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tech tips

Testing Digital TV Tuners

The digital tuners found in today's TVs and VCRs are more reliable than older mechanically switched tuners, yet they still fail. When they do, the VA62A Universal Video Analyzer provides the signals and tests needed to isolate and correct the problem. The VA62A's all-channel operation, with the ability to offset any channel's frequency, provides dynamic testing of digital tuners.

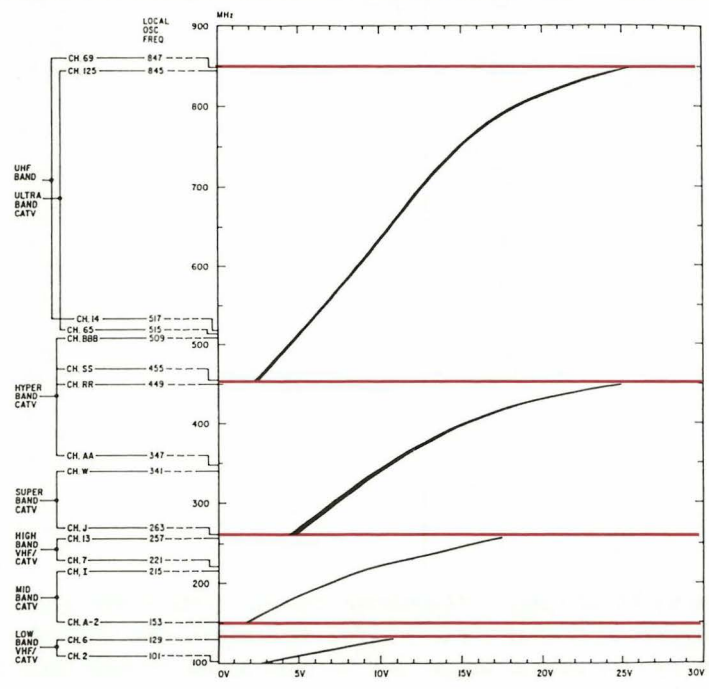
This Tech Tip explains how to relate service literature to tuner symptoms, and then how to use the VA62A to isolate problems.

Understanding Band Switching

Most conventional (non-digital) tuners have only three tuning bands. The low-band VHF tuner covers channels 2-6, the high-band VHF tuner covers channels 7-13, and the UHF tuner covers from channel 14 through the top UHF channel. (Older UHF tuners covered through channel 83, while newer ones stop at channel 69, since the FCC has allocated channels 70 through 83 to other uses.)

Digital tuners often add cable bands to the VHF and UHF tuner sections. This requires several more tuner sections. The channel numbers where bandswitching occurs vary from one receiver design to the next. Knowing where bandswitching occurs helps in troubleshooting suspected tuner problems. Channels in each band should be tested to confirm that the tuning system works correctly.

While it is possible for a tuner to improperly tune channels in the center of a band, the most likely problem channels are at the upper and lower edge of each band. These channels require the tuned stages to be set to their extreme limits, making them the most difficult for the automatic circuits to capture. You need to know where bands switch, in order to know which channels need extra attention. Service literature usually shows which channels fall at band edges, although some interpretation of the literature may be needed.



Courtesy Philips Consumer Electronics

Fig. 1: This tuning chart from a TV schematic lets you determine the number of tuning bands and the channels at each band edge.

Interpreting Service Literature

Fig.1 shows a typical tuning voltage chart found on a tuner schematic. Notice that this chart has four curves, indicating the tuner has four bands. Drawing a line from ends of each curve to the left-hand scale identifies the ends of each band.

The channels for this particular tuner break out as follows:

Band	Channel	Chart Frequency	Channel Frequency
I Bottom	2	101	55.25
I Top	6	129	83.25
II Bottom	A-2	153	109.25
II Top	13	257	211.25
III Bottom	J	263	217.25
III Top	RR	449	403.25
IV Bottom	SS	455	409.25
IV Top	125	845	799.25
UHF Bottom*	14	517	471.25
UHF Top*	69	847	801.25

**NOTE: Cable band IV and UHF use the same tuner band.*

Fig. 2: The top and bottom channel for each of the tuning bands represented by the curves in Fig. 1

Notice that the frequencies listed in the service literature (3rd column) do not agree with standard channel assignments (fourth column). The tuning chart references the frequency of the tuner's local oscillator, not the video carrier frequency. To convert from the oscillator frequency to the carrier, subtract 45.75 MHz, which produces the intermediate frequency (IF) after mixing.

Converting Channel Numbers

The tuning chart in Fig. 4 shows another problem that you may encounter. The channel assignments are listed using the older alphanumeric cable channels, instead of the digital numbers used on the TV tuner or on the VA62A. Fig. 4 shows the frequency/channel conversion chart from the VA62A manual which lets you easily convert from frequency or alphanumeric assignment to digital tuner number.

You can use either the alphanumeric channel number or the video carrier frequency to determine which channels represent the edge of each band. In this example, the digital tuner and VA62A channels are:

Band	Chart Channel	VA62A Channel
I Bottom	2	2
I Top	6	6
II Bottom	A-2	98
II Top	13	13
III Bottom	J	23
III Top	RR	54
IV Bottom	SS	55
IV Top	125	94*

** Channels from 94-125 can be tested using VA62A UHF channels.*

Fig. 3: The band-edge channels from Figure 1 as they are translated using the VA62A chart. Notice that the channel numbers agree with those used by most digital tuners.

You may see some variations in the way channels are numbered, because there are no industry standards for the numbering of cable channels. The VA62A follows the numbering scheme most commonly used by TV manufacturers.

The biggest variation is on the channels called "A-5" through "A-1" (pronounced "A minus one" and "A minus 5"). Most cable systems don't use these channels, since they are in the FM broadcast band. But a few cable systems place TV channels in this band, and most tuners have a means to reach them.

The VA62A numbers these channels as 95-99. Many TV tuners do the same. The older VA62 (without the "A") only tuned through cable channel 68, so these special channels were called 69-73, which also agrees with many TV digital tuner numbering schemes which do not include the "ultraband" cable channels.

When you're not sure of the TV's numbering scheme, select a VA62A channel, and then tune through likely channel numbers until you find the signal. Then, make a note on the schematic, so you know the number sequence when working on a similar model.

Absent Channels

Unlike continuously tuned systems, it is possible for a digital tuner to miss one channel while the others work correctly. More likely, groups of channels will be missing, such as every 4th channel or every 16th channel in a sequence. Your customer, however, may not notice that several channels are affected if their antenna or cable system only delivers some of the channels the tuner is capable of selecting.

To find these patterns, step through all of the channels in a band to confirm each works correctly. When making this test, it's important to set the VA62A to the new channel before of changing channels on the tuner, because most tuners need a carrier present when the new channel number is entered. This is easy to do using the VA62A's "channel up" button. Press it a moment before pressing the "channel up" button on the tuner.

The grouping of channels is usually based on the frequency sequence, not the channel numbers. If you find that more than one channel is affected, plot the missing channels against the frequency chart in Fig. 3. This will show if a digital line running between the microprocessor and the programmable divider in the tuner is stuck in a "high" or "low" condition.

VHF And Cable Frequency Allocations

Band	Digital Tuner Number	Alpha Numeric Designation	Video Carrier Frequency
Low Band VHF	2	2	55.25
	3	3	61.25
	4	4	67.25
	5	5	77.25
	6	6	83.25
Mid Band Cable	95	A-5	91.25
	96	A-4	97.25
	97	A-3	103.25
	98	A-2	109.25
	99	A-1	115.25
	14	A	121.25
	15	B	127.25
	16	C	133.25
	17	D	139.25
	18	E	145.25
	19	F	151.25
	20	G	157.25
	21	H	163.25
	22	I	169.25
High Band VHF	7	7	175.25
	8	8	181.25
	9	9	187.25
	10	10	193.25
	11	11	199.25
	12	12	205.25
	13	13	211.25
Super Band Cable	23	J	217.25
	24	K	223.25
	25	L	229.25
	26	M	235.25
	27	N	241.25
	28	O	247.25
	29	P	253.25
	30	Q	259.25
	31	R	265.25
	32	S	271.25
	33	T	277.25
	34	U	283.25
	35	V	289.25
	36	W	295.25
Hyper Band Cable	37	AA	301.25
	38	BB	307.25
	39	CC	313.25
	40	DD	319.25
	41	EE	325.25
	42	FF	331.25
	43	GG	337.25
	44	HH	343.25

Band	Digital Tuner Number	Alpha Numeric Designation	Video Carrier Frequency
Hyper Band Cable (cont.)	45	II	349.25
	46	JJ	355.25
	47	KK	361.25
	48	LL	367.25
	49	MM	373.25
	50	NN	379.25
	51	OO	385.25
	52	PP	391.25
	53	QQ	397.25
	54	RR	403.25
	55	SS	409.25
	56	TT	415.25
	57	UU	421.25
	58	VV	427.25
	59	WW	433.25
	60	XX	439.25
	61	YY	445.25
	62		451.25
	63		457.25
	64		463.25
Ultra Band Cable	65		469.25
	66		475.25
	67		481.25
	68		487.25
	69		493.25
	70		499.25
	71		505.25
	72		511.25
	73		517.25
	74		523.25
	75		529.25
	76		535.25
	77		541.25
	78		547.25
	79		553.25
	80		559.25
	81		565.25
	82		571.25
	83		577.25
	84		583.25
	85		589.25
	86		595.25
	87		601.25
	88		607.25
	89		613.25
	90		619.25
	91		625.25
	92		631.25
	93		637.25
	94		643.25
	95-99		See Mid Band

Fig. 4: The chart from the VA62A instruction manual lets you easily cross-reference channel charts which use frequencies or which use older alphabetic channel codes. Remember to subtract 45.75 MHz from the channel frequency if the chart shows the local oscillator frequency, as in Fig. 1.

Shifted Cable Channels

Cable TV systems often move some or all of the channels from the frequencies used for over-the-air broadcast to prevent picture interference from harmonics or mixing products of signals in the cable system itself.

The TV tuner must be able to compensate for these shifted channels. Manually tuned systems require the customer to adjust the fine tuning to match the offset carrier. Digital systems need extra circuits to do this automatically. Some tuners have a user-operated switch which changes the tuning to "HRC" shifts. Most use a form of automatic tuning.

In addition to the normal Automatic Fine Tuning (AFT) circuits in the IF stages, digital tuners have a second automatic tuning circuit. These "auto-search" circuits tune shifted carriers. After the auto-search circuit finds the carrier, they turn the job of maintaining tuning over to the conventional AFT circuits.

Auto-search circuits are activated differently, depending on the TV receiver's design. Some sweep through a range of frequencies every time a new channel is entered into the keyboard, stopping when the circuits indicate a signal. They do not try to re-tune the carrier until a new channel number is entered.

Channel 2 Carrier = 55.25 MHz

Third Harmonic of Channel 2 = 55.25x3 = 165.75 MHz

Carrier for channel 21 = 163.25 MHz

Picture Beat = Interference **minus** Carrier Frequencies = 165.75 - 163.25 = 2.5 MHz

Fig. 5: Any combination of carriers and interference signals with frequencies between zero and 4.2 MHz can cause beats in the picture.

Other tuners jump to a different offset if the same channel number is entered more than once. For example, enteringchannel 3 once tunes the local oscillator to the non-shifted frequency. Entering channel 3 a second time causes the local oscillator to tune for a carrier below the normal frequency. Entering channel 3 a third time tunes to a frequency above the normal carrier.

Still other systems go into a hunting mode any time the IF AFT voltage falls out the normal tuning range. These tuners do not require you to re-enter a channel number to hunt for a shifted channel, but may randomly hunt when the IF AFT is not correctly adjusted.

If the testing of the tuner shows the problem actually lies in the AFT, refer to Tech Tip #180 for details on further testing and troubleshooting.

STANDARD NORTH AMERICAN CABLE SHIFTS

Channel	HRC Shift	ICC Shift
2	-1.25	0
3	-1.25	0
4	-1.25	0
4+*	4(+4.75) or 5(-5.25)	4(+6.00) or 5(-4.00)
5	+0.75	+2.00
6	+0.75	+2.00
7-99	-1.25	0

Fig. 6: The two most common cable shift systems reduce picture interference. The more popular "Harmonically Related Carrier" (HRC) system eliminates beats by locking all possible interference signals to a common crystal.

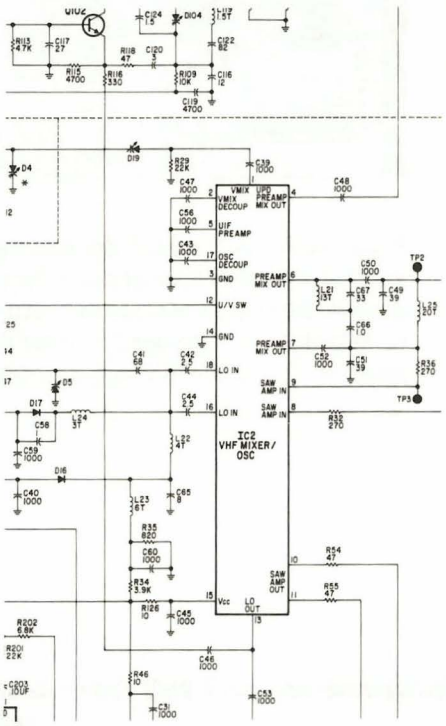


Fig. 7: Digital tuners have circuits which shift the local oscillator in the tuner until shifted channels are located. Then, the tuning is turned over to the IF Automatic Fine Tuning (AFT) for constant correction.

Testing the Tuner

Unless the TV or VCR owner is complaining about particular channels, you can do a quick performance test by checking the channels at each band edge. When performing this test, be sure that you tune the channel on the VA62A before you select the channel on the TV or VCR tuner. This is important, because many automatic channel search circuits will not work correctly unless there is a carrier at the expected channel. By having the VA62A's carrier in place before switching channels, the tuner will hunt for the signal, just as it does when tuning a signal from an antenna or cable system.

Duplicate the shifts your customer normally must tune. For example, if they will connect to a cable system using HRC shifting, preset the programmable tuner of the VA62A to correspond to the HRC shifts. This duplicates the signal at the customer's location, even if their cable system operates differently than the one at your testing location.

One handy feature of the VA62A is that you can switch from the "STD Cable" to the "Prog Cable" function without the channel number changing. When the VA62's function is set to "STD Cable", the programmed shift is removed (it is set to zero offset). When you move to the "Prog Cable" function, the programmed offset is instantly applied to the RF generator.

A second feature of the VA62A's programmable generator further helps test tuner shifting abilities. This allows the direction of the programmed shift on any channel to be temporarily reversed without changing the shift stored in program memory. (The memory, by the way, does not require power or a backup battery. Once you've applied shifting assignments, the VA62A's microprocessor will remember the shifts until you change the program.)

The temporary program shift is controlled by the special-function "+/-" key on the channel keypad. First, set the RF-IF SIGNAL switch to the "Prog Cable" position. The RF carrier for the selected channel will now be offset by the programmed amount. Next, press the "+/-" key one time. The left-hand digital display will change from a channel number to a frequency reading. The frequency shows how far the generator has been moved from the normal non-shifted channel.

Next, press the "+/-" key again. This time, the frequency in the window will remain the same, but the polarity will reverse. If the display showed

a "-" before, it will now show no sign (meaning a positive shift) or vice versa.

The generator has shifted to the opposite direction of the programmed value. If, for example, the carrier has been programmed to be 0.5 MHz lower in frequency than normal, the carrier will shift to be 0.5 MHz higher in frequency when the key is pressed. Pressing the key a third time will return it to a shift in the negative direction.

The shift is only temporary. It does not change the direction of the shift stored in the program memory. In this way, you can watch for the response of the tuner on a given channel as you shift the signal higher or lower in frequency, without changing the testing sequence you've programmed.

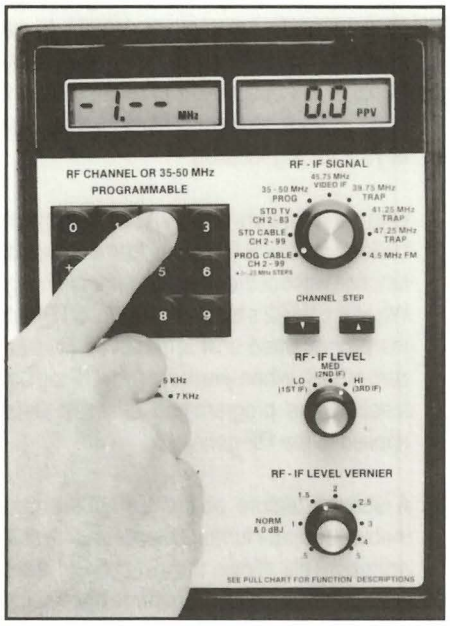


Fig. 8: The programmable cable channels produced by the VA62A let you dynamically test the lock-in range of the tuner through the antenna terminals.

Additional details on using the programmable cable function of the VA62A are found in Sencore Tech Tip #180, which explains how to test and service AFT circuits.

Conventional Performance Tests

Just like conventional tuners, a digital system should also be tested for proper sensitivity and AGC performance. The VA62A tests are the same for a digital system as for a conventional tuner. The picture should be clear with an attenuator setting of "High" and "Normal" (which produces 1000 microvolts). The picture should hold sync, although there may be some snow, at "Med" and "Normal" (100 microvolts). The picture should be visible, even though it has high levels of noise, at "Low" and "Normal" (10 microvolts).

To confirm AGC performance, the picture shoul not overload or tear with maximum output. As with a conventional system, a problem may be in the tuner, the AGC circuits, or the IF amplifiers. Use the VA62A's substitution signals to isolate the cause of the problem.

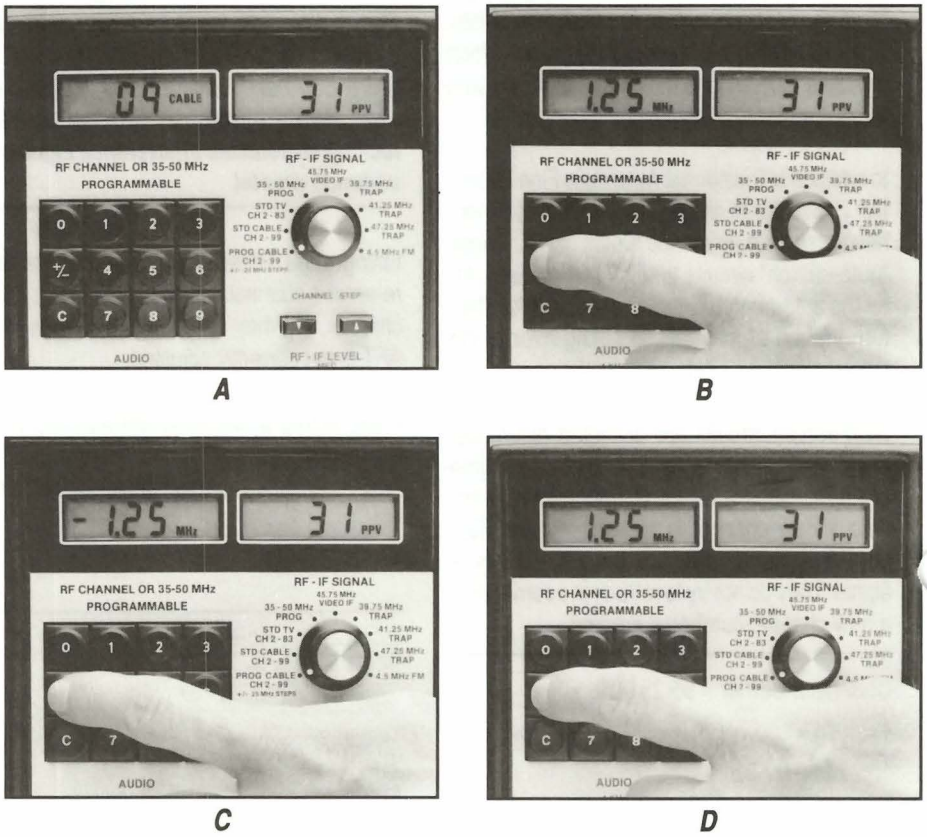


Fig. 9: The Programmable Cable shift may be temporarily shifted in direction: A. When first selected, the digital readout shows the channel number. B. Pressing the "+/-" key one time displays the amount of shift programmed into the generator without changing the output. C. Pressing the"+/-" key again reverses the direction of the shift without changing the internal program. D. The direction may be shifted any number of times to complete the test.