Listen Before Talk Test Report

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PURPOSE:

The purpose of this test report is to demonstrate the Listen Before Talk (LBT) operation of the Medical Implant Communications System (MICS) System that Medtronic has proposed to the MPT for including in their Radio Law. This system consists of a MICS Implant and a MICS Programmer/Controller that uses the LBT circuit to select the channel for communications based on the channel with the lowest ambient measured signal. The LBT operation of the programmer/controller was designed to comply with the protocol proposed by Medtronic to the MPT. This protocol has been adopted for these systems by the FCC and is nearing adoption in Europe by the European Telecommunications Standards Institute (ETSI).

BACKGROUND:

In reviewing the proposal for sharing the 401- 406 MHz band between the Meteorological Aids users and medical implant communications systems, the ITU-R SA 1346 study group concluded that interference between the two services must be reduced to the lowest possible level. It was their conclusion that medical implant communications systems should employ technology to avoid existing users of the band. By implementing a mechanism for interference avoidance, the medical implant communications systems would have little or no potential to interfere with the Meteorological Aids users, and the potential for interference between MICS users would also be lowered.

The MICS programmer/controller contains the circuitry required to select the channel of operation of the system according to the LBT protocol. The protocol was designed to select a channel for operation with a very low potential for interfering with an existing user of the spectrum.   The method of selecting this channel is to measure the existing ambient levels at the installation site and select the channel that meets the requirements of the protocol specification.

TEST SET-UP:

A series of signal generators were used to simulate existing ambient signals in a typical medical hospital environment. Each signal generator was used to represent an interfering ambient signal in one of the ten available channels in the 402 – 405 MHz band. The signals from these generators were combined and injected into the MICS monitoring system and its performance noted in a series of tests. Once the interfering signals were set up (amplitude and frequency of each signal) a data communications session was opened. For the first test, 5 generators were set to simulate ambient level signals ranging from –45 to –80 dBm as measured by the RSSI circuit in the programmer/controller. The programmer/controller was then instructed to start a MICS session and the frequency of the selected channel recorded. The recorded frequency was then compared to the frequencies of the interfering signal sources to insure the channel selected was the channel with the lowest measured ambient signal level. The next test added another signal generator in one of the remaining clear channels in order to show the LBT circuitry could successfully measure the additional signal in the band and select a new channel with the lowest ambient signal level.

The MICS programmer/controller and implant system were connected via cabling to the signal generator interfering sources with a, fixed, signal path-loss of approximately 73 dB between the MICS Implant and the MICS Programmer Controller to enable normal two-way data communication of the system (see Figure 1). Seventy-three dB is the calculated path loss that will occur during typical physician patient programming sessions. Interfering "noise signals" were injected into the conducted RF path for the Programmer/Controller and the Implant RF Transceivers. The frequency, amplitude, and modulation characteristics of the interfering signal sources were set and the combined signal was injected into the RF Path (as shown in Figure 1). The Programmer/Controller was manually instructed, the process used by a physician, to open a communications session with the MICS Implanted device. The channel that the session originated on (and remained on) was the channel selected according to the LBT protocol. The test was repeated with different injected noise levels and patterns using additional signal generators as described below.
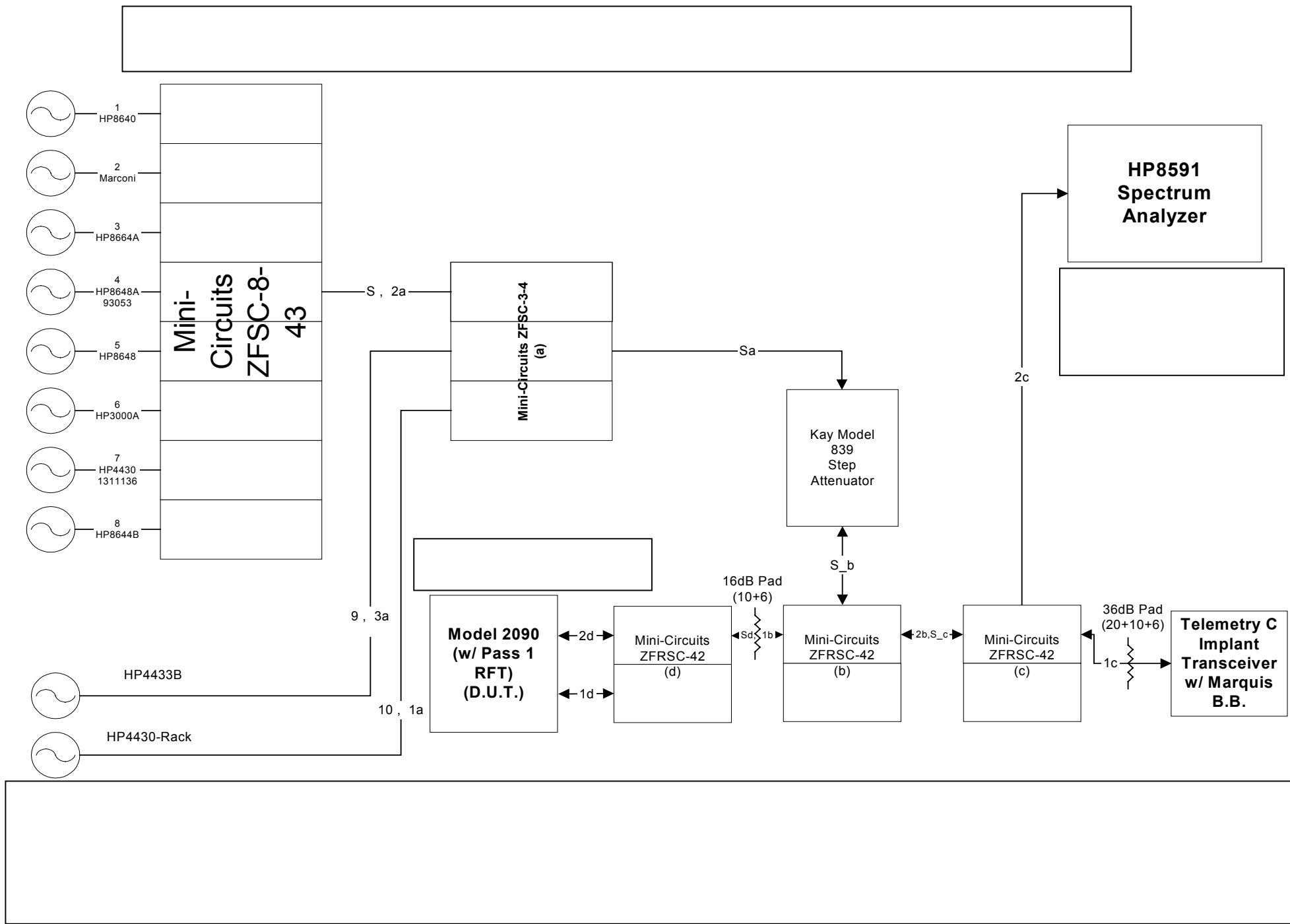
TEST METHOD:

The following test is designed to use direct connection of the interfering sources to the programmer/controller monitoring input circuits and the implant as shown in Figure 1. This test set-up allows the communications link to operate normally in the presence of the applied RF interference.

The RF signal generators used as the interference sources were modulated with 24 kHz frequency deviation at a 1 kHz sinusoidal rate. This produces an occupied bandwidth for the interfering signals of 50 kHz. The center frequency of each RF generator is set to one of the center frequencies of each of the ten 300 kHz MICS channels from 402 MHz to 405 MHz. The level of each of the RF signal generators may be set independently to obtain the interfering signal level profiles as described below. The procedure that was previously shown to the MPT and accepted by them for showing the performance of the LBT circuitry is listed below.

1. Set a signal generator to a frequency within one of ten 300 kHz wide channels in the 402-405 MHz band. The signal should be FM modulated with a 1 kHz tone, 50 kHz occupied bandwidth, and have an output level between –30 and –80 dBm
2. Repeat the above until a total of five interfering signals are placed in separate channels within the 402-405 MHz band. Output levels from signal sources should range from –30 to –80 dBm. Spacing between signals should allow five 300 kHz wide channels with no interfering signals.
3. Activate the programmer/controller and scan the band. Read out the results of the scan from its memory and record the data as a chart of frequency versus amplitude.
4. Initiate a request to open a telemetry channel.

5. Measure and record the frequency the programmer/controller selects as the transmit frequency and record it as frequency, F1. Compare the transmit frequency, F1, to the read out chart obtained in Step 3 to insure the frequency selected was in a clear channel.
6. Stop the telemetry session initiated by the programmer/controller.
7. Add another signal generator as an additional interfering source with its level and modulation adjusted as in Step 1 above, with its frequency of operation set to F1 as determined in Step 5.
8. Activate the programmer/controller and scan the band. Read out the results of the scan from memory and record the data as a chart of frequency versus amplitude.
9. Initiate a request to open a telemetry channel.
10. Measure and record the frequency the programmer/controller selects as the transmit frequency and record it as frequency, F2. Compare F2 to F1 to insure that they are not the same. Compare F2 to the chart obtained in Step 8 to insure the frequency selected was in one of the four remaining clear channels.
11. Stop the telemetry session initiated by the programmer/controller.
12. Repeat the above process by adding another signal generator as an interference source per Step 7 except the frequency will be adjusted to F2 for a total of 7 interfering signal sources each occupying one individual MICS channel.
13. Continue executing the above procedure checking each additional interfering source is added to insure the programmer/controller initiates a telemetry session on a clear channel until there are no more clear channels available.
14. Continue executing the above procedure by adding an interfering source on the tenth channel (all channels have interfering sources on them). Check to insure the programmer/controller initiates a telemetry session on the channel with the lowest level of measured interference from the programmer/controller's monitoring receiver.

The above process shows the LBT mechanism can measure, store, select available clear channels and avoid channels with interfering ambient signals. The interfering signal levels are representative of the expected ambient levels that will be encountered with the system in use.

**Mini-Circuits ZFSC-8-43**

#	Source
1	HP8640
2	Marconi
3	HP8664A
4	HP8648A 93053
5	HP8648
6	HP3000A
7	HP4430 1311136
8	HP8644B

HP4433B

HP4430-Rack

Mini-Circuits ZFSC-3-4 (a)

S , 2a

9 , 3a

10 , 1a

Sa

HP8591 Spectrum Analyzer

Kay Model 839 Step Attenuator

S_b

2c

Model 2090 (w/ Pass 1 RFT) (D.U.T.)

2d

1d

Mini-Circuits ZFRSC-42 (d)

16dB Pad (10+6)

Sd, 1b

Mini-Circuits ZFRSC-42 (b)

2b, S_c

Mini-Circuits ZFRSC-42 (c)

36dB Pad (20+10+6)

1c

Telemetry C Implant Transceiver w/ Marquis B.B.

TEST RESULTS:

The LBT test was performed according to the above test procedure.
Below, listed in the same numerical order as the test method, are the test results for each test step.

1. RF Signal Generators/interferers were set-up accordingly:
2. Levels were adjusted as shown.

Channel	dBm
1	-45
3	-30
5	-55
7	-65
9	-80

3. The graph shown in Figure 2 below illustrates the information stored by the programmer/controller with the interferer profile input as shown in steps 1 & 2 above.
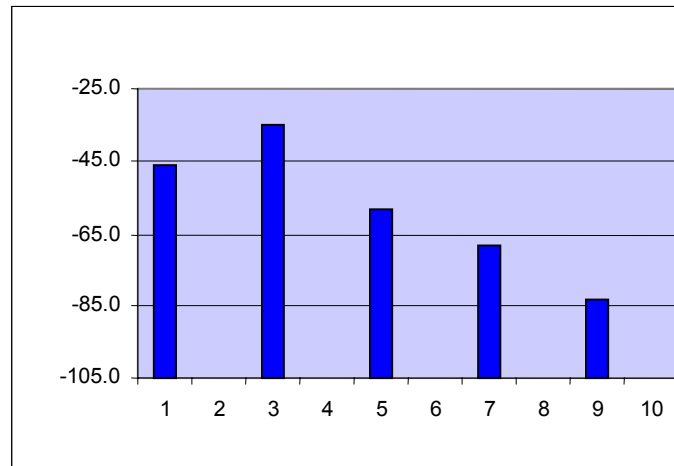
4. A MICS Telemetry session was opened by manual operation of the MICS Programmer/Controller.

5. The Programmer/Controller performed an LBT channel scan and saved the monitored noise levels associated with the channel scan. It then opened a MICS Telemetry Session on Channel 8. The MICS System correctly chose Channel 8 that was an unused/non-interfered channel. (F1 = Channel 8). The MICS Telemetry Session was stopped by manual operation of the Programmer/Controller. The RF signals associated with the session were turned off.

6. A sixth RF interfering signal generator was placed on Channel 8 at a level of –75 dBm.

7. The graph shown below illustrates the information stored by the programmer/controller with the interferer profile input as shown in step 6 above.
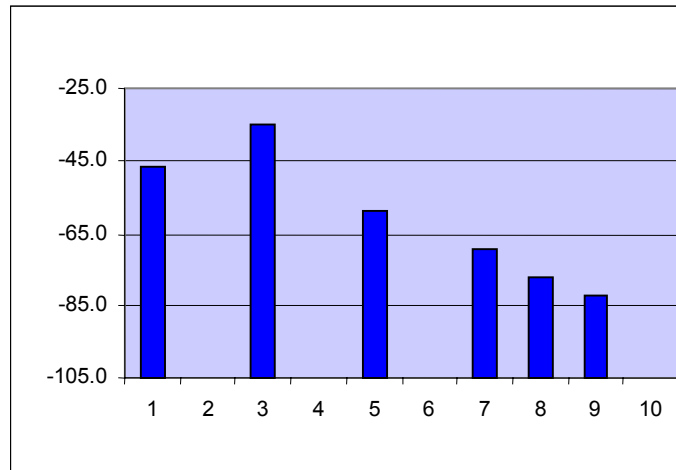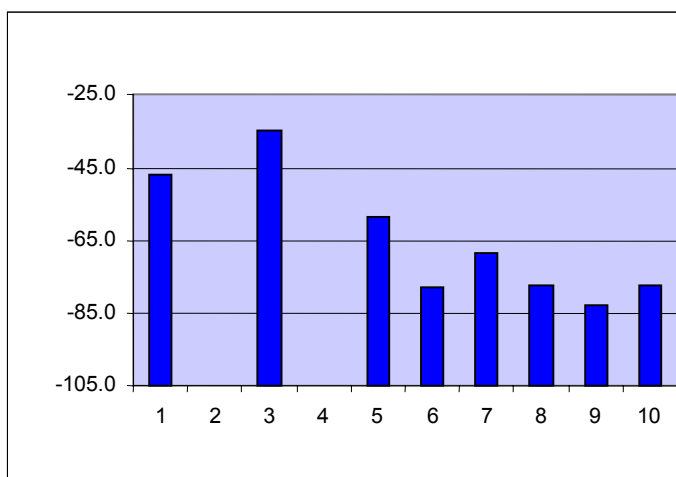
8. A MICS Telemetry session was opened by manual operation of the MICS Programmer/Controller.

9. The Programmer/Controller performed an LBT channel scan, saved the monitored noise levels associated with the channel scan, and then opened a MICS Telemetry Session on Channel 6. The MICS System correctly chose Channel 6 that was an unused/non-interfered channel. (F2 = Channel 6). F2 does not equal F1. This channel choice was also correct.

10. The MICS Telemetry Session was stopped by manual operation of the Programmer/Controller. The RF signals associated with the session stopped.

11. A seventh RF interfering signal generator was placed on Channel 6 at a level of −75 dBm.

12. The graph shown below illustrates the information stored by the programmer/controller with the interferer profile input as shown in step 11 above.
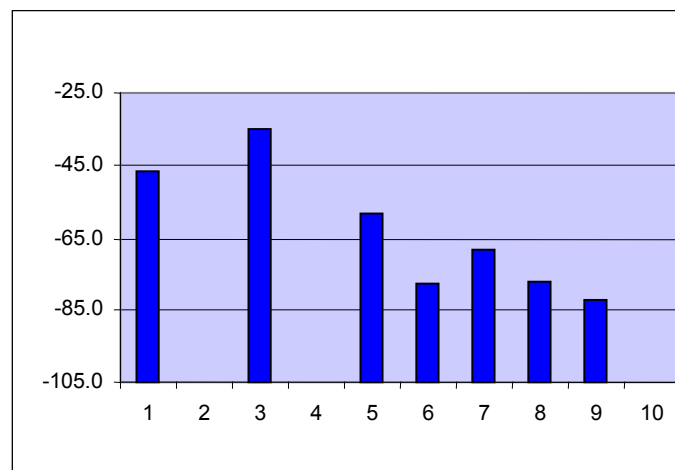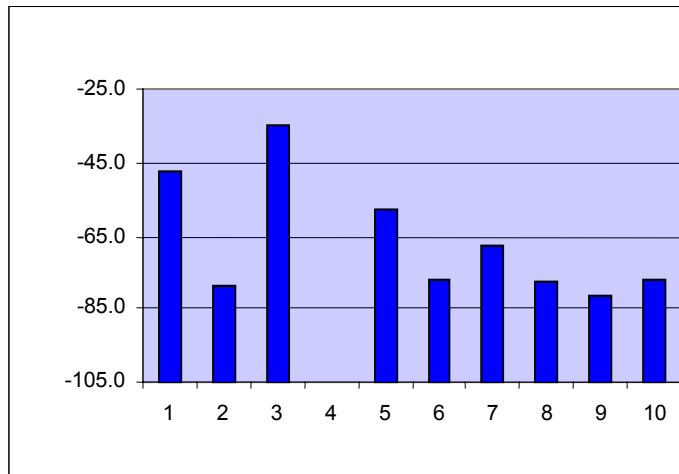

13. A MICS Telemetry session was opened by manual operation of the MICS Programmer/Controller.
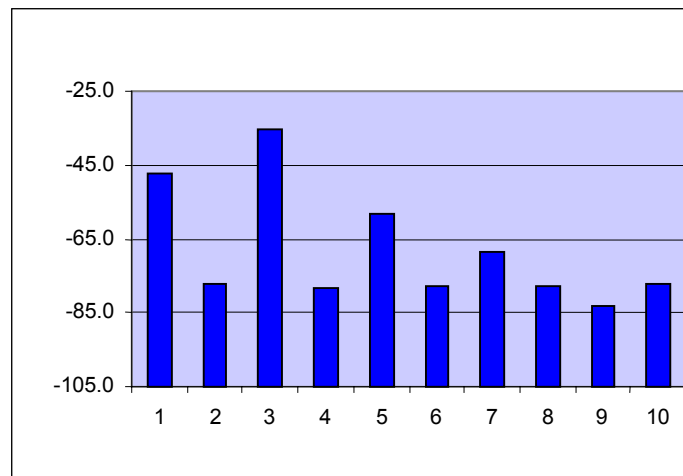
14. The Programmer/Controller performed an LBT channel scan, saved the monitored noise levels associated with the channel scan, and then opened a MICS Telemetry Session on Channel 10. The MICS System correctly chose Channel 10 that was an unused/non-interfered channel. (F3 = Channel 10). F3 does not equal F1 or F2. This channel choice was also correct.

15. The MICS Telemetry Session was stopped by manual operation of the Programmer/Controller. The RF signals associated with the session stopped.

16. An eighth RF interfering signal generator was placed on Channel 10 at a level of −75 dBm.

17. The graph shown below illustrates the information stored by the programmer/controller with the interferer profile input as shown in step 16 above.

18. A MICS Telemetry session was opened by manual operation of the MICS Programmer/Controller.

19. The Programmer/Controller performed an LBT channel scan, saved the monitored noise levels associated with the channel scan, and then opened a MICS Telemetry Session on Channel 2. The MICS System correctly chose Channel 2 that was an unused/non-interfered channel. (F4 = Channel 2). F4 does not equal F1 or F2, or F3. This channel choice was also correct.

20. The MICS Telemetry Session was stopped by manual operation of the Programmer/Controller. The RF signals associated with the session stopped.

21. A ninth RF interfering signal generator was placed on Channel 2 at a level of −75 dBm.

22. The graph shown below illustrates the information stored by the programmer/controller with the interferer profile input as shown in step 21 above.

23. A MICS Telemetry session was opened by manual operation of the MICS Programmer/Controller.

24. The Programmer/Controller performed an LBT channel scan, saved the monitored noise levels associated with the channel scan, and then opened a MICS Telemetry Session on Channel 4. The MICS System correctly chose Channel 4 that was the only remaining unused/non-interfered channel. (F5 = Channel 4). F5 does not equal F1 or F2, F3, or F4. This channel choice was also correct.

25. The MICS Telemetry Session was stopped by manual operation of the Programmer/Controller. The RF signals associated with the session stopped.

26. A tenth RF interfering signal generator was placed on Channel 4 at a level of −75 dBm.

27. The graph shown below illustrates the information stored by the programmer/controller with the interferer profile input as shown in step 26 above.

28. A MICS Telemetry session was opened by manual operation of the MICS Programmer/Controller.

29. The Programmer/Controller performed an LBT channel scan, saved the monitored noise levels associated with the channel scan, and then opened a MICS Telemetry Session on Channel 9. The MICS System

correctly chose Channel 9 because channel 9 was the Least Interfered Channel. This channel choice was also correct.

30. The MICS Telemetry Session was stopped by manual operation of the Programmer/Controller. The RF signals associated with the session stopped.

31. This concludes the MPT Listen Before Talk Test. As seen above, the MICS Programmer/Controller correctly follows the LBT protocol.

CONCLUSIONS

At each step of the procedure, the MICS programmer/controller successfully selected the channel with the lowest ambient signal level. In some cases, the levels in one or more channels were approximately equal with the only difference due to internal system noise and the system was successful in selecting the correct channel for operation. As shown in Steps 26 through 30, when interfering signal generator sources were added to show an environment with numerous high level ambient signals, the LBT mechanism successfully selected the channel with the lowest ambient signal even though the ambient level in an adjacent channel was only 5 dB higher. The operation of the LBT system clearly shows its ability to perform as designed according the LBT protocol specifications proposed by Medtronic.

Monitor System Bandwidth, 95.628(a)(1)

1. Connect circuit as shown in figure 1. Set the signal generators to CW and to each of the 10 channels. Set the RF on the channel 2 generator to –100 dbm at 1d and 2d on the spectrum analyzer. Set the 9 other channels to –97 dbm at 2d and 1d on the spectrum analyzer. Reconnect the spectrum analyzer to point 2b.

2. With the spectrum analyzer set to monitor channel 2, initiate an "open" request on the 2090. The 2090 should transmit on channel 2. Increase the level of the channel 2 signal generator in 1 dB increments until the 2090 transmits on another channel as monitored on the spectrum analyzer.   Record this level as P_A .

3. Repeat this procedure with the channel 2 generator adjusted above and below the center frequency in 10 KHz increments. Record these levels (P_+ & P_-) and the frequency delta from $F_{Ch.2}$ Continue until P_+ & P_- exceed P_A by 20 db. Record these frequency deltas. Then the monitor bandwidth is equal to ΔF_+- ΔF_-. This shall equal or exceed the implant transmit emission bandwidth of 200 KHz.

4. Repeat steps (1), (2), and (3) on channel 9.

Monitor sensitivity, 95.628(a)(3)

1. Connect the circuit as shown in figure 1. Set the signal generators to CW and to each of the 10 channels. Turn the RF level on channel 5 signal generator to –110 dbm at 1d and 2d on the spectrum analyzer. Set the 9 other channels to –105 dbm at 1d and 2d on the spectrum analyzer. Connect the spectrum analyzer back to pt. 2b.

2. Start an "open" sequence and see which channel the 2090 interrogates on. If it comes up on a channel other than 5, increase the 9 off channel generators by 1 db and repeat until the unit comes up 10 consecutive times on channel 5.   Then increase the channel 5 generator in 1 db steps and reinitiate an "open" each time until the unit comes up on a channel other than channel 5. Record the level of the channel 5 generator at 1d and 2d.

3. Repeat steps 1 and 2 on channels 2 and 9. The maximum reading is the monitor sensitivity. This shall be –97dbm or less based on a 200 KHz emission BW and a 0 db gain antenna.

Monitor System Scan cycle time, 95.628(a)(2)

1. Connect the circuit as shown in figure 2. Set the waveform generator to 20 seconds off and 20 seconds on. Set the oscilloscope to single sweep, .2 sec/div and positive trigger. The HP 83732A is used throughout the test to establish the initial channel to open a session since it can be externally pulse modulated.   Set the level of this generator to –30 dbm at 1d and 2d and to

channel 2. Set the remaining generators to the 9 other channels, CW, and –94 dbm (3 db above minimum required sensitivity) at 1d and 2d. During the 20 seconds that the channels 2 generator is gated off establish a session on channel 2 by disconnecting the implant, forcing the 2090 to map the channels, and reconnecting it when the spectrum analyzer shows the 2090 is interrogating on channel 2.   Turn the RF off on the channel 6 generator during this time and reset the single sweep on the scope. When the channel 2 generator is gated-on it will break the session on channel 2 forcing the 2090 to re-map all the channels. With the channel 6 generator off, the session should be re-established on channel 6 which can be monitored on the spectrum analyzer. The time it takes to start this process (break link, re-map, and go to new channel) can be measured on the scope (Tx data on broken link, followed by no implant data, followed by initiate data on the new channel). Record the time from the start of the sweep to the end of the silent period as tp1. Repeat this procedure 10 times on channel 2 & 6 and record the times.

2. Repeat this procedure setting the HP83732A to the 9 other channels using a different channel as the "go to" channel for each set of 10 measurements.   Record all the measurements and the channels used.

3. The longest time is the maximum scan cycle time and shall be less than 5 seconds. This time should be predictable based on the protocol algorithm. Ensure that data is always transmitted once the link is established. This can be seen on the scope and the spectrum analyzer.

# Minimum channel monitoring period and minimum pulse detect time, 95.628(a)(5)

1. Connect the equipment as shown in figure 3 with a 50 Ω termination in place of the 10th generator.

2. Set the 9 generators for pulse operation with a pulse width of 1 msec and with an off period of 9 msec. Set one generator on each channel and one channel with no interfering signal.

3. Set the level of the generators at point 1d and 2d at 6 db above the monitor sensitivity measured previously. Initiate a "discover" on the 2090 followed by an "open" and monitor the spectrum analyzer for the channel on which communications is established. This should be the channel without an interfering signal.

4. Repeat this check 10 times on each channel rotating the open channel through the 10 channels. Communication should always be established on the open channel. If this occurs every time, this is sufficient to establish that the unit detects 1 msec pulses and dwells on each channel at least 10 msec.

Protocol Test Block Diagram   FIGURE 1
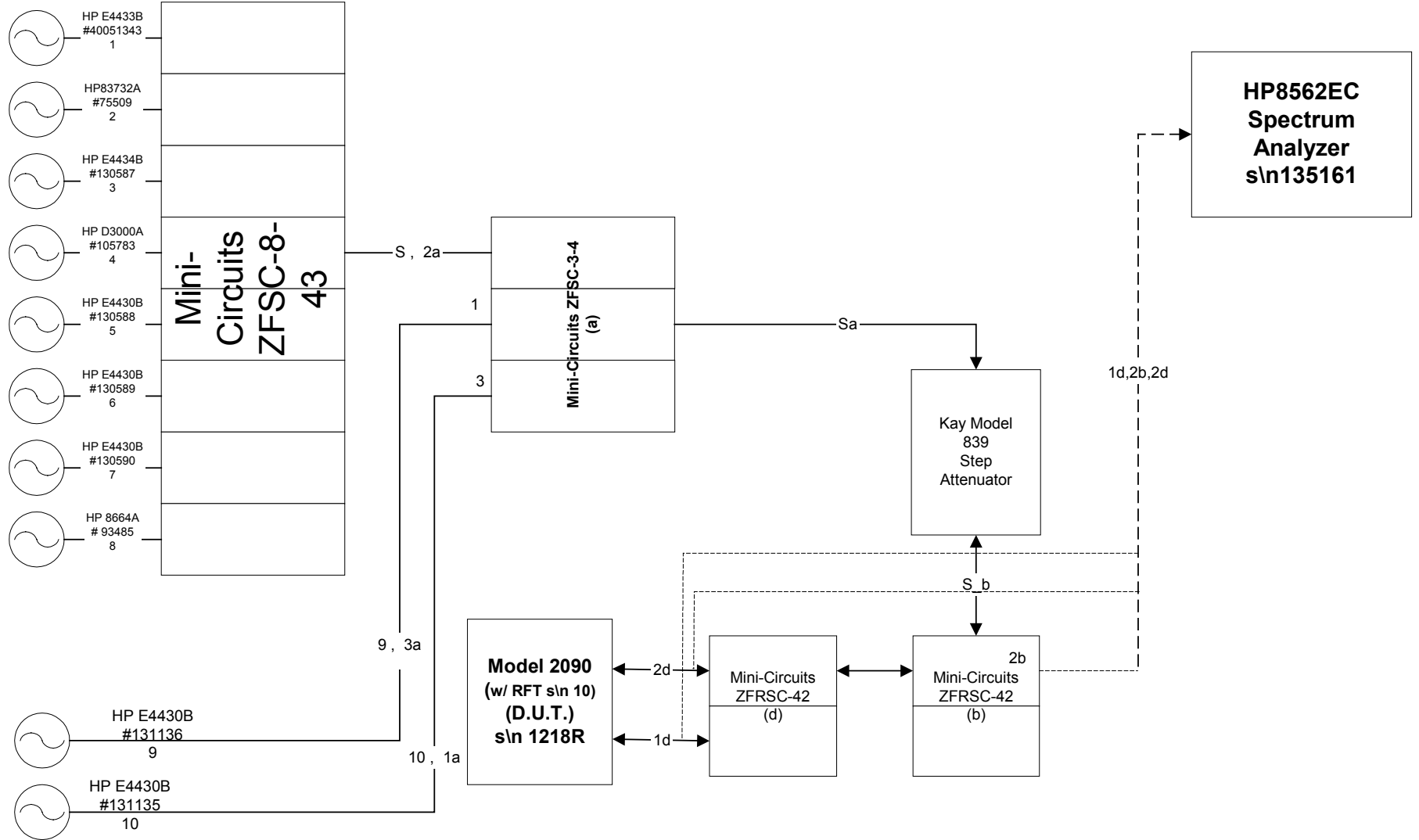
Note 2 : Freq.1 = 402.150 MHz, F2=402.450MHz, F3=402.750MHz, F4=403.050MHz, F5=403.350MHz, F6=403.650MHz, F7=403.950MHz, F8=404.250, F9=404.550, F10=404.850MHz
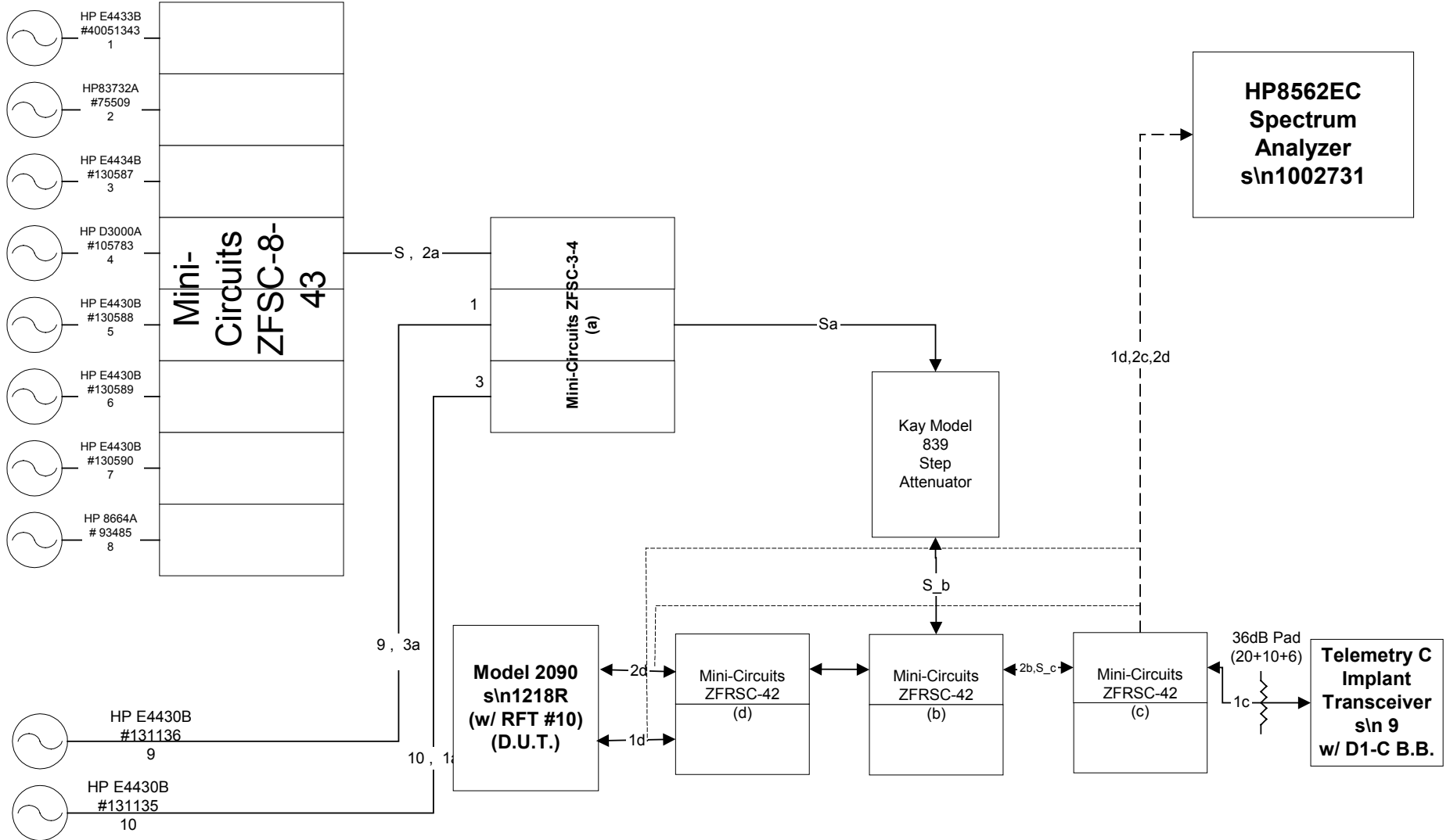
Protocol Test Block Diagram   FIGURE 2
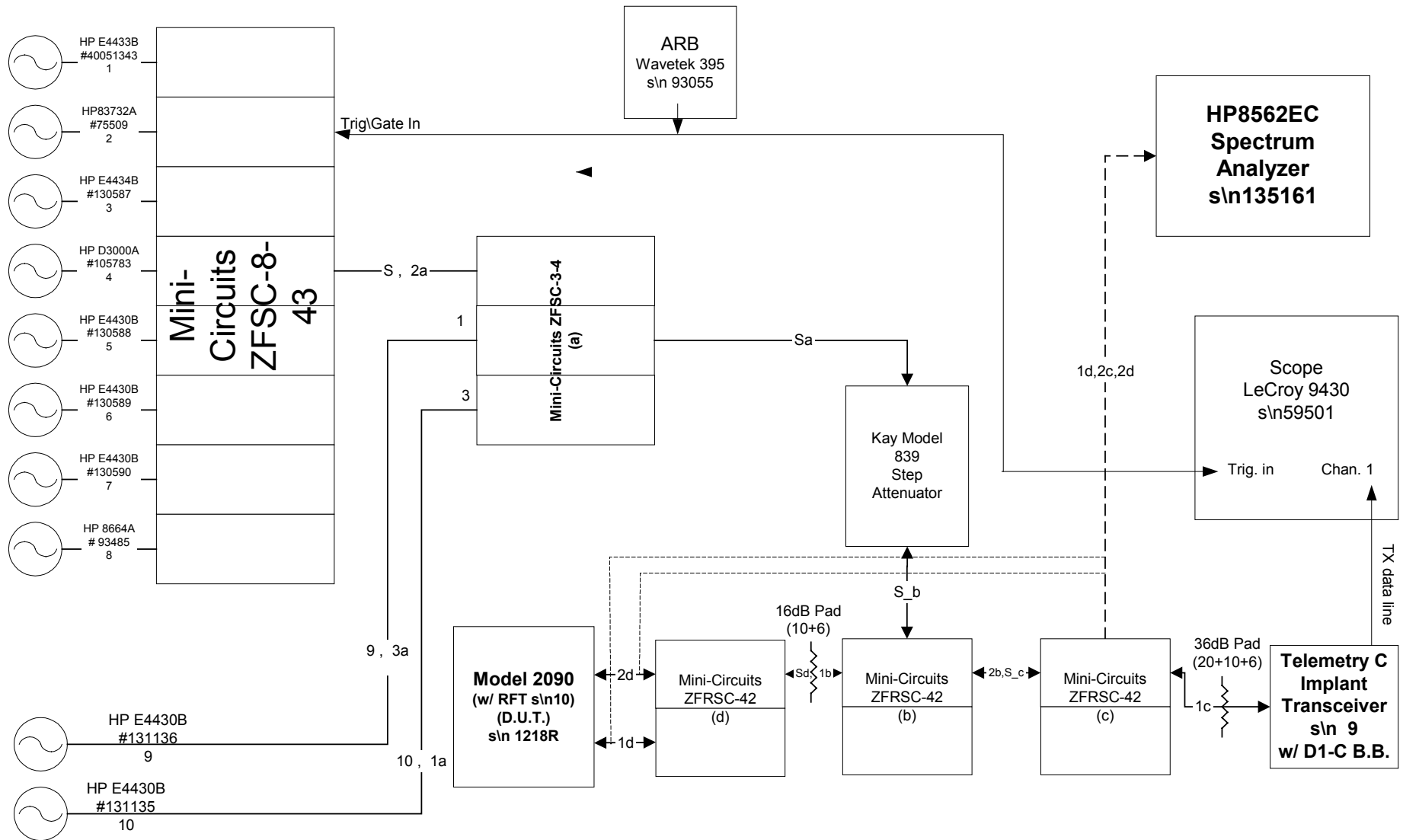
Note 1 : Mini-Circuits ZFSC-8-43 is an 1:8 Reactive Power Splitter/Combiner (10dB Splitting Loss), Mini-Circuits ZFSC-3-4 is a 1:3 Reactive Power Splitter/Combiner (5.5dB Splitting Loss), and Mini-Circuits ZFRSC-42 is a Resistive 3 port Power Splitter/Combiner (6.0 dB Splitting Loss).

Note 2 : Freq.1 = 402.150 MHz, F2=402.450MHz, F3=402.750MHz, F4=403.050MHz, F5=403.350MHz, F6=403.650MHz, F7=403.950MHz, F8=404.250, F9=404.550, F10=404.850MHz (Each RF Generator is modulated with 50KHz FM Deviation at a 1KHz Sinusoidal Rate).

Protocol Test Block Diagram   FIGURE 3

Note 1 : Mini-Circuits ZFSC-8-43 is an 1:8 Reactive Power Splitter/Combiner (10dB Splitting Loss), Mini-Circuits ZFSC-3-4 is a 1:3 Reactive Power Splitter/Combiner (5.5dB Splitting Loss), and Mini-Circuits ZFRSC-42 is a Resistive 3 port Power Splitter/Combiner (6.0 dB Splitting Loss).

Note 2 : Freq.1 = 402.150 MHz, F2=402.450MHz, F3=402.750MHz, F4=403.050MHz, F5=403.350MHz, F6=403.650MHz, F7=403.950MHz, F8=404.250, F9=404.550, F10=404.850MHz

FCC Protocol Testing
Equipment and Path losses

Sig. Gen #	HP\Agilent Model #	S\N #		Channel #	Chan. Freq. MHz.
1	E4433B	40051343		1	402.15
2	83732A	75509		2	402.45
3	E4434B	130587		3	402.75
4	D3000A	105783		4	403.05
5	E4430B	130588		5	403.35
6	E4430B	130589		6	403.65
7	E4430B	130590		7	403.95
8	8664A	93485		8	404.25
9	E4430B	131136		9	404.55
10	E4430B	131135		10	404.85

Settings with Path Loss:

Sig. Gen #	Path Loss dBm	(-94 dBm) (@ 1d & 2d) dBm	(-97 dBm) (@ 1d & 2d) dBm	(-100 dBm) (@ 1d & 2d) dBm	(-105 dBm) (@ 1d & 2d) dBm	(-110 dBm) (@ 1d & 2d) dBm
1	29.6	-64.4	-67.4	-70.4	-75.4	-80.4
2	29.1	-64.9	-67.9	-70.9	-75.9	-80.9
3	28.8	-65.2	-68.2	-71.2	-76.2	-81.2
4	28.7	-65.3	-68.3	-71.3	-76.3	-81.3
5	28.5	-65.5	-68.5	-71.5	-76.5	-81.5
6	28.6	-65.4	-68.4	-71.4	-76.4	-81.4
7	28.6	-65.4	-68.4	-71.4	-76.4	-81.4
8	28.8	-65.2	-68.2	-71.2	-76.2	-81.2
9	18.5	-75.5	-78.5	-81.5	-86.5	-91.5
10	18.6	-75.4	-78.4	-81.4	-86.4	-91.4

Additional Equip. used:

Model	Type	S\N
Wavetek 395	ARB	93055
HP 8562EC	Spec. Ana	135161
Medtronic 2090	Programmer.	1218R
Medtronic D1-C Sys.	Transceiver	9
LeCroy 9430	Scope	59501

LBT Protocol Testing 2090 Operating Modes

The following operating sequences were investigated:
1. Discover with no implant present
2. Discover with implants(s) present and no open request
3. Discover with implant present, open request, and blocked communication
4. Discover, implant present, open request, response
5. Discover, implant present, open request, link established, session broken
6. Discover, implant present, normal session

Some of these six items were specifically tested to FCC requirements. These six items were also tested in various combinations to see if either unexpected or undesirable results might occur. The results are listed in the following paragraphs.

1. Discover with no implant present: The 2090 maps all channels, interrogates on the LIC channel asking implants to respond with ID on that channel. 2090 then listens for response, remaps all channels and again interrogates on the LIC channel. This continues with the unit mapping, interrogating and listening. This discontinues after approximately one minute if there are no responses. This time is set in the application level of the 2090.

2. Discover, implant present, no open request: 2090 interrogates and listens as noted in (1.) and if the operator makes no open request it discontinues after approximately one minute.

3. Discover, implant present, open request, and blocked channel or no response: 2090 interrogates on previous mapped LIC channel, waits for a response, then remaps and interrogates on the LIC channel, and listens for response. This continues until a time set in the application software expires. This is presently about 2 hours.

4. Discover, implant present, open request, implant responds: 2 way communication established on previously mapped LIC channel, and continues until data transfer complete or session is broken.

5. Discover, implant present, open request, link established, session broken: Initially as in (4). When session is broken, the 2090 remaps in less than 2 seconds as data shows. It then interrogates on LIC channel, listens for response. This cycle continues until application level software times out in approximately 2 hours.

6. Discover, implant present, open request, normal session: Same as (4). Session terminated on completion of data transfer.

Chan 2 402.45MHz

| F Ch +( )KHz	dBm	F Ch -( )KHz	dBm
0	-97	0	-97
10	-96	-10	-98
20	-96	-20	-98
30	-94	-30	-94
40	-95	-40	-96
50	-95	-50	-95
60	-95	-60	-94
70	-96	-70	-94
80	-96	-80	-94
90	-95	-90	-93
100	-94	-100	-94
110	-93	-110	-94
120	-90	-120	-92
130	-88	-130	-91
140	-85	-140	-91
150	-83	-150	-87
160	-80	-160	-85
170	-75	-170	-82
180	-67	-180	-80
190		-190	-79
200		-200	-75

SYSTEM BW

BW=195+165=360KHz>200KHz Required

Protocol_Chan2A_BW.xls
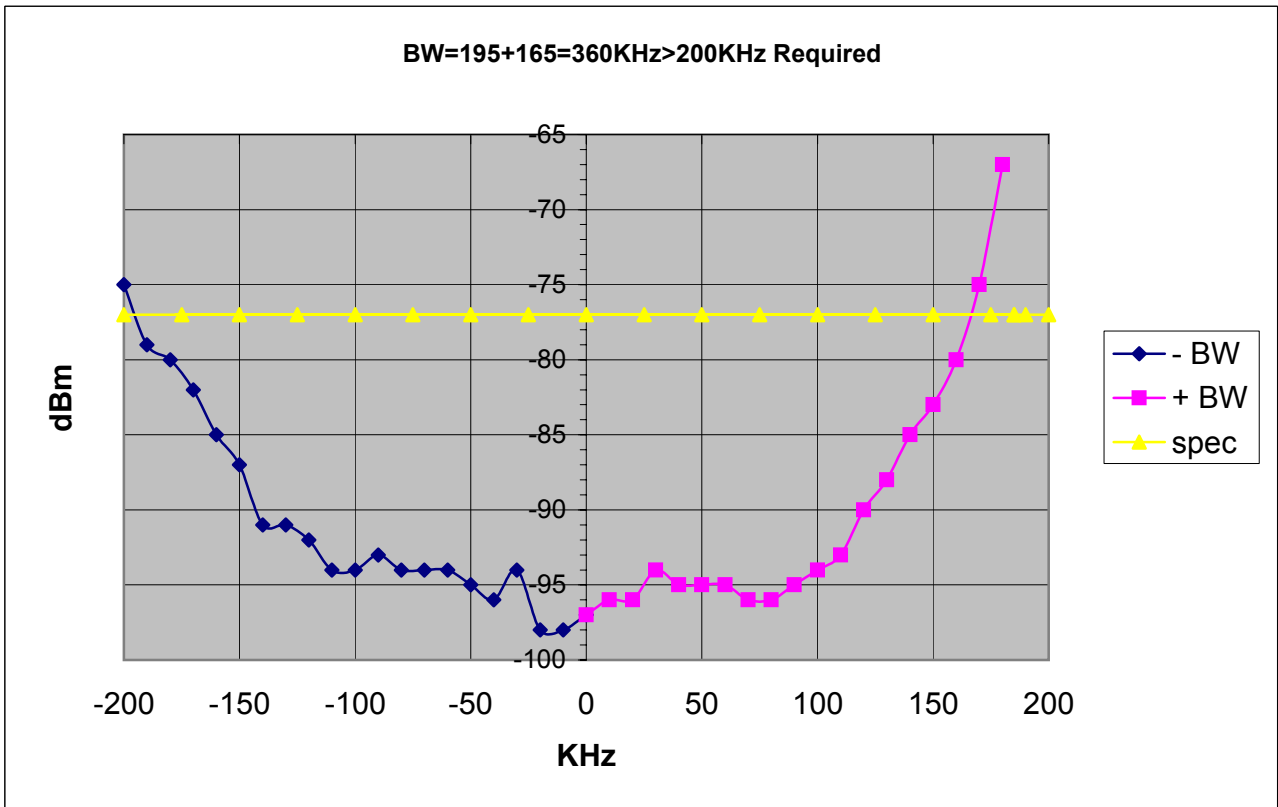
Chan 9 404.55MHz

PA=-97dBm@F Ch

F Ch +( )KHz	dBm	F Ch -( )KHz	dBm
0	-97	0	-97
10	-95	-10	-96
20	-94	-20	-96
30	-93	-30	-96
40	-94	-40	-94
50	-94	-50	-94
60	-94	-60	-94
70	-96	-70	-94
80	-95	-80	-92
90	-96	-90	-93
100	-93	-100	-91
110	-91	-110	-92
120	-89	-120	-92
130	-89	-130	-93
140	-86	-140	-90
150	-84	-150	-88
160	-79	-160	-86
170	-75	-170	-82
180		-180	-81
190		-190	-77
200		-200	-75

SYSTEM BW

BW=190+165=355KHz>200KHz Required
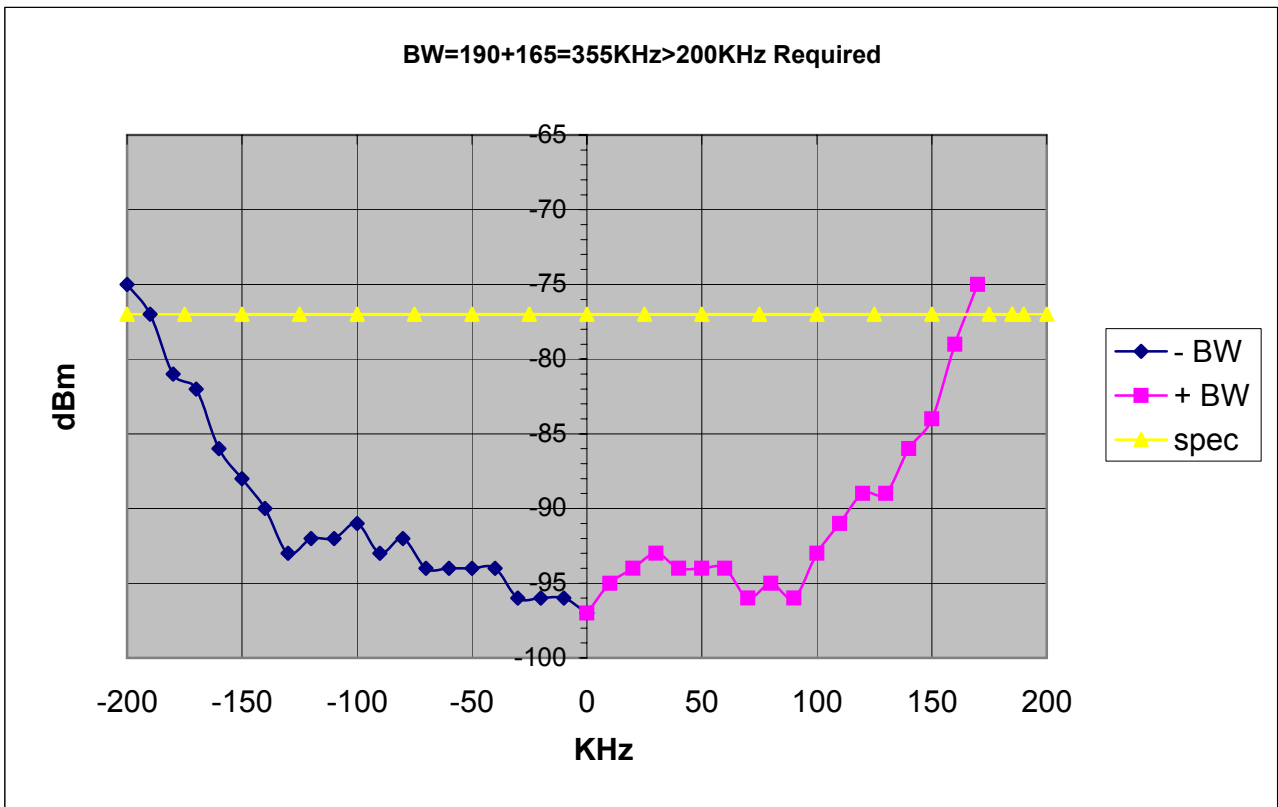
Monitor sensitivity

1. Connect the circuit as shown in figure 1. Set the signal generators to CW and to each of the 10 channels. Turn the RF level on channel 5 signal generator to –110 dbm at 1d and 2d on the spectrum analyzer. Set the 9 other channels to –105 dbm at 1d and 2d on the spectrum analyzer. Connect the spectrum analyzer back to pt. 2b.

2. Start an "open" sequence and see which channel the 2090 interrogates on. If it comes up on a channel other than 5, increase the 9 off channel generators by 1 db and repeat until the unit comes up 10 consecutive times on channel 5.   Then increase the channel 5 generator in 1 db steps and reinitiate an "open" each time until the unit comes up on a channel other than channel 5. Record the level of the channel 5 generator at 1d and 2d.

3. Repeat steps 1 and 2 on channels 2 and 9. The maximum reading is the monitor sensitivity. This shall be –97dbm or less based on a 200 KHz emission BW and a 0 db gain antenna.

Results:

Chan. #	Sensitivity dBm
Chan 5	-105
Chan 2	-105
Chan 9	-104

Scan Cycle Time

(see previous page forTest Descriptions)

Gated Cha	6			Gated Cha	6	
Off Chan.	2			Off Chan.	3	
Test #	T1 (sec.)	T2 (Sec.)		Test #	T1 (sec.)	T2 (Sec.)
1	0.536	1.42		1	0.536	1.26
2	0.481	0.918		2	0.476	0.95
3	0.459	1.59		3	0.516	1.12
4	0.504	1.32		4	0.472	1.15
5	0.477	1.57		5	*0.52*	*1.61*
6	0.49	1.39		6	0.504	1.3
7	0.452	1.16		7	0.524	1.1
8	0.504	1.31		8	0.48	1.17
9	0.528	0.944		9	0.532	1.02
10	0.476	1.44		10	0.472	0.95
11	*0.514*	*1.6*				
Gated Cha	1			Gated Cha	9	
Off Chan.	7			Off Chan.	2	
Test #	T1 (sec.)	T2 (Sec.)		Test #	T1 (sec.)	T2 (Sec.)
1	0.508	1.435		1	0.52	0.95
2	0.475	0.922		2	0.54	1.03
3	0.495	1.67		3	0.46	1.09
4	0.501	1.526		4	0.47	1.36
5	*0.551*	*1.727*		5	0.52	1.43
6	0.487	0.871		6	0.52	1.31
7	0.463	1.53		7	0.51	1.45
8	0.488	1.49		8	*0.46*	*1.57*
9	0.439	0.954		9	0.509	1.24
10	0.489	1.67		10	0.516	1.33
Gated Cha	3			Gated Cha	8	
Off Chan.	5			Off Chan.	1	
Test #	T1 (sec.)	T2 (Sec.)		Test #	T1 (sec.)	T2 (Sec.)
1	*0.499*	*1.67*		1	0.479	1.56
2	0.511	1.31		2	0.524	1.04
3	0.477	1.42		3	*0.507*	*1.66*
4	0.539	0.971		4	0.54	1.54
5	0.499	1.36		5	0.51	1.49
6	0.539	1.15		6	0.52	1.01
7	0.507	1.19		7	0.543	1.53
8	0.523	1.1		8	0.496	1.12
9	0.519	1.09		9	0.508	1.03
10	0.48	1.18		10	0.5	1.18
Gated Cha	4			Gated Cha	7	
Off Chan.	8			Off Chan.	10	

Test #	T1 (sec.)	T2 (Sec.)		Test #	T1 (sec.)	T2 (Sec.)
1	0.486	1.23		1	*0.54*	*1.47*
2	0.495	1.22		2	0.46	1.45
3	0.479	0.859		3	0.46	1.39
4	0.474	0.894		4	0.51	1.33
5	*0.533*	*1.71*		5	0.494	1.36
6	0.495	1.7		6	0.465	1.12
7	0.513	0.946		7	0.511	1.3
8	0.495	1.26		8	0.464	1.03
9	0.512	1.16		9	0.466	1.27
10	0.51	1.67		10	0.486	1.34
Gated Cha	**5**			Gated Cha	**10**	
Off Chan.	**4**			Off Chan.	**9**	
Test #	T1 (sec.)	T2 (Sec.)		Test #	T1 (sec.)	T2 (Sec.)
1	0.479	1.53		1	0.477	1.22
2	0.481	1.53		2	0.482	0.95
3	0.496	0.969		3	*0.491*	*1.81 ***
4	0.485	0.885		4	0.487	0.96
5	0.487	1.19		5	0.538	1.12
6	0.55	1.52		6	0.52	1.77
7	0.484	1.42		7	0.483	1.67
8	*0.483*	*1.59*		8	0.48	1.46
9	0.495	1.16		9	0.466	1.31
10	0.535	0.962		10	0.517	1.31

*Note: Longest time to map and interrogate on the "off" Channel is 1.81Sec.

This occured when Channel 10 was the "Gated " channel and Channel 9 was the off channel

Minimum channel monitoring period and minimum pulse detect time

1. Connect the equipment as shown in figure 3 with a 50 Ω termination in place of the 10th generator.

2. Set the 9 generators for pulse operation with a pulse width of 1 msec and with an off period of 9 msec. Set one generator on each channel and one channel with no interfering signal.

3. Set the level of the generators at point 1d and 2d at 6 db above the monitor sensitivity measured previously. Initiate a "discover" on the 2090 followed by an "open" and monitor the spectrum analyzer for the channel on which communications is established. This should be the channel without an interfering signal. The "discover" mode is tested here to ensure all modes operate properly. The "discover" mode is similar to the "open" mode in that the 2090 maps all channels, and then sends out a message on the least interfered channel. The difference is that in "discover" the 2090 requests any implant in the area send back its ID and the 2090 then sits on the channel listening for responses. The "discover" request is repeated intermittently after each remapping for an amount of time set in the application software.

4. Repeat this check 10 times on each channel rotating the open channel through the 10 channels. Communication should always be established on the open channel. If this occurs every time, this is sufficient to establish that the unit detects 1 msec pulses and dwells on each channel at least 10 msec.

Results:

Chan. #	Tests	Pass	Fail
Chan 8	10	10	0
Chan 9	10	10	0
Chan 10	10	10	0
Chan 1	10	10	0
Chan 2	10	10	0
Chan 3	10	10	0
Chan 4	10	10	0
Chan 5	10	10	0
Chan 6	10	10	0
Chan 7	10	10	0
Total	100	100	0