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WHITE PAPER

Selecting the right radio test set can save you 77%

2nd Edition

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Whether you are investing in a new radio test set or service monitor to handle today's new digital radio technologies or looking to boost productivity with automated test features, not all test sets are created equal. When investing in a system to test P25, P25 Phase 2, DMR, NXDN or dPMR radios, understanding the capabilities of the system that you are investing in is critical to maximizing the return on your sizeable investment. When evaluating the capabilities of automated digital capable test systems, there are a few questions you need to ask first:

1. What is the actual time difference between different manufacturers offered automated tests?
2. The accuracy of test set overall.
3. What do the automated tests offer for radio types? Does the automated test suite cover all the radios you intend to test?
4. Do the automated tests cover all the required tests, alignments and documenta tion required to verify the radio's operation?
5. Are the automated test suites fully approved by the radio OEM?

In addition to the automated tests, there are other questions you should ask regarding the capabilities of the test set, particularly how it will impact the following:

1. Radio system coverage of your LMR radio system.
2. The accuracy of test set overall.
3. The portability and use of the test set for most applications where you need to test the entire radio system. This includes user interaction and ease of use of the instrument.

For those of us that are technically oriented, we sometimes get lost in the specifications and how the system operates, which is important. We need to remember, however, that our financial managers will be looking to maximize the return on a capital investment that could otherwise be spent on other operational equipment, such as vehicles or other test equipment requirements.

TIME DIFFERENCE IN THE AUTOMATED TEST MODE

When it comes to automated testing, not every service monitor or radio test set is created equal. When we look at the amount of time that a test system takes to perform an automated test, there are clear areas that we need to evaluate. This includes the amount of time to perform the test, how much technical supervision is required during the test and any required interaction during the automated test process.

The amount of time taken to perform each aspect of the test is very important. This includes how much time is spent on the actual physical measurement parameters, such as power, RF error, modulation and receiver sensitivity. This is especially important when looking at multiband or multimode radios, like the new Motorola APX series, the Harris XL200P or the NX-5000 from Kenwood. Let's see how two common test systems compare in this aspect looking at the popular Motorola radios. We'll start with a basic XTS-5000 portable test results from a Viavi 8800SX Radio Test Instrument:

```
--------------------------------------------------------------------------------
                          Aeroflex Auto Test
--------------------------------------------------------------------------------
Date/Time          : 03282018-115538
Unit Type          : 8800SX
Frequency Ref      : Internal
Serial Number      : 1002000934
Unit Version       : 2.2.1 2
Core Version       : 2.0.6
Radio Script       : Motorola ASTRO 25
Script Version     : 1.17
Model-Band Select  : P VHF
Menu Select        : Align & Test

Model Number  : H18KEH9PW7AN           Firmware : 12.00.17
Serial Number : 123AER0003                  DSP : 12.00.05
CPS           : 0019                 Bootloader : 03.50.00
Secure        : 05.05.03                 Tuning : C527
UCM           : R050503

Radio Information (0:03): PASS
```

Reference Oscillator

Freq(MHz)	bspv	espv	Lower Limit(Hz)	Reading(Hz)	Upper Limit(Hz)	
173.975	375	375	-50.00	-9.00	50.00	PASS

Tx High Power : Cable Loss = -0.24 dB

Freq(MHz)	bspv	espv	Lower Limit(W)	Reading(W)	Upper Limit(W)	
136.025	83	83	6.15	6.33	6.45	PASS
142.125	85	85	6.15	6.24	6.45	PASS
154.225	77	77	6.15	6.20	6.45	PASS
160.125	72	72	6.15	6.29	6.45	PASS
168.075	65	65	6.15	6.28	6.45	PASS
173.975	61	61	6.15	6.26	6.45	PASS

Tx High Power (0:15): PASS

Tx Low Power : Cable Loss = -0.24 dB

Freq(MHz)	bspv	espv	Lower Limit(W)	Reading(W)	Upper Limit(W)	
136.025	45	45	2.10	2.19	2.30	PASS
142.125	47	47	2.10	2.25	2.30	PASS
154.225	41	41	2.10	2.16	2.30	PASS
160.125	38	38	2.10	2.17	2.30	PASS
168.075	34	34	2.10	2.15	2.30	PASS
173.975	32	32	2.10	2.16	2.30	PASS

Tx Low Power (0:15): PASS

Deviation Balance

Difference < 2.0

Freq(MHz)	bspv	espv	Target(kHz)	Reading(kHz)	Diff(%)	
136.025	35	35	3616.00	3631.00	0.4	PASS
142.125	40	41	3619.00	3663.00	1.2	PASS
154.225	40	40	3614.00	3583.00	0.9	PASS
160.125	37	37	3614.00	3571.00	1.2	PASS
168.075	35	35	3614.00	3643.00	0.8	PASS
173.975	35	35	3514.00	3482.00	0.9	PASS

Deviation Balance (0:56): PASS

Deviation Limiting

Freq(MHz)	bspv	espv	Lower Limit(kHz)	Reading(kHz)	Upper Limit(kHz)	
136.025	17581	17581	2780.00	2838.00	2880.00	PASS
142.125	17716	17164	2780.00	2808.67	2880.00	PASS
154.225	17478	17478	2780.00	2830.33	2880.00	PASS
160.125	17502	17502	2780.00	2834.33	2880.00	PASS
168.075	17279	17279	2780.00	2822.00	2880.00	PASS
173.975	17568	17568	2780.00	2843.33	2880.00	PASS

Deviation Limiting (0:50): PASS

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Tx Para metrics

Modulation Fidelity

Freq(MHz)	Lower Limit(%)	Reading(%)	Upper Limit(%)	
136.025	0.10	1.13	5.00	PASS
142.125	0.10	0.86	5.00	PASS
154.225	0.10	1.08	5.00	PASS
160.125	0.10	1.06	5.00	PASS
168.075	0.10	0.99	5.00	PASS
173.975	0.10	1.02	5.00	PASS

Symbol Deviation

Freq(MHz)	Lower Limit(Hz)	Reading(Hz)	Upper Limit(Hz)	
136.025	1620.00	1837.03	1980.00	PASS
142.125	1620.00	1810.40	1980.00	PASS
154.225	1620.00	1824.41	1980.00	PASS
160.125	1620.00	1827.24	1980.00	PASS
168.075	1620.00	1818.28	1980.00	PASS
173.975	1620.00	1833.40	1980.00	PASS

Tx Parametrics (0:39): PASS

Rx BER

Freq(MHz)	Lvl(dBm)	BitError	BER(%)	Upper Limit(%)	
136.075	-116	37	0.087	5	PASS
142.075	-116	28	0.058	5	PASS
154.275	-116	26	0.058	5	PASS
160.175	-116	24	0.058	5	PASS
168.125	-116	42	0.116	5	PASS
173.925	-116	54	0.145	5	PASS

Rx BER (1:15): PASS

Radio Information	: PASS
Reference Oscillator	: PASS
Rx Front End	: SKIP
Tx High Power	: PASS
Tx Mid Power	: SKIP
Tx Low Power	: PASS
Deviation Balance	: PASS
Deviation Limiting	: PASS
Tx Parametrics	: PASS
Rx BER	: PASS

Time Taken: 5:12

Now let's compare it with the Freedom R8X00 Auto Test. You will probably notice that there are some items missing on the test report compared to the Viavi 8800SX test.

Test Result Report

Model #: H18KEH9PW7AN   Date/Time: 3/28/2018 10:48 AM
Serial #: 123AER0003   Operator ID: 0147

Info:

Reference Frequency Align

Result	Frequency	Freq Error	Min Limit	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	20 Hz	-348 Hz	348 Hz	377	377

TX Power Out Align High

Result	Frequency	Power Out	Min Limit	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	6.3 W	6.2 W	6.4 W	59	61
Pass	168.0750 MHz	6.3 W	6.2 W	6.4 W	63	65
Pass	160.1250 MHz	6.3 W	6.2 W	6.4 W	70	71
Pass	154.2250 MHz	6.4 W	6.2 W	6.4 W	75	101
Fail	142.1250 MHz	5.9 W	6.2 W	6.4 W	82	82
Pass	136.0250 MHz	6.2 W	6.2 W	6.4 W	80	104

TX Power Out Align Low

Result	Frequency	Power Out	Min Limit	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	1.4 W	1.2 W	1.4 W	32	24
Pass	168.0750 MHz	1.3 W	1.2 W	1.4 W	34	25
Pass	160.1250 MHz	1.2 W	1.2 W	1.4 W	38	26
Pass	154.2250 MHz	1.2 W	1.2 W	1.4 W	41	28
Pass	142.1250 MHz	1.3 W	1.2 W	1.4 W	44	33
Pass	136.0250 MHz	1.3 W	1.2 W	1.4 W	44	33

Deviation Balance Align

Result	Frequency	Variance	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	1.5 %	+/-1.5 %	35	36
Pass	168.0750 MHz	0.6 %	+/-1.5 %	34	35
Pass	160.1250 MHz	-1.3 %	+/-1.5 %	37	37
Pass	154.2250 MHz	-1.4 %	+/-1.5 %	40	40
Pass	142.1250 MHz	1.5 %	+/-1.5 %	40	41
Pass	136.0250 MHz	0.1 %	+/-1.5 %	35	35

TX Power Out Align Low

Result	Frequency	Power Out	Min Limit	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	1.4 W	1.2 W	1.4 W	32	24
Pass	168.0750 MHz	1.3 W	1.2 W	1.4 W	34	25
Pass	160.1250 MHz	1.2 W	1.2 W	1.4 W	38	26
Pass	154.2250 MHz	1.2 W	1.2 W	1.4 W	41	28
Pass	142.1250 MHz	1.3 W	1.2 W	1.4 W	44	33
Pass	136.0250 MHz	1.3 W	1.2 W	1.4 W	44	33

Deviation Balance Align

Result	Frequency	Variance	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	1.5 %	+/-1.5 %	35	36
Pass	168.0750 MHz	0.6 %	+/-1.5 %	34	35
Pass	160.1250 MHz	-1.3 %	+/-1.5 %	37	37
Pass	154.2250 MHz	-1.4 %	+/-1.5 %	40	40
Pass	142.1250 MHz	1.5 %	+/-1.5 %	40	41
Pass	136.0250 MHz	0.1 %	+/-1.5 %	35	35

Deviation Limit Align

Result	Frequency	Deviation	Min Limit	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	2.823 kHz	2.780 kHz	2.880 kHz	17463	17079
Pass	168.0750 MHz	2.827 kHz	2.780 kHz	2.880 kHz	17343	17279
Pass	160.1250 MHz	2.842 kHz	2.780 kHz	2.880 kHz	17310	17502
Pass	154.2250 MHz	2.836 kHz	2.780 kHz	2.880 kHz	17414	17478
Pass	142.1250 MHz	2.827 kHz	2.780 kHz	2.880 kHz	17359	17231
Pass	136.0250 MHz	2.836 kHz	2.780 kHz	2.880 kHz	17453	17581

Distortion Test

Result	Frequency	Distortion	Max Limit
Pass	136.0750 MHz	1.4 %	3.0 %

Sensitivity (SINAD) Test

Result	Frequency	12dB SINAD	Max Limit
Pass	136.0750 MHz	-123.2 dBm	-116.0 dBm

Noise Squelch Threshold Test

Result	Frequency	Unsquelch	Max Limit
Pass	136.0750 MHz	-123.0 dBm	-119.0 dBm

Modulation Fidelity

Result	Frequency	Mod Fidelity	Max Limit
Pass	136.0250 MHz	1.3 %	5 %
Pass	142.1250 MHz	1.1 %	5 %
Pass	154.2250 MHz	1.0 %	5 %
Pass	160.1250 MHz	0.7 %	5 %
Fail	168.0750 MHz	34.8 %	5 %
Fail	173.9750 MHz	33.1 %	5 %

Symbol Deviation

Result	Frequency	Symbol Dev	Min Limit	Max Limit
Pass	136.0250 MHz	1826.0 Hz	1620 Hz	1980 Hz
Pass	142.1250 MHz	1809.6 Hz	1620 Hz	1980 Hz
Pass	154.2250 MHz	1817.9 Hz	1620 Hz	1980 Hz
Pass	160.1250 MHz	1816.7 Hz	1620 Hz	1980 Hz
Fail	168.0750 MHz	2637.6 Hz	1620 Hz	1980 Hz
Fail	173.9750 MHz	2862.1 Hz	1620 Hz	1980 Hz

Digital Sensitivity (BER) Test

Result	Frequency	5% BER	Max Limit
Pass	136.0750 MHz	-122.4 dBm	-116.0 dBm

Internal Voice Modulation Test

Result	Frequency	Deviation	Min Limit	Max Limit
Fail	136.0250 MHz	22.597 kHz	3.600 kHz	5.000 kHz

External Voice Modulation Test

Result	Frequency	Deviation	Min Limit	Max Limit
Pass	136.0250 MHz	4.508 kHz	3.800 kHz	5.000 kHz

You'll note that the other test equipment results do not show the actual time taken. The actual time for this test was over 17 minutes compared to 5 minutes, 12 seconds (or 5.2 minutes) on the Aeroflex 8800SX, or 327% longer to perform these tests. These test were performed in a lab environment; however, we encourage you to do your own comparisons.

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Another aspect of the automated test that needs to be understood is the human interaction required to do the test. For example, when testing Motorola APX Dual-Band Mobiles, with two ports (low-band and high-band), the other unit requires that for each type of alignment and test conducted during the automated process, the user has to swap the test cable from one port to the other for each alignment and test frequency, requiring the user to change the cable ports a minimum of 9 times during the course of the automated alignment and test. The Viavi 8800SX, on the other hand, does each band sequentially, requiring only one cable change during the test.

From the other available test equipment APX Auto Test Manual:

"Dual-Band: Dual Band equipped radios have two RF connectors at the rear of the radio. They are labeled on the top and on the rear of the radio to identify which band they should be used with. During most tests and alignments, it will be necessary to change the test setup cabling to test both bands. The test operator will be prompted to connect the RF cable to the appropriate RF Output port on the radio.

Dual-Band: This alignment is performed consecutively for all test frequencies in both bands."

THE ACCURACY OF TEST SET

Whether you are using the radio test set to perform an automated test or using it in a manual mode, the primary reason to use any type of test instrument is to precisely test the performance of the device under test. The ability of the test set to accomplish this is based on its ability to perform the test both repeatably and accurately. Repeatability means that the instrument performs the test the same way, with the same results every time.

With this in mind, let's look again at the test results from the other test set. We'll start with the TX Power Out Align High test. You'll notice that at 142.125 MHz, this unit measures the power out at 5.9 Watts versus the other frequencies that measure from 6.2 to 6.4 Watts. When compared to the Viavi 8800SX, the same frequency of 142.125MHz had power measured at 6.24 W. This could be due to an actual low level from the radio, but the other frequencies measure within the specification limit, and the measurements from the 8800SX also confirm a consistent level at that frequency. This is an example of a measurement repeatability issue. What that means in terms of time spent, is that you must either rerun the test to get it to pass, or you must verify with another instrument to determine whether the power measurement is correct or incorrect. Either way, you must rerun the test, which at least doubles the amount of time spent testing the radio.

TX Power Out Align High

Result	Frequency	Power Out	Min Limit	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	6.3 W	6.2 W	6.4 W	59	61
Pass	168.0750 MHz	6.3 W	6.2 W	6.4 W	63	65
Pass	160.1250 MHz	6.3 W	6.2 W	6.4 W	70	71
Pass	154.2250 MHz	6.4 W	6.2 W	6.4 W	75	101
Fail	142.1250 MHz	5.9 W	6.2 W	6.4 W	82	82
Pass	136.0250 MHz	6.2 W	6.2 W	6.4 W	80	104

Let's look at some additional tests performed on the test set. The Deviation Balance Alignment and the Deviation Limit Alignments are analog tests and alignments that are critical in establishing the digital P25 modulation fidelity and P25 symbol deviation performance, which can significantly impact system performance . In other words, correct alignment of the analog deviation balance and deviation limiting should give the correct modulation fidelity and symbol deviation when tested in the digital mode. In the previously referenced test sequence above, we can see that the other unit appears to give consistent and valid information for both tests. However, let's look further at the analog deviation balance and limiting tests and alignment at two test frequencies, 168.0750 and 173.9750 MHz.

[1] See Is Your Digital RF Communication System Optimized to Provide the High Performance it was Designed to Deliver White Paper.

Deviation Balance Align

Result	Frequency	Variance	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	1.5 %	+/-1.5 %	35	36
Pass	168.0750 MHz	0.6 %	+/-1.5 %	34	35
Pass	160.1250 MHz	1.3 %	+/-1.5 %	37	37
Pass	154.2250 MHz	-1.4 %	+/-1.5 %	40	40
Pass	142.1250 MHz	1.5 %	+/-1.5 %	40	41
Pass	136.0250 MHz	0.1 %	+/-1.5 %	35	35

Deviation Limit Align

Result	Frequency	Deviation	Min Limit	Max Limit	Old Softpot	New Softpot
Pass	173.9750 MHz	2.823 kHz	2.780 kHz	2.880 kHz	17463	17079
Pass	168.0750 MHz	2.827 kHz	2.780 kHz	2.880 kHz	17343	17279
Pass	160.1250 MHz	2.842 kHz	2.780 kHz	2.880 kHz	17510	17502
Pass	154.2250 MHz	2.836 kHz	2.780 kHz	2.880 kHz	17414	17478
Pass	142.1250 MHz	2.827 kHz	2.780 kHz	2.880 kHz	17359	17231
Pass	136.0250 MHz	2.836 kHz	2.780 kHz	2.880 kHz	17453	17581

Now let’s look at the corresponding results when the same unit tests digital modulation fidelity and symbol deviation later on during the same automated test.

Modulation Fidelity

Result	Frequency	Mod Fidelity	Max Limit
Pass	136.0250 MHz	1.3 %	5 %
Pass	142.1250 MHz	1.1 %	5 %
Pass	154.2250 MHz	1.0 %	5 %
Pass	160.1250 MHz	0.7 %	5 %
Fail	168.0750 MHz	34.8 %	5 %
Fail	173.9750 MHz	33.1 %	5 %

Symbol Deviation

Result	Frequency	Symbol Dev	Min Limit	Max Limit
Pass	136.0250 MHz	1826.0 Hz	1620 Hz	1980 Hz
Pass	142.1250 MHz	1809.6 Hz	1620 Hz	1980 Hz
Pass	154.2250 MHz	1817.9 Hz	1620 Hz	1980 Hz
Pass	160.1250 MHz	1816.7 Hz	1620 Hz	1980 Hz
Fail	168.0750 MHz	2637.6 Hz	1620 Hz	1980 Hz
Fail	173.9750 MHz	2862.1 Hz	1620 Hz	1980 Hz

We can see that both the modulation fidelity and symbol deviation are dramatically out of specification with measurements that over 650% in error. The term “dramatically” is valid, since performance at these levels means that that radio simply will not operate at all at these frequencies. While we don’t know the exact reason for this error, we have a hint that it is related to at least a measurement repeatability problem and potentially even an instrumentation design flaw when we look further at the Internal Voice Modulation Test that is performed during the same automated test that also tests analog deviation.

Internal Voice Modulation Test

Result	Frequency	Deviation	Min Limit	Max Limit
Fail	136.0250 MHz	22.597 kHz	3.600 kHz	5.000 kHz

External Voice Modulation Test

Result	Frequency	Deviation	Min Limit	Max Limit
Pass	136.0250 MHz	4.508 kHz	3.800 kHz	5.000 kHz

APP Version 3.1

Here we see that the deviation test shows deviation at over 4.5 times the maximum limit. Per the other available equipment vendor’s Motorola XTL and XTS User Guide, this test checks the ability of the radio’s internal microphone audio circuit to accurately transfer the received signal. Since these radios operate with an audio response of 300Hz to 3kHz and with a modulation limits of 5kHz (in a 25kHz channel) , we know that the radio simply cannot pass the audio frequencies required to get a deviation of 22.597kHz through the audio circuits. Whether there is noise induced within the test set during the test or if the system is just producing wrong data we cannot know specifically without further analysis, however we do know that the test will have to either be rerun or the test set verified again by another instrument for accuracy.

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One other area that we can observe from the results relates to the absolute accuracy of the instrument. Looking at the same modulation fidelity test, we can see that the results from the other instrument at 136.0250 and 142.1250 MHz shows a higher modulation fidelity measurement while the measurements at 154.225 and 160.1250 MHz show a lower modulation fidelity measurement when compared to the results from the Viavi 8800SX (1.3% vs 1.13%, 1.1% vs 0.86%, 1.0% vs 1.08% and 0.7% vs 1.06% respectively).

Modulation Fidelity

Result	Frequency	Mod Fidelity	Max Limit
Pass	136.0250 MHz	1.3 %	5 %
Pass	142.1250 MHz	1.1 %	5 %
Pass	154.2250 MHz	1.0 %	5 %
Pass	160.1250 MHz	0.7 %	5 %
Fail	168.0750 MHz	34.8 %	5 %
Fail	173.9750 MHz	33.1 %	5 %

Other available test equipment Modulation Fidelity measurement results

Tx Para metrics

Modulation Fidelity

Freq(MHz)	Lower Limit(%)	Reading(%)	Upper Limit(%)	
136.025	0.10	1.13	5.00	PASS
142.125	0.10	0.86	5.00	PASS
154.225	0.10	1.08	5.00	PASS
160.125	0.10	1.06	5.00	PASS
168.075	0.10	0.99	5.00	PASS
173.975	0.10	1.02	5.00	PASS

Viavi 8800SX Modulation Fidelity measurement results

Calculating the mean deviation of the frequency test points on the other test set versus the Viavi 8800SX shows a mean of 17% (0.175) versus 7% (0.067), or a difference of 262%. While looking at a variation of a few tenths of a percent on a measurement might seem trivial, this can and does impact measurement accuracy, especially impacting measurements that are borderline which can incorrectly pass a bad radio (or vice versa). This all adds up to extra test time to determine the real result.

AUTOMATED TESTS SUPPORTED FOR EACH FAMILY OF RADIOS

If you are buying a radio test set to improve efficiencies by using the built-in automated test and alignment functions, it is important to know if that test does test all the radios that you have in your inventory. A quick survey of covered radios shows how the Viavi 8800SX compares to the other available test equipment for the number of models covered by each automated test/alignment suite.

[2] **Motorla ASTRO XTS 500**

Motorola	
ASTRO	
8800SX	R8XXXX
63	36

Motorola	
APX (All Models)	
8800SX	R8XXXX
106	87

Motorola	
APX (Mobile PA Bias)	
8800SX	R8XXXX
36	0

Motorola	
MOTOTRBO	
8800SX	R8XXXX
247	150*

Hytera	
DMR	
8800SX	R8XXXX
39	0

Relm/BK	
KNG/KNG2	
8800SX	R8XXXX
10	4

Kenwood	
NXDN	
8800SX	R8XXXX
35	25

Kenwood	
NX-5000	
8800SX	R8XXXX
16	0

EF Johnson	
Viking	
8800SX	R8XXXX
12	0

Harris	
P7300/P5500/XG75	
8800SX	R8XXXX
20	17

Harris	
XL200P	
8800SX	R8XXXX
1	1

* Estimate - Actual Models Not Disclosed

As you can clearly see, the Viavi 8800SX covers many more radios than the Freedom R8X00. That means that you must test radios that are not covered by Freedom's automated test in a manual mode, which typically can take 3 times longer.

DO THE AUTOMATED TESTS COVER ALL THE REQUIRED TESTS, ALIGNMENTS AND DOCUMENTATION?

Radios have specific tests and alignment per the radio manufacturer. An important aspect when evaluating a test instrument, such as the Viavi 8800SX, is to understand if the automated test and alignment actually performs **ALL** the tests that the OEM specifies as part of the alignment. Once again, we'll look at the Freedom R8X00 series to determine if all the tests are being completed.

Let's look at the Motorola APX series as an example. While the actual number of APX models claimed to be tested and aligned by their equipment is 87, it is important to understand that of those 87, 36 are mobile versions where their test set does not perform the PA Bias Alignment which allows the mobile to be aligned for TX power output. While power can be aligned without alignment of the PA Bias, if the power will not align properly, the only way to correct it is to align the PA Bias. This alignment also must be performed if replacing the PA board. If this alignment must be done manually, it adds 10 minutes to each test. This is in addition to the 14 minutes that their automated alignment takes compared to the Viavi 8800SX at 9 minutes. That means the total time for their unit is 24 minutes versus 9 minutes for the Viavi 8800SX or 266% longer.

Another area to look at to verify if all tests are done in conformance to the OEM test, is the receiver BER test. From test results above, we know that the Viavi 8800SX does the BER measurements across the six different frequencies specified by the OEM.

Rx BER

Freq(MHz)	Lvl(dBm)	BitError	BER(%)	Upper Limit(%)	
136.075	-116	37	0.087	5	PASS
142.075	-116	28	0.058	5	PASS
154.275	-116	26	0.058	5	PASS
160.175	-116	24	0.058	5	PASS
168.125	-116	42	0.116	5	PASS
173.925	-116	54	0.145	5	PASS

Rx BER (1:15): PASS

However, when we look at the Freedom R8X00, BER is only done on one frequency.

Digital Sensitivity (BER) Test

Result	Frequency	5% BER	Max Limit
Pass	136.0750 MHz	-122.4 dBm	-116.0 dBm

We can only guess why this is done that way, perhaps to save time on the overall test. What this means to you, however, is that if you are going to align a radio for either your own use or as a service for a customer, you will have to do the remaining 5 frequencies manually to provide the test results as recommended by the OEM to your customer. This can easily add 5 or more minute to the test time. Then you have to figure out how to document it separately from the test set results print out.

While we are on the subject of documentation, if there is a performance issue with the radio, many times the OEM will ask what software version the radio has installed. The OEM often will recommend specific firmware versions in the radio to ensure proper operation with infrastructure or to resolve past software issues. With the Viavi 8800SX, you can see that the test set reads the radio information regarding the Firmware Version (12.00.17), the DSP Version (12.00.05). The Freedom unit, however does not capture that information from the radio. That means you must have to have a separate process to document the version of software in the radio to your customer. This usually means having to disconnect the radio from the test set and connecting the radio to a PC and then using the OEM tuner or programming software to read software version. This all takes additional time.

ARE THE AUTOMATED TEST SUITES FULLY APPROVED BY THE RADIO OEM?

The final question you need to ask – "is the automated test is approved by the OEM". You may think that this is minor, but for the reasons we've covered so far, you can see why the OEM would be concerned with the type of test equipment you are using. OEM's are starting to evaluate the equipment used by 3rd party service organizations to ensure that the measurements taken are correct and can accurately test to the OEM's specifications. This goes back to being able to correlate your test data with the OEM product test data. The OEM does not want to get into battle between you or your customer regarding the performance of their radio. They adopt published test specifications for a reason, which is to eliminate any confusion in the performance of their radios.

There are times where radios vary compared to the published specifications. Some of the variance is due to the test equipment, while other time the variance is due to radio software revisions or actual issues with the radio. The last thing that the OEM wants to do is spend time figuring out the variation of your test equipment measurement results compared to their test results. We've all had calls with various OEMs when the test equipment results don't match theirs, and those conversations are difficult, at best, and end up taking an extraordinary amount of time to resolve.

Viavi has done extensive work with ALL OEMs to secure their approvals on ALL automated test and alignment software. In addition, all major OEM's use the Viavi 3920B or 8800SX as part of their R&D, production, product support and field test operations because they have done the assessment and verified the test set performance against their stringent internal specifications. If in doubt, ask your OEM.

TIME COST MATRIX

So, does saving 15% on your test set really cost you 77% more? Let's do the math. Below is an actual Utilization Analysis using the data that we accumulated above. This analysis tracks the actual utilization of the instrument in a typical radio test environment. In this case, we used an assumed price of $30,000 for the Viavi 8800SX compared to the Freedom unit at 15% less. As you can see, you would need twice as many test sets to get the same amount of work done that the 8800SX does.

Time Cost Matrix

Utilization Analysis

Time Spent Category	8800SX	R8X00		Radios Per Day	8800SX Time	R8X00 Time	Time Difference	Percent of Radio Affected
Non Automated Test Time (2 hours non automated)	120.0	120.0	Minutes		120.0	120.0		
Actual Test Time Difference	5.2	17.0	Minutes	14	72.8	238.0	327%	74%
Accuracy of Measurement Issues Requiring Radio Retest (enter time for each units typical test time - assume time is simply double)	5.2	17.0	Minutes	1	5.2	34.0	654%	5%
Radios Not Covered by Automated Test Requiring Manual Alignment (automated test can typically be done in 1/3 the time)	5.2	15.6	Minutes	2	10.4	31.2	300%	11%
Additional Time for Tests not done (enter test time per unit and include added minutes per test not covered)	9.0	24.0	Minutes	2	18.0	48.0	267%	11%
					3.8	7.9	Hours Utilized	
TOTAL TIME DIFFERENCE					Minutes	244.8	208%	
Instrument Cost	$30,000.00	$ 25,500.00		Actual Cost			$ 53,072.44	
				Percent More			76.9%	

A slightly different approach can also be used, if you field a significant number of radios in your system or are responsible for testing a number of radios, to evaluate the overall amount of time saved across the number or radios. This is called the "Total Radio Time Analysis" method and it simply calculates the amount of time it would take to test all radios in your system using the automated tests available on the Viavi 8800SX and the Freedom R8X00.

Time Cost Matrix

Total Radios Time Analysis

Time Spent Category	8800SX	R8X00		Total Radios in the System	8800SX Time	R8X00 Time	Time Difference
Actual Test Time Difference	5.2	17.0	Minutes	1200	6240.0	20400.0	327%
					104.0	340.0	Hours Utilized
TOTAL TIME DIFFERENCE					Days	29.5	327%
Instrument Cost	$30,000.00	$ 25,500.00		Actual Cost			$ 83,365.38
				Percent More			177.9%

CONCLUSION

Test equipment used to align todays advanced digital radios requires a thorough evaluation to ensure that the test set selected meets your requirements. These requirements should include, at a minimum, an evaluation of the total cost of the instrument over time, the base accuracy of the instrument and the coverage of specific automated tests in relation to the radios in your inventory that will be tested and aligned. Additionally, you may consider other aspects of the test equipment including high power applications, cable sweep (VSWR/Return Loss/ Distance to Fault) measurements and battery life for use in the field.

Only by doing a thorough investigation can you be assured that the investment made in radio test instruments actually provides the return on investment that you and your financial managers require.

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