, FCC Part 15, Paragraph 15.205, 15.209, 15.247

The *RADIATED EMISSIONS* measurements were performed at the following test location :

☐ **- Test not applicable**

■ - Canyon #3 (Open Area Test Site), Carroll Canyon, San Diego

Testing was performed at a test distance of:

☐ - 1 meters
■ - 3 meters
☐ - 10 meters

Test Equipment Used :

Model No.	Prop. No.	Description	Manufacturer	Serial No.	Cal Date
3115	251	Antenna, Double Ridge Guide	EMCO	2495	10/01
3146	243	Antenna, Log Periodic Dipole	EMCO	1063	02/02
8566B	720	Spectrum Analyzer	Hewlett Packard	211500842	03/17/01
8566B	721	Spectrum Analyzer Display	Hewlett Packard	2112A02185	03/17/01
ESVS30	466	Receiver	Rohde & Schwarz	833825/003	02/02
3110B	491	Biconnical Antenna	EMCO	9508-2134	06/01

Remarks: ______________________________

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Field Strength Calculation

If a preamplifier was used during the Radiated Emission Testing, it is required that the amplifier gain must be subtracted from the Spectrum Analyzer (Meter) Reading. In addition, a correction factor for the antenna , cable used and a distance factor, if any, must be applied to the Meter Reading before a true field strength reading can be obtained. In the automatic measurement, these considerations are automatically presented as a part of the print out. In the case of manual measurements and for greater efficiency and convenience, instead of using these correlation factors for each meter reading, the specification limit was modified to reflect these correlation factors at each frequency value so that the meter readings can be compared directly to the modified specification limit. This modified specification limit is referred to as the "Corrected Meter Reading Limit" or simply the CMRL, which is the actual field strength present at the antenna. The quantity can be derived in the following manner:

Corrected Meter Reading Limit (CMRL) = SAR + AF + CL - AG - DC

Where, SAR = Spectrum Analyzer Reading
AF = Antenna Factor
CL = Cable Loss
AG = Amplifier Gain (if any)
DC = Distance Correction (if any)

Assume the following situation: A meter reading of 29.4 dBuV was obtained from a Class A computing device measured at 83 MHz. Assume an antenna factor of 9.2 dB, a cable loss of 1.4 dB and amplifier gain of 20.0 dB at 83 MHz. The final field strength would be determined as follows:

CMRL = 29.4 dBuV + 9.2dB = 1.4 dB - 20 dB/M - 0.0 dB

CMRL = 20.0 dBuV/M

This result is well below the FCC and CSA Class A limit of 29.5 dbuV/m at 83 MHz.

For the manual mode of measurement, a table of corrected meter reading limit was used to permit immediate comparison of the meter reading to determine if the measure emission amplitude exceeded the specification limit at that specific frequency.

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4 CONDUCTED EMISSION EQUIPMENT/DATA

See following page(s).

Emissions Test Conditions: CONDUCTED EMISSIONS, FCC Part15, Paragraph 15.247(a)(1)(ii)

The *CONDUCTED EMISSIONS* measurements were performed at the following test location :

☐ - Test not applicable

■ **-** SR-3, Shielded Room, 12’ x 20’ x 8’, Metal Chamber

Test Equipment Used :

Spectrum Analyzer, HP8566B, P/N 10308, S/N 2115A00842, Cal: 03/02
Horn Antenna, 3115, P/N 453, EMCO, S/N 9412-4364, Cal: 10/02

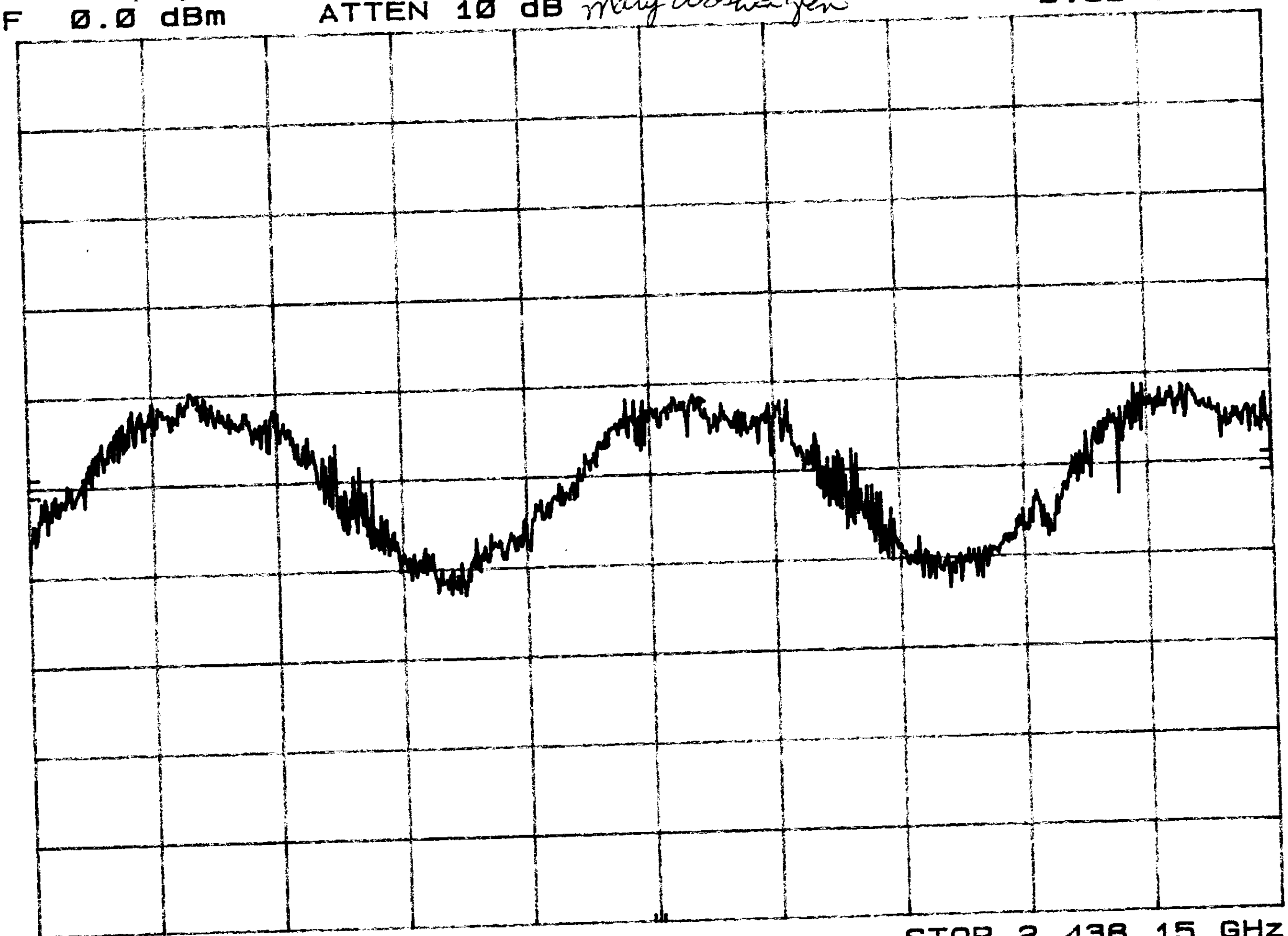
Remarks: ____

____

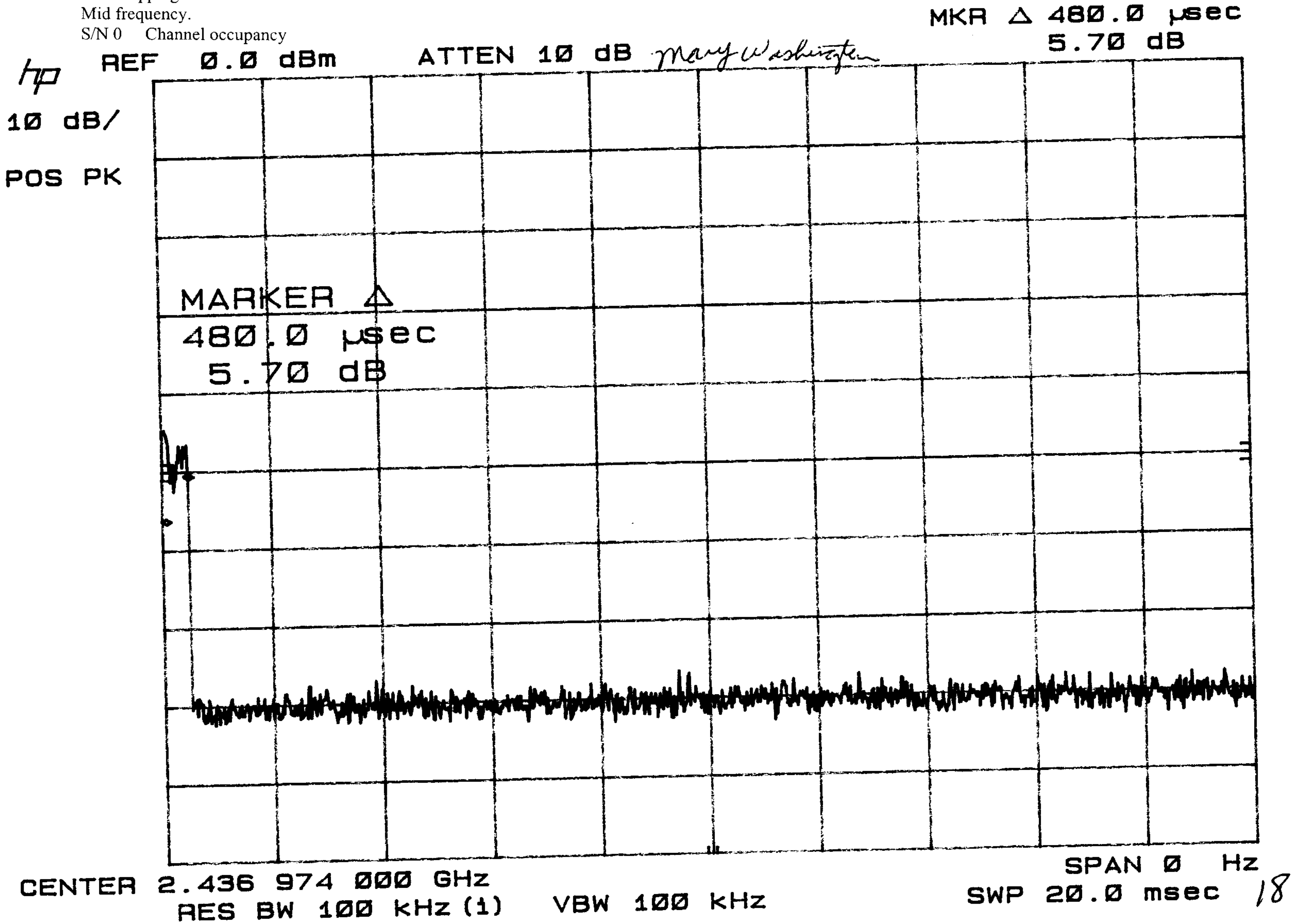
CLIENT: WIDCOMM DATE: 3/21/01 SPECIFICATION: CFR 47, Part 15, Para. 15.247(a)(1)(ii)

Blueconnect Wireless PDA Data Transceiver

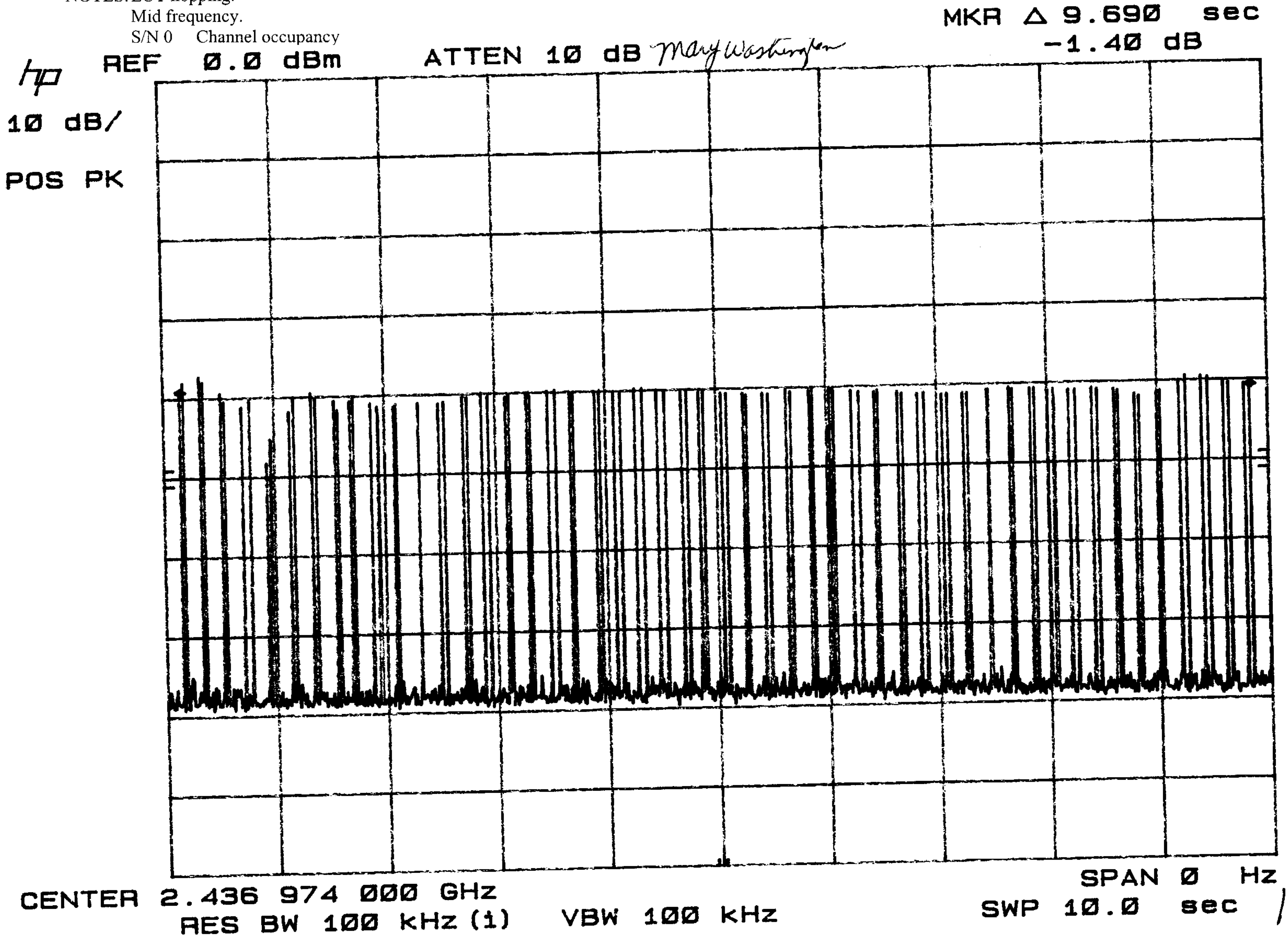
NOTES: EUT hopping.
Mid frequency.
S/N 0 Channel spacing.



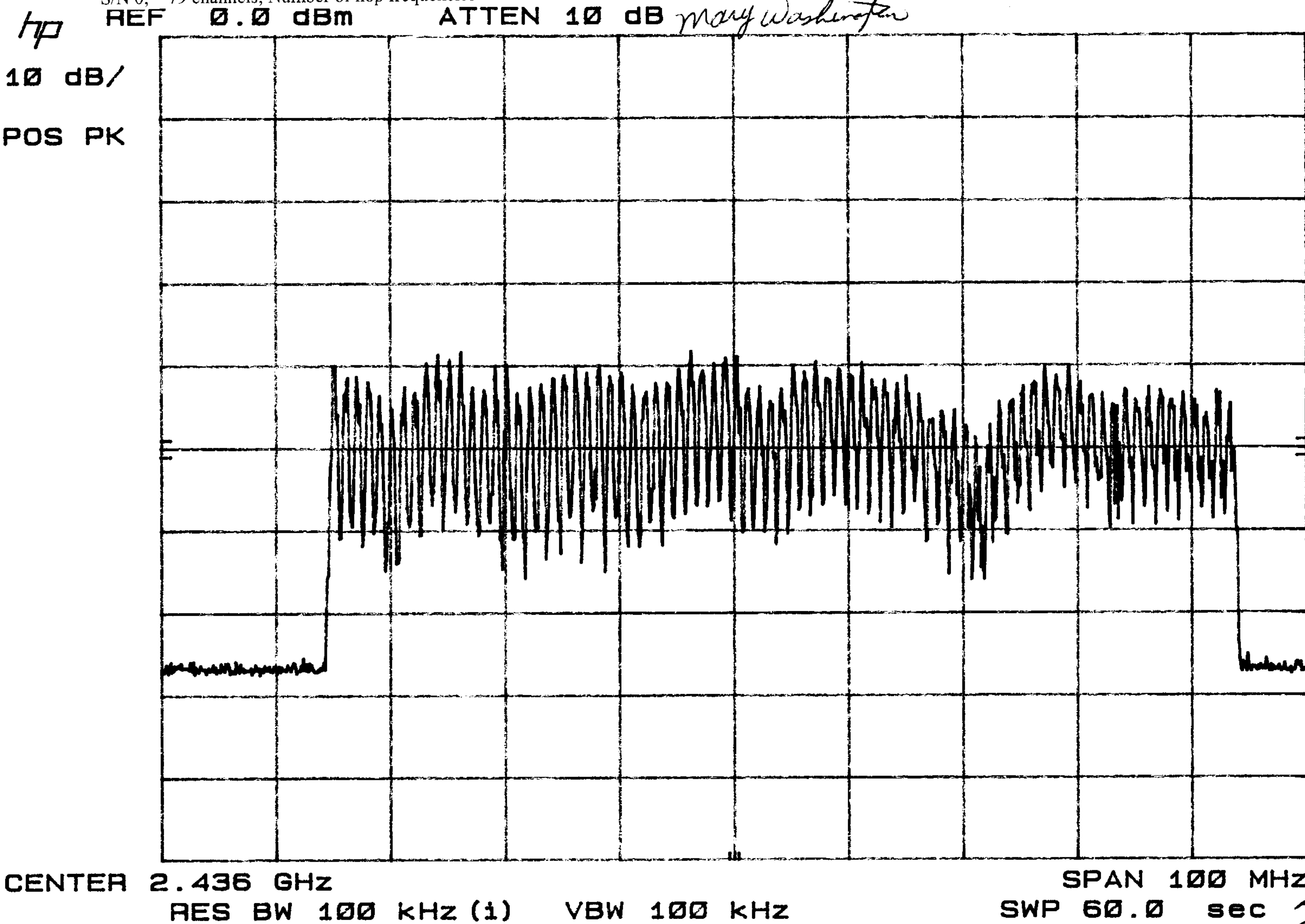
CLIENT: WIDCOMM DATE: 3/21/01 SPECIFICATION: CFR 47, Part 15, Para. 15.247(a)(1)(ii)
Blueconnect Wireless PDA Data Transceiver
NOTES: EUT hopping.
Mid frequency.
S/N 0 Channel occupancy



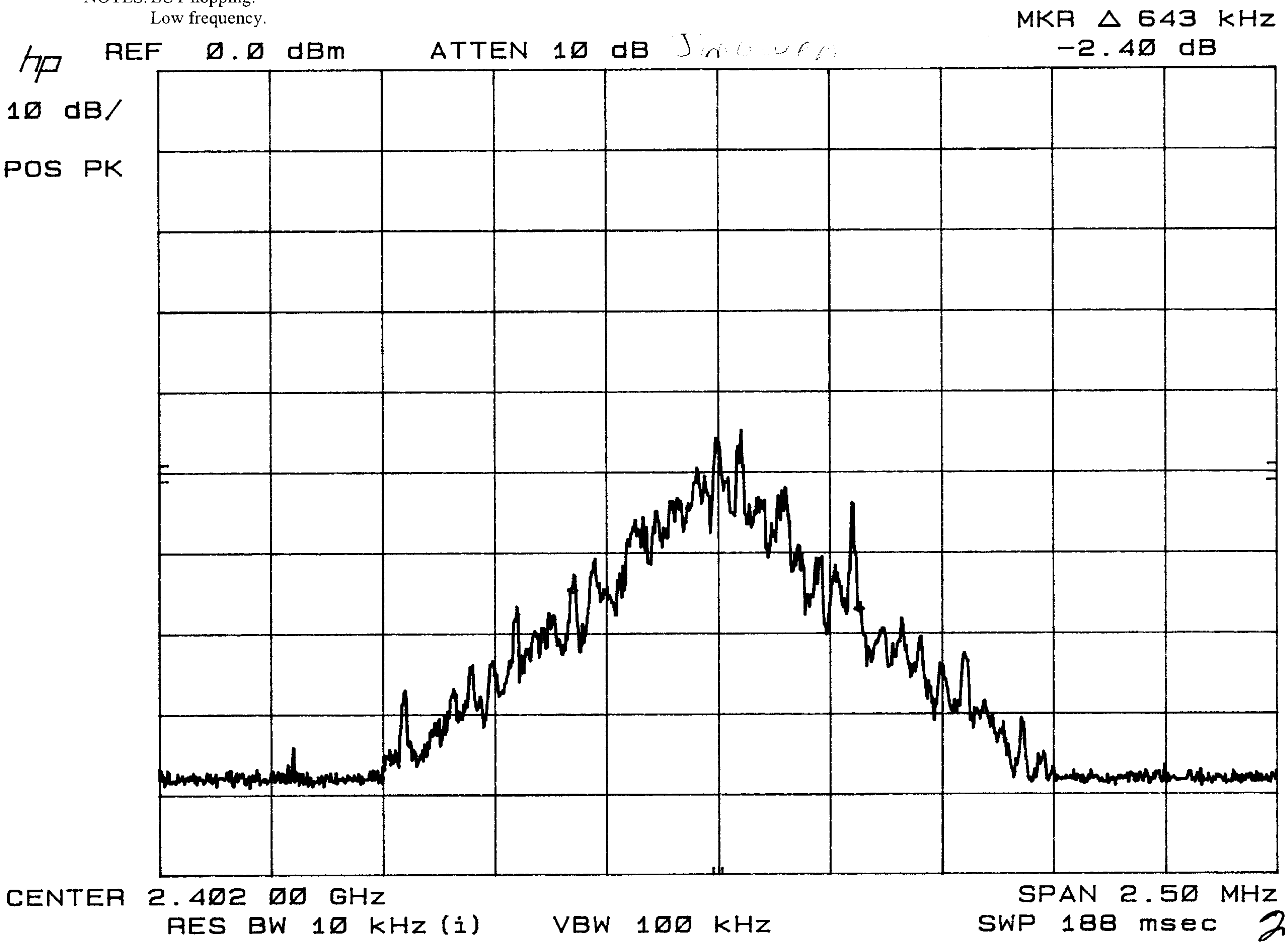
CLIENT: WIDCOMM DATE: 3/21/01 SPECIFICATION: CFR 47, Part 15, Para. 15.247(a)(1)(ii)
Blueconnect Wireless PDA Data Transceiver
NOTES: EUT hopping.
Mid frequency.
S/N 0 Channel occupancy



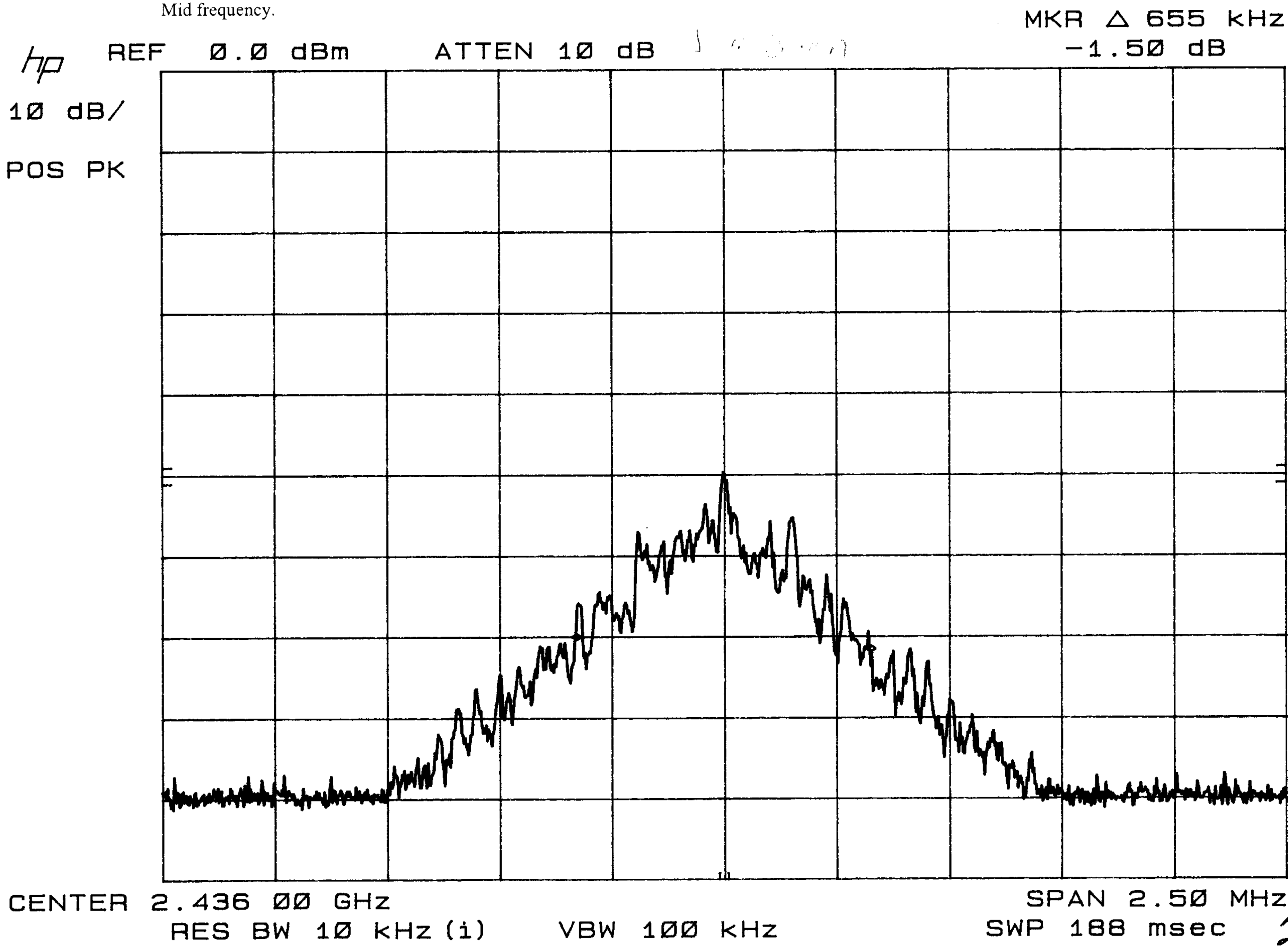
CLIENT: WIDCOMM DATE: 3/21/01 SPECIFICATION: CFR 47, Part 15, Para. 15.247(a)(1)(ii)
Blueconnect Wireless PDA Data Transceiver
NOTES: EUT hopping.
Mid frequency.
S/N 0; 79 channels; Number of hop frequencies



CLIENT: WIDCOMM DATE: 3/21/01 SPECIFICATION: CFR 47, Part 15, Para. 15.247(a)(1)(ii)
Blueconnect Wireless PDA Data Transceiver
NOTES: EUT hopping.
Low frequency.



CLIENT: WIDCOMM DATE: 3/21/01 SPECIFICATION: CFR 47, Part 15, Para. 15.247(a)(1)(ii)
Blueconnect Wireless PDA Data Transceiver
NOTES: EUT hopping.
Mid frequency.

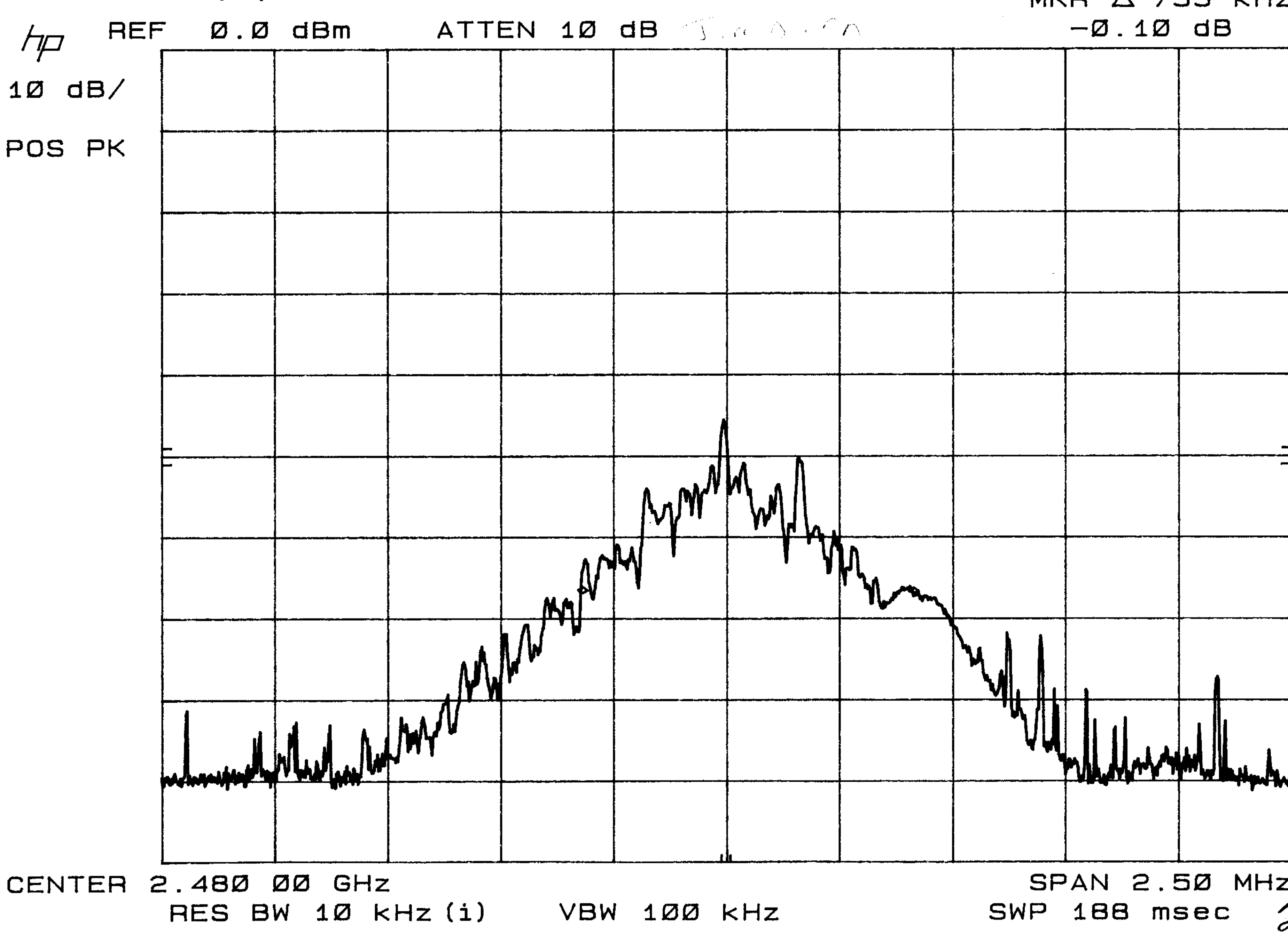


CLIENT: WIDCOMM DATE: 3/21/01

Blueconnect Wireless PDA Data Transceiver

NOTES: EUT hopping.
High frequency.

SPECIFICATION: CFR 47, Part 15, Para. 15.247(a)(1)(ii)



ATTESTATION STATEMENT

GENERAL REMARKS:

SUMMARY:

All tests were performed per CFR 47, *FCC Part 15, Paragraphs 15.205; 15.209; 15.209(a); 15.247; 15.247(a)(1)(ii)*

■ - Performed

The Equipment Under Test

■ - **Fulfills** the requirements of CFR 47, *FCC Part 15, Paragraphs 15.205; 15.209; 15.209(a); 15.247; 15.247(a)(1)(ii)*

- TÜV PRODUCT SERVICE, INC. -

Responsible Engineer:

Mary Washington
(EMC Engineer)

TÜV PRODUCT SERVICE 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone 858 546 3999 FAX 858 546 0364

Frequency Hopping Compliance Statement

The Frequency Hopping Sequence follows the Bluetooth Pseudorandom Hop Sequence Specification. The sequence is described in the Part B Baseband Specification of the Bluetooth SIG Specification available at http://www.bluetooth.com/link/spec11/core/Bluetooth_11_PartB_Baseband.pdf. The section of particular interest is page 127 in Chapter 11 of this document. Chapter 11 is attached to this application for convenience, please refer to Section 11.2 entitled Selection Kernel (the third page of the chapter) for a description of the Hopping Selection Algorithm.

The Ericsson Bluetooth Module (Ericsson part number ROK 101 007) is entirely responsible for the execution of the frequency hopping operation. No Widcomm circuitry is used to control the hopping operation.

See following pages.

11 HOP SELECTION

In total, 10 types of hopping sequences are defined – five for the 79-hop and five for the 23-hop system, respectively. Using the notation of parentheses () for figures related to the 23-hop system, these sequences are:

- A **page hopping sequence** with 32 (16) unique wake-up frequencies distributed equally over the 79 (23) MHz, with a period length of 32 (16);
- A **page response sequence** covering 32 (16) unique response frequencies that all are in an one-to-one correspondence to the current page hopping sequence. The master and slave use different rules to obtain the same sequence;
- An **inquiry sequence** with 32 (16) unique wake-up frequencies distributed equally over the 79 (23) MHz, with a period length of 32 (16);
- A **inquiry response sequence** covering 32 (16) unique response frequencies that all are in an one-to-one correspondence to the current inquiry hopping sequence.
- A **channel hopping sequence** which has a very long period length, which does not show repetitive patterns over a short time interval, but which distributes the hop frequencies equally over the 79 (23) MHz during a short time interval;

For the page hopping sequence, it is important that we can easily shift the phase forward or backward, so we need a 1-1 mapping from a counter to the hop frequencies. For each case, both a hop sequence from master to slave and from slave to master are required.

The inquiry and inquiry response sequences always utilizes the GIAC LAP as lower address part and the DCI (Section 5.4 on page 72) as upper address part in deriving the hopping sequence, even if it concerns a DIAC inquiry.

11.1 GENERAL SELECTION SCHEME

The selection scheme consists of two parts:

- selecting a sequence;
- mapping this sequence on the hop frequencies;

The general block diagram of the hop selection scheme is shown in Figure 11.1 on page 127. The mapping from the input to a particular hop frequency is performed in the selection box. Basically, the input is the native clock and the current address. In **CONNECTION** state, the native clock (CLKN) is modified by an offset to equal the master clock (CLK). Only the 27 MSBs of the clock are used. In the **page** and **inquiry** substates, all 28 bits of the clock are used. However, in **page** substate the native clock will be modified to the master's estimate of the paged unit.

The address input consists of 28 bits, i.e., the entire LAP and the 4 LSBs of the UAP. In **CONNECTION** state, the address of the master is used. In **page** substate the address of the paged unit is used. When in **inquiry** substate, the UAP/LAP corresponding to the GIAC is used. The output constitutes a pseudo-random sequence, either covering 79 hop or 23 hops, depending on the state.

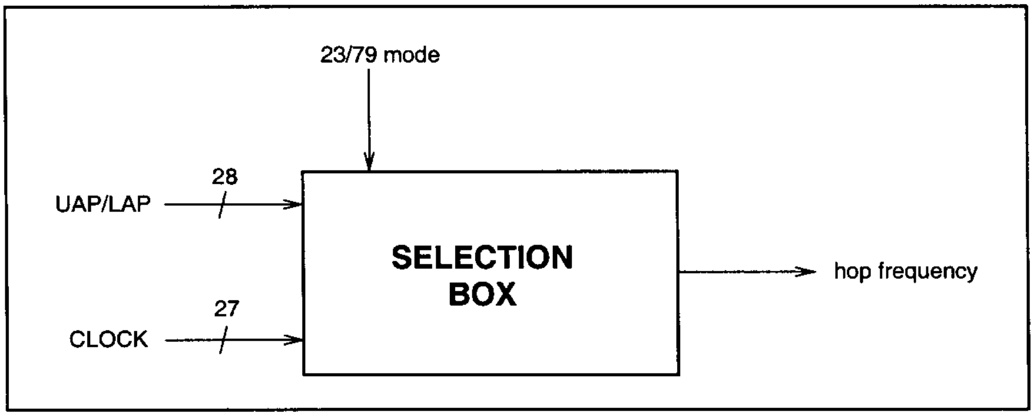
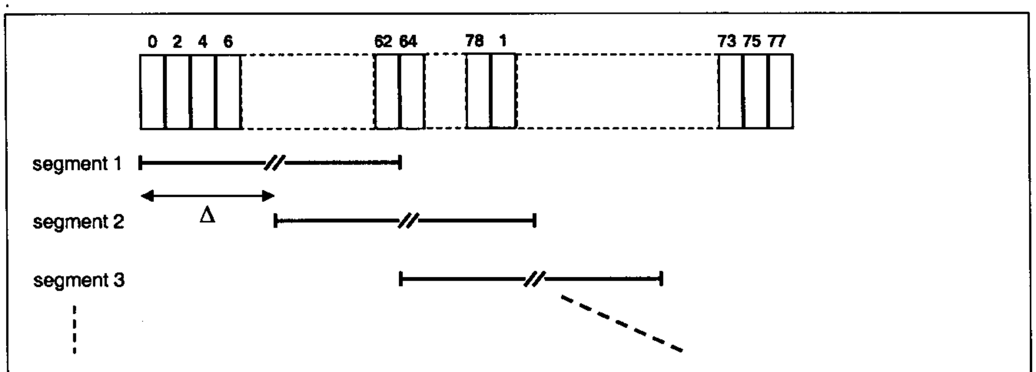


Figure 11.1: General block diagram of hop selection scheme.

For the 79-hop system, the selection scheme chooses a segment of 32 hop frequencies spanning about 64 MHz and visits these hops once in a random order. Next, a different 32-hop segment is chosen, etc. In case of the **page, page scan,** or **page response** substates, the same 32-hop segment is used all the time (the segment is selected by the address; different units will have different paging segments). In connection state, the output constitutes a pseudo-random sequence that slides through the 79 hops or 23 hops, depending on the selected hop system. For the 23-hop systems, the segment size is 16. The principle is depicted in Figure 11.2



	# of hops	segment length	Δ
Europe/US	79	32	16
Japan/France/Spain	23	16	8

Figure 11.2: Hop selection scheme in CONNECTION state.

11.2 SELECTION KERNEL

The hop selection kernels for the 79 hop system and the 23 hop system are shown in Figure 11.3 on page 128 and Figure 11.4 on page 128, respectively. The X input determines the phase in the 32-hop segment, whereas Y1 and Y2 selects between master-to-slave and slave-to-master transmission. The inputs A to D determine the ordering within the segment, the inputs E and F determine the mapping onto the hop frequencies. The kernel addresses a register containing the hop frequencies. This list should be created such that first all even hop frequencies are listed and then all odd hop frequencies. In this way, a 32-hop segment spans about 64 MHz, whereas a 16-hop segment spans the entire 23-MHz.

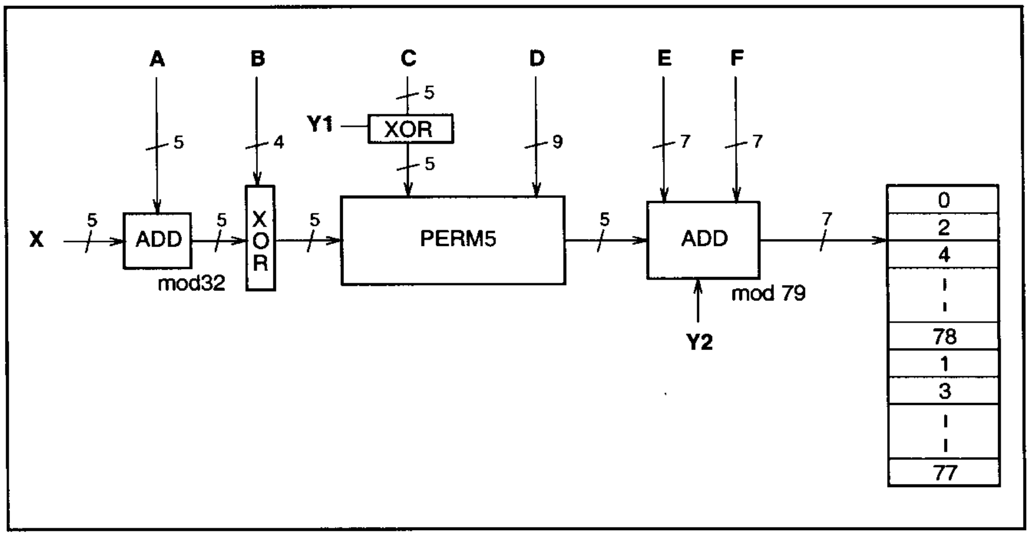


Figure 11.3: Block diagram of hop selection kernel for the 79-hop system.

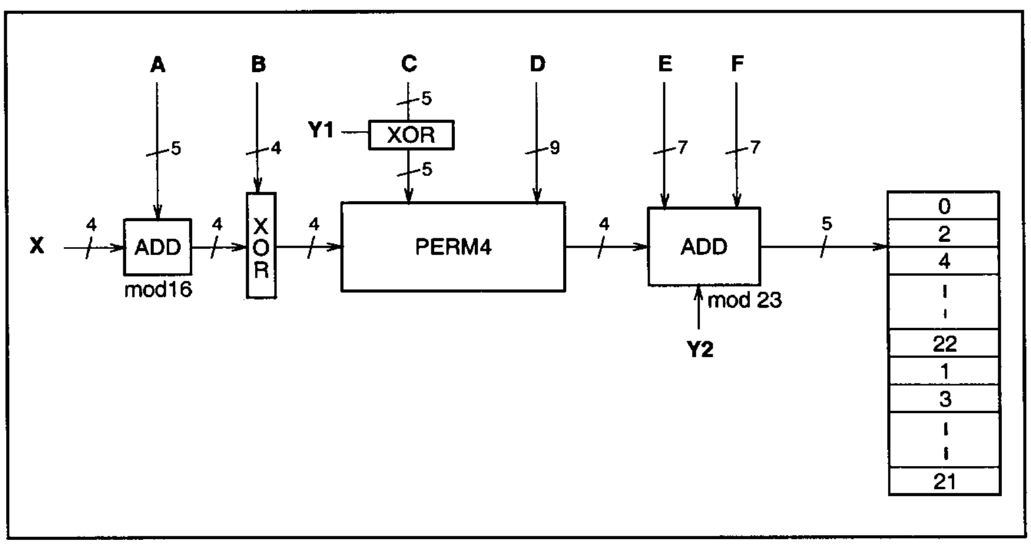


Figure 11.4: Block diagram of hop selection kernel for the 23-hop system.

The selection procedure consists of an addition, an XOR operation, a permutation operation, an addition, and finally a register selection. In the remainder of this chapter, the notation A_i is used for bit i of the BD_ADDR.

11.2.1 First addition operation

The first addition operation only adds a constant to the phase and applies a modulo 32 or a modulo 16 operation. For the page hopping sequence, the first addition is redundant since it only changes the phase within the segment. However, when different segments are concatenated (as in the channel hopping sequence), the first addition operation will have an impact on the resulting sequence.

11.2.2 XOR operation

Let Z' denote the output of the first addition. In the XOR operation, the four LSBs of Z' are modulo-2 added to the address bits $A_{22\text{-}19}$. The operation is illustrated in Figure 11.5 on page 129.

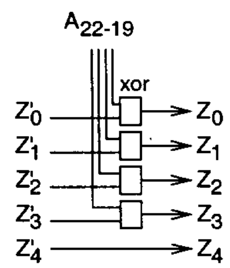


Figure 11.5: XOR operation for the 79-hop system. The 23-hop system is the same except for the Z'_4/Z_4 wire that does not exist.

11.2.3 Permutation operation

The permutation operation involves the switching from 5 inputs to 5 outputs for the 79 hop system and from 4 inputs to 4 outputs for 23 hop system, in a manner controlled by the control word. In Figure 11.6 on page 131 and Figure 11.7 on page 131 the permutation or switching box is shown. It consists of 7 stages of butterfly operations. Table 11.1 and Table 11.2 shows the control of the butterflies by the control signals P. Note that $P_{0\text{-}8}$ corresponds to $D_{0\text{-}8}$, and, P_{i+9} corresponds to $C_i \oplus Y1$ for $i = 0 \ldots 4$ in Figure 11.3 and Figure 11.4.

Control signal	Butterfly		Control signal	Butterfly
P_0	{Z_0,Z_1}		P_8	{Z1,Z4}
P_1	{Z_2,Z_3}		P_9	{Z_0,Z_3}
P_2	{Z_1,Z_2}		P_{10}	{Z_2,Z_4}
P_3	{Z_3,Z_4}		P_{11}	{Z_1,Z_3}
P_4	{Z_0,Z_4}		P_{12}	{Z_0,Z_3}
P_5	{Z_1,Z_3}		P_{13}	{Z_1,Z_2}
P_6	{Z_0,Z_2}			
P_7	{Z_3,Z_4}			

Table 11.1: Control of the butterflies for the 79 hop system

Control signal	Butterfly		Control signal	Butterfly
P_0	{Z_0,Z_1}		P_8	{Z_0,Z_2}
P_1	{Z_2,Z_3}		P_9	{Z_1,Z_3}
P_2	{Z_0,Z_3}		P_{10}	{Z_0,Z_3}
P_3	{Z_1,Z_2}		P_{11}	{Z_1,Z_2}
P_4	{Z_0,Z_2}		P_{12}	{Z_0,Z_1}
P_5	{Z_1,Z_3}		P_{13}	{Z_2,Z_3}
P_6	{Z_0,Z_1}			
P_7	{Z_2,Z_3}			

Table 11.2: Control of the butterflies for the 23 hop system

The Z input is the output of the XOR operation as described in the previous section. The butterfly operation can be implemented with multiplexers as depicted in Figure 11.8 on page 131.

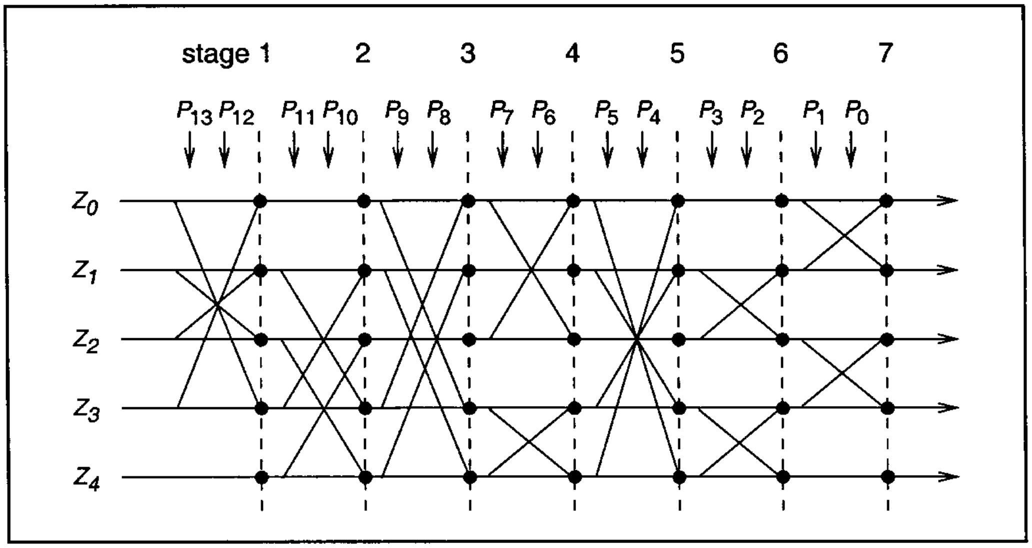


Figure 11.6: Permutation operation for the 79 hop system.

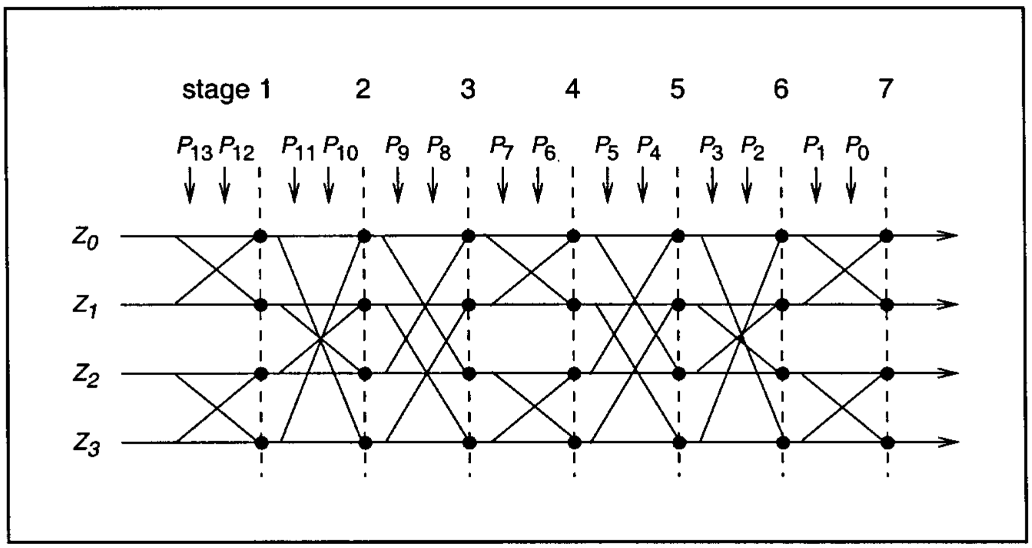


Figure 11.7: Permutation operation for the 23 hop system.

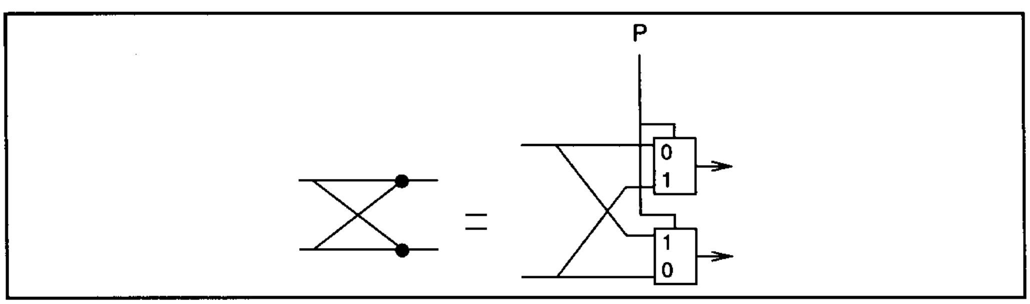


Figure 11.8: Butterfly implementation.

11.2.4 Second addition operation

The addition operation only adds a constant to the output of the permutation operation. As a result, the 16-hop or 32-hop segment is mapped differently on the hop frequencies. The addition is applied modulo 79 or modulo 23 depending on the system type (Europe/US vs. others).

11.2.5 Register bank

The output of the adder addresses a bank of 79 or 23 registers. The registers are loaded with the synthesizer code words corresponding to the hop frequencies 0 to 78 or 0 to 22. Note that the upper half of the bank contains the even hop frequencies, whereas the lower half of the bank contains the odd hop frequencies.

11.3 CONTROL WORD

In the following section X_{j-i}, $i<j$, will denote bits $i, i+1, ..., j$ of the bit vector X. By convention, X_0 is the least significant bit of the vector X.

The control word P of the kernel is controlled by the overall control signals X, Y1, Y2, and A to F as illustrated in Figure 11.3 on page 128 and Figure 11.4 on page 128. During paging and inquiry, the inputs A to E use the address values as given in the corresponding columns of Table 11.3 on page 133 and Table 11.4 on page 133. In addition, the inputs X, Y1 and Y2 are used. The F input is unused. In the 79-hop system, the clock bits CLK_{6-2} (i.e., input X) specifies the phase within the length 32 sequence, while for the 23-hop system, CLK_{5-2} specifies the phase within the length 16 sequence. For both systems, CLK_1 (i.e., inputs Y1 and Y2) is used to select between TX and RX. The address inputs determine the sequence order within segments. The final mapping onto the hop frequencies is determined by the register contents.

In the following we will distinguish between three types of clocks: the piconet's master clock, the Bluetooth unit's native clock, and the clock estimate of a paged Bluetooth unit. These types are marked in the following way:

1. CLK_{27-0}: Master clock of the current piconet.
2. $CLKN_{27-0}$: Native clock of the unit.
3. $CLKE_{27-0}$: The paging unit's estimate of the paged unit's native clock.

During the **CONNECTION** state, the inputs A, C and D result from the address bits being bit-wise XORed with the clock bits as shown in the "Connection state" column of Table 11.3 on page 133 and Table 11.4 on page 133 (the two MSBs are XORed together, the two second MSBs are XORed together, etc.). Consequently, after every 32 (16) time slots, a new length 32 (16) segment is selected in the 79-hop (23-hop) system. The sequence order within a specific segment will not be repeated for a very long period. Thus, the overall hopping sequence consists of concatenated segments of 32-hops each. Since each 32-hop sequence spans more than 80% of the 79 MHz band, the desired frequency spreading over a short time interval is obtained.

	Page scan/ Inquiry scan	Page/Inquiry	Page response (master/slave) and Inquiry response	Connection state
X	$\mathrm{CLKN}_{16-12}/$ $Xir^{(79)}_{4-0}$	$Xp^{(79)}_{4-0}/Xi^{(79)}_{4-0}$	$Xprm^{(79)}_{4-0}/Xprs^{(79)}_{4-0}/Xir^{(79)}_{4-0}$	CLK_{6-2}
Y1	0	$\mathrm{CLKE}_1/\mathrm{CLKN}_1$	$\mathrm{CLKE}_1/\mathrm{CLKN}_1/1$	CLK_1
Y2	0	$32\times\mathrm{CLKE}_1/$ $32\times\mathrm{CLKN}_1$	$32\times\mathrm{CLKE}_1$ / $32\times\mathrm{CLKE}_1$ 32×1	$32\times\mathrm{CLK}_1$
A	A_{27-23}	A_{27-23}	A_{27-23}	$A_{27-23}\oplus\mathrm{CLK}_{25-21}$
B	A_{22-19}	A_{22-19}	A_{22-19}	A_{22-19}
C	$A_{8,6,4,2,0}$	$A_{8,6,4,2,0}$	$A_{8,6,4,2,0}$	$A_{8,6,4,2,0}\oplus\mathrm{CLK}_{20-16}$
D	A_{18-10}	A_{18-10}	A_{18-10}	$A_{18-10}\oplus\mathrm{CLK}_{15-7}$
E	$A_{13,11,9,7,5,3,1}$	$A_{13,11,9,7,5,3,1}$	$A_{13,11,9,7,5,3,1}$	$A_{13,11,9,7,5,3,1}$
F	0	0	0	$16\times\mathrm{CLK}_{27-7}\ \mathrm{mod}\ 79$

Table 11.3: Control for 79-hop system.

	Page scan/ Inquiry scan	Page/Inquiry	Page response (master/slave) and Inquiry response	Connection state
X	$\mathrm{CLKN}_{15-12}/$ $Xir^{(23)}_{3-0}$	$Xp^{(23)}_{3-0}/Xi^{(23)}_{3-0}$	$Xprm^{(23)}_{3-0}/Xprs^{(23)}_{3-0}/Xir^{(23)}_{3-0}$	CLK_{5-2}
Y1	0	$\mathrm{CLKE}_1/\mathrm{CLKN}_1$	$\mathrm{CLKE}_1/\mathrm{CLKN}_1/1$	CLK_1
Y2	0	$16\times\mathrm{CLKE}_1/$ $16\times\mathrm{CLKN}_1$	$16\times\mathrm{CLKE}_1$ / $16\times\mathrm{CLKE}_1$ 16×1	$16\times\mathrm{CLK}_1$
A	A_{27-23}	A_{27-23}	A_{27-23}	$A_{27-23}\oplus\mathrm{CLK}_{25-21}$
B	A_{22-19}	A_{22-19}	A_{22-19}	A_{22-19}
C	$A_{8,6,4,2,0}$	$A_{8,6,4,2,0}$	$A_{8,6,4,2,0}$	$A_{8,6,4,2,0}\oplus\mathrm{CLK}_{20-16}$

Table 11.4: Control for 23-hop system.

	Page scan/ Inquiry scan	Page/Inquiry	Page response (master/slave) and Inquiry response	Connection state
D	A_{18-10}	A_{18-10}	A_{18-10}	$A_{18-10} \oplus CLK_{15-7}$
E	$A_{13,11,9,7,5,3,1}$	$A_{13,11,9,7,5,3,1}$	$A_{13,11,9,7,5,3,1}$	$A_{13,11,9,7,5,3,1}$
F	0	0	0	$6 \times CLK_{27-6} \bmod 23$

Table 11.4: Control for 23-hop system.

11.3.1 Page scan and Inquiry scan substates

In **page scan**, the Bluetooth device address of the scanning unit is used as address input. In **inquiry scan**, the GIAC LAP and the four LSBs of the DCI (as A_{27-24}), are used as address input for the hopping sequence. Naturally, for the transmitted access code and in the receiver correlator, the appropriate GIAC or DIAC is used. The application decides which inquiry access code to use depending on the purpose of the inquiry.

The five X input bits vary depending on the current state of the unit. In the **page scan** and **inquiry scan** substates, the native clock (CLKN) is used. In **CONNECTION** state the master clock (CLK) is used as input. The situation is somewhat more complicated for the other states.

11.3.2 Page substate

In the **page** substate of the 79-hop system, the paging unit shall start using the **A**-train, i.e., $\{f(k-8), \ldots, f(k), \ldots, f(k+7)\}$, where $f(k)$ is the source's estimate of the current receiver frequency in the paged unit. Clearly, the index k is a function of all the inputs in Figure 11.3. There are 32 possible paging frequencies within each 1.28 second interval. Half of these frequencies belongs to the **A**-train, the rest (i.e., $\{f(k+8), \ldots, f(k+15), f(k-16), \ldots, f(k-9)\}$) belongs to the **B**-train. In order to achieve the -8 offset of the **A**-train, a constant of 24 can be added to the clock bits (which is equivalent to -8 due to the modulo 32 operation). Clearly, the **B**-train may be accomplished by setting the offset to 8. A cyclic shift of the order within the trains is also necessary in order to avoid a possible repetitive mismatch between the paging and scanning units. Thus,

$$Xp^{(79)} = [CLKE_{16-12} + k_{offset} + (CLKE_{4-2,0} - CLKE_{16-12}) \bmod 16] \bmod 32, \quad \text{(EQ 2)}$$

where

$$k_{offset} = \begin{cases} 24 & \text{A-train,} \\ 8 & \text{B-train.} \end{cases} \quad \text{(EQ 3)}$$

11.3.5 Inquiry response

The **inquiry response** substate is similar to the **slave response** substate with respect to the X-input. However, there is no need to freeze the clock input, thus

$$Xir^{(79)} = [\mathrm{CLKN}_{16-12} + N] \mod 32, \qquad \text{(EQ 12)}$$

and

$$Xir^{(23)} = [\mathrm{CLKN}_{15-12} + N] \mod 16, \qquad \text{(EQ 13)}$$

for the 79-hop and 23-hop systems, respectively. Furthermore, the counter N is increased not on CLKN_1, but rather after each **FHS** packet has been transmitted in response to the inquiry. There is no restriction on the initial value of N as it is independent of the corresponding value in the inquiring unit.

The GIAC LAP and the four LSBs of the DCI (as A_{27-24}) are used as address input for the hopping sequence generator. The other input bits to the generator are the same as in the case of page response.

11.3.6 Connection state

In **CONNECTION** state, the clock bits to use in the channel hopping sequence generation are always according to the master clock, CLK. The address bits are taken from the Bluetooth device address of the master.