CATJ

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OUR COVER

CATV field engineer John Falconer puts the Jerrold/Texscan VSM-1 through the paces, something that CATJ will also do in the January issue as we wrap-up signal level reading devices, Part 4.

PART TWO: HOW THE FSM/SLM INSTRUMENT FUNCTIONS IN CATV

READING THE SCALE

One of the most difficult things for any new user of any FSM instrument to master is the *proper interpretation of the meter scale.* Most FSM manufacturers recognize this fact and try to make the learning process less complicated with multi-colored scales. In the first part of this four-part series on signal level instruments, we made the point that the scale (or range) actually is a static thing; that is, it remains the same basic scale with voltage levels broken into either 10 or 20 db "windows" and the range chosen by placing one or more fixed precision attenuators in front of the basic instrument.

Let's review for just a paragraph. Most instruments read a basic calibrated range of -40 dbmv (10 microvolts) to -20 dbmv (100 microvolts), with all external front-end attenuation removed from the signal path to the instrument. As the tear-out reference chart to the right shows, this region (-40 to -20 dbmv) is really at the bottom of the signal level regions we deal with. This means this is a range or region which we seldom *really* use, except at the head end, and then only when the head end signals are frightfully weak. The expansion of the basic range of any instrument is accomplished by switching fixed pads into the signal path, between the instrument input and the basic range electronics. Switching 10 db of pad into the instrument results in the basic range moving upwards from -40/-20 dbmv to -30/-10 dbmv; switching 20 db of pad into the instrument results in the basic range moving upward from -40/-20 dbmv to -20/0 dbmv; etc.

The easiest and quickest way to adjust to any new instrument is to ask yourself one question: *What is the basic range of the instrument,* with switched pads in place (i.e. switched in)?

Once you determine that answer, your actual range for any given measurement is that basic range, *plus* the cumulative total of the switched-in pads.

Where we usually get into trouble is with the negative and then positive values of db's. Many-many years ago industry pioneers established that 1,000 microvolts was a desirable set-delivered signal, and borrowing from the audio industry, the dbmv log scale was developed. In the audio (and radio communications) industry the end result is usually converted into sound (audio). The decibel scale originated with Bell Labs as an engineering handle on the *relative measurement of sound loudness, as detected by the human ear.* It is a peculiarity of the human ear that an increase (or decrease) in audio loudness is directly related to the amount of audio *power* involved. In audio, a 1 db change in *audio power* is just about the smallest (or lowest) net-change which the human ear can detect (as change). By the same token, for the average human ear to respond with "that is twice as loud as before", the change in *audio power* required is an increase by a factor of four. In real numbers, a 1 watt audio amplifier delivering a steady tone output would have to increase to 4 watts of *audio power* before the listener would say "now it is twice as loud". In a nutshell, the human ear has a logarithmic response.

Tests conducted by the TASO group (1), along with Bell Lab tests previously conducted, indicated that the human eye has characteristics (when viewing a television screen) very *similar* to the characteristics of the human ear.

In CATV, our db scale is an *expression of voltage levels*. That is, 0 dbmv is 1,000 microvolts, while +20 dbmv is 10,000 microvolts. The decibel scale is also used in power level ratios. Chart One indicates the differences between voltage (or current) ratios on a db scale, and power ratios on a db scale. In the audio world, the db scale is used primarily as a power scale.

In CATV, the db scale we live with is referenced to a 75 ohm line and a 75 ohm termination. In referencing db's of this to db's of that, we must always compare apples and apples, which means we must always be talking about *the same characteristic line impedance*. For example, all audio db's are referenced to a 600 ohm balanced line, and some TV decibels are referenced to a 300 ohm balanced line (2); but fortunately, in CATV we almost always think about 75 ohm unbalanced line.

So for CATV purposes, we have established 0 dbmv as a 1,000 microvolt (or 1 millivolt) reference level, in a 75 ohm unbalanced transmission cable, terminated on both ends by a 75 ohm (essentially) resistive load or source/load.

Most human eyes, like most human ears, can just barely detect a 1 db *power change* (not voltage change), and a 1 db power change is *approximately* equal to a 2 db voltage change. Most human eyes will see a "twice as loud" improvement in a TV picture when there is a 400% *power increase*, which is the same as 6 db of power increase, or 12 of voltage increase.

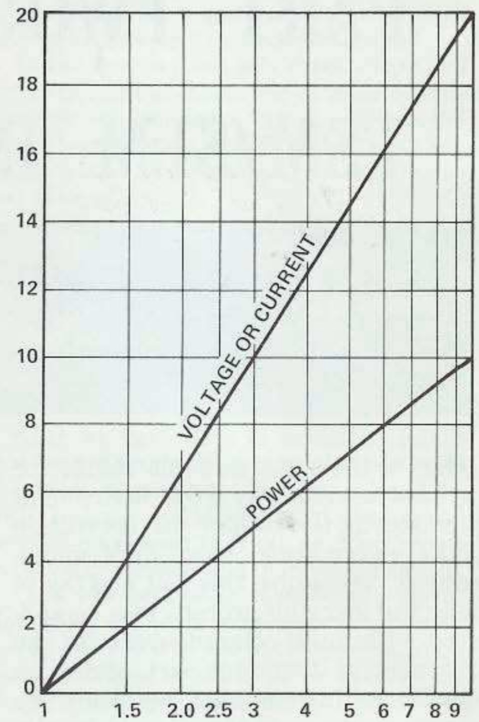

CHART ONE

In real life, subjective picture quality ratings run something like this when you take a sufficiently large sampling of test-viewers to develop norms or averages:

Microvolt Level	General Viewer Reaction	dbmv Level
100 uV	Reference signal	-20 dbmv
130 uV	"I **think** it is better"	-18 dbmv
200 uV	"I **know** it is better"	-14 dbmv
400 uV	"Twice as good as original"	- 8 dbmv

(*1*) *See CATJ for June 1974, Page 7.*

CATJ SIGNAL LEVELS REFERENCE CARD

dbmv	µV	ANTENNA LEVEL SIGNAL	HEAD END OUTPUTS	PLANT LEVELS	DROP LEVELS	dbmv
−40	10	GENERALLY NOT USEABLE				−40
−37	14					−37
−34	20					−34
−31	28					−31
−28	40	LOW NOISE HIGH GAIN PRE-AMP REQUIRED				−28
−25	56					−25
−22	80					−22
−19	110					−19
−16	160					−16
−13	220	MODERATE GAIN PRE-AMP REQUIRED				−13
−10	320					−10
−7	450					−7
−4	630				USE-ABLE B/W LEVEL	−4
−1	900					−1
+2	1,300	INPUT DIRECT TO PROCESSOR O.K.			0+ FCC RANGE OF 75 OHM RECEIVER LEVELS +12	+2
+5	1,800					+5
+8	2,500					+8
+11	3,600			NORMAL TRUNK LINE RANGES (input)		+11
+14	5,000					+14
+17	7,000	INPUT PAD GENERALLY USED		NORMAL LINE EXTENDER RANGES (input)		+17
+20	10,000					+20
+23	14,000					+23
+26	20,000					+26
+29	28,000					+29
+32	40,000	INPUT PAD REQUIRED				+32
+35	56,000		NORMAL LOW BAND LEVELS			+35
+38	80,000					+38
+41	110,000		NORMAL HIGH BAND LEVELS			+41
+44	160,000			(output) NORMAL TRUNK LINE RANGES		+44
+47	220,000			(output) NORMAL LINE EXTENDER RANGES		+47
+50	320,000					+50
+53	450,000					+53
+56	630,000					+56
+59	900,000					+59

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dBmv To μV Conversion Table

REFERENCE LEVEL: 0 dBmv = 1000 v = 1 mv

dBmv	μV	dBmv	μV	dBmv	μV
−40	10.00	0	1,000	41	112,200
−39	11.22	1	1,122	42	125,900
−38	12.59	2	1,259	43	141,300
−37	14.13	3	1,413	44	158,500
−36	15.85	4	1,585	45	177,800
−35	17.78	5	1,778	46	199,500
−34	19.95	6	1,995	47	223,900
−33	22.39	7	2,239	48	251,200
−32	25.12	8	2,512	49	281,800
−31	28.18	9	2,818	50	316,200
−30	31.62	10	3,162	51	354,800
−29	35.48	11	3,548	52	398,100
−28	39.81	12	3,981	53	446,700
−27	44.67	13	4,467	54	501,200
−26	50.12	14	5,012	55	562,300
−25	56.23	15	5,623	56	631,000
−24	63.10	16	6,310	57	707,900
−23	70.79	17	7,079	58	794,300
−22	79.43	18	7,943	59	891,300
−21	89.13	19	8,913	60	1,000,000
−20	100.0	20	10,000	61	1,122,000
−19	112.2	21	11,220	62	1,259,000
−18	125.9	22	12,590	63	1,413,000
−17	141.3	23	14,130	64	1,585,000
−16	158.5	24	15,850	65	1,778,000
−15	177.8	25	17,780	66	1,995,000
−14	199.5	26	19,950	67	2,239,000
−13	223.9	27	22,390	68	2,512,000
−12	251.2	28	25,120	69	2,818,000
−11	281.8	29	28,180	70	3,162,000
−10	316.2	30	31,620	71	3,548,000
− 9	354.8	31	35,480	72	3,981,000
− 8	398.1	32	39,810	73	4,467,000
− 7	446.7	33	44,670	74	5,012,000
− 6	501.2	34	50,120	75	5,623,000
− 5	562.3	35	56,230	76	6,310,000
− 4	631.0	36	63,100	77	7,079,000
− 3	707.9	37	70,790	78	7,943,000
− 2	794.3	38	79,430	79	8,913,000
− 1	891.3	39	89,130	80	10,000,000
− 0	1,000.0	40	100,000		

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300 OHM vs. 75 OHMS

The entire CATV world is referenced to 75 ohm (impedance) voltage levels. Yet there are 300 ohm receivers and some 300 ohm antennas that must be "mated" with the 75 ohm system.

All FSM instruments we will discuss are 75 ohm instruments; their scales and attenuators are 75 ohms. If you run into a 300 ohm antenna (for example) and need to know the voltage level (at 300 ohms) of the antenna, install a good quality 300 to 75 ohm matching transformer at the antenna and take your readings. Multiply the readings at 75 ohms, through the 300 to 75 ohm transformer, by 2.2 (i.e. 200 microvolts x 2.2 = 440 microvolts) **to determine the 300 ohm impedance signal level present.**

If you suspect a television receiver is sending its local oscillator signal back into the cable system via the drop, and you need to determine the **level of the local oscillator,** connect a 300 to 75 ohm matching transformer to the TV set antenna terminals and a short length of RG-59/U cable to the input of the FSM from the matching transformer. Tune the FSM and note the 75 ohm local oscillator level present. Multiply by 2.2 to determine the 300 ohm local oscillator level present.

Unfortunately, electronic equipment is much more exact as to its operating parameters than the human eye. A 2 db *voltage* change will cause most people to *think* they saw an improvement (or degradation if the signal went down). But when you are operating an amplifier within 2 db of its *maximum* rated output specs, and you increase its input level by 2 db, the 2 db rise in *output power* will suddenly show up as cross-mod. Now, every eye in town will *know* the picture is *worse!*

(2) *See 300 ohm vs. 75 ohms of this article.*

Because our industry adopted *part* of the audio 0 dbm scale (1 milliwatt across 600 ohms) and found it fit fairly well to the kind-of-level that a TV receiver "liked to see" for a quality picture, we ended up with negative and positive db's.

In most measurement schemes, zero is zero; but not in all. The temperature scale is a good example of a scale that has both positive and negative numbers. Most of us cope with the negative values of temperature quite well. Zero degrees Centigrade is simply the freezing point of water; minus values are *colder* than the freezing point of water.

Minus 1 dbmv is simply a signal that is 1 db weaker than 1,000 microvolts (0 dbmv); +20 dbmv is simply a signal that is 20 db stronger than 1,000 microvolts (0 dbmv). It really is not all that complicated.

Most of us run into scale-reading errors when we have a combination of differing switchable pad values to "play with". If the basic scale is simply -40/-20 dbmv, and *all switched pads* are 20 db attenuation steps, it is fairly easy to stay on top of the scale range we are actually dealing with. But when some of the attenuators are 6 db, some are 10 db, and some are 20 db, we are forced to add and subtract in more than simple 20 db steps.

IF THERE IS A MENTAL PROCESS

If there is a mental process you should go through, it is simply this:

(1) Determine, as previously noted, *the scale range with no attenuation switched into the front end* pad system;

(2) *Note how many total db of front end pad you have switched into the instrument* to obtain an on-scale reading;

(3) Add the range db's from Step 1 and the db's from Step 2. This will tell you the scale range for

the pad position you are reading.

That means that if the full scale no-pad range is -40/-20, and you have switched in 40 db of pad, the real scale you are reading is now on a range of +0/+20 dbmv (-40 plus 40 = 0). The *low end* of this range *becomes 0 dbmv*, and the *top end* of this range *becomes +20 dbmv.*

SIGNAL LEVEL REFERENCE CHART

On Page 9 there appears a special 3 db step signal level reference chart prepared by CATJ. This chart lists dbmv levels in 3 db steps, from a -40 dbmv level to a +59 dbmv level. The far left hand column and the far right hand column note signal levels in dbmv values. The second column from the left lists the dbmv to microvolt conversion; for example, +11 dbmv is the same as 3,600 microvolts on a 75 ohm line.

The third column from the left is titled "Antenna Level Signal", and it contains statements about the signal level quality which you should *expect* with dbmv (or microvolt) levels throughout the -40/+59 dbmv range.

The fourth column from the left notes the typical head end output voltage levels most CATV systems employ. The fifth column from the left notes typical CATV trunk line and distribution (extender) line level signals between amplifiers. The sixth column from the left brackets the normal signal ranges for CATV drops. Note that *FCC* requirements call for *all signals to be between 0 dbmv and +12 dbmv;* although as we note, levels for black and white receivers can be most-subscriber-acceptable for something lower than the 0 dbmv FCC specified minimums.

As you can see, if you do most of your work in and around CATV head ends, the ranges you can reasonably be expected to measure run the full spectrum from very weak (-31 dbmv) to the very strong (+52 dbmv processor out-

CHANGE YOUR F CONNECTOR

How many times each day do you insert (shove, push, etc.) an F fitting into the F-81 (or similar) chassis mounted connector on your FSM?

The spring-tensioned metal in the center of the connector **gives a little** each time you insert a piece of 59 into the fitting. Many operators have used the same meter for years and have never thought about the fitting.

They wear out . . . much sooner than you suspect.

You go in at an angle, forcing the metal contacts apart even further than a straight-ahead shot would do. A little bit of moisture, dirt or grime on the end of the 59 center conductor inserted into the fitting, **and corrosion sets in.**

A corroded, loose-tension fitting on your FSM can cost you 1,3,6 or even 10 db of meter sensitivity (and therefore accuracy).

So you set out to change it. . . the fitting.

Some fittings are a direct part of the input attenuator, and getting to them involves (1) taking the case off of the meter, (2) removing the input attenuator from the innards, (3) taking the input attenuator apart, (4) replacing the fitting, (5) putting the input attenuator back together, (6) re-installing the input attenuator to the innards, and, (7) putting the case back on.

It sounds like a bunch of work, and it may take two or three hours with some FSM instruments. However, **it is something you should do,** possibly as often as once a year for an average meter, more often for a meter that is used heavily. And it is a bunch easier than having to go back and re-set a whole bunch of amplifier levels in the middle of the evening because the levels were actually 3, 6 or 10 db higher than your **otherwise** accurately calibrated FSM indicated!

put levels are common). The head end instrument *use-range* is the most diverse of all CATV uses of the FSM.

And while the range for measurements is high, the only area where really accurate measurements (i.e. within say +/— 0.5 db true voltage level accuracy) is required in the head end is at the trunk output to the system. This happens to be typically in the +32 to +52 dbmv region, a measurement area where 70 to 90 db of switched-in pad is employed. *If there are errors* in the switchable pads, they tend to *accumulate* for maximum real error in this region, simply because of the high total db of pad switched in to read in this region.

On the opposite end of the system, the measurement region required for house drops is tightly congested between 0 dbmv and +12 dbmv. The degree of absolute accuracy required in checking house drop levels is minimal; it is almost a "*go/no-go*" situation. A meter for installers only is basically a different "animal" than those currently being discussed in this series (3).

Perhaps the greatest requirement for exact, *true voltage level readings* is in the CATV plant. Most amplifier input/output signal levels fall within the +11 dbmv/+42 dbmv *range*, although a few go slightly higher than this. The call for *high accuracy* is usually on amplifier *outputs* rather than inputs, since most amplifier installations tend to be more tolerant of slightly incorrect input levels than of incorrect output levels. This means the highest calls for accuracy in the system is at the *CATV head end output*, and at *the amplifier output* areas. Both fall well *up the scale* of relative signal voltage levels, and cumulative errors in switched-in pads tend to be greatest here.

REVIEWING METERS

In the course of this four-part series, we will be investigating the operational characteristics of five separate FSM instruments. They are:

(1) *Blonder-Tongue Model FSM-2*
(2) *Delta-Benco Model FST-4*
(3) *Jerrold Model 727*
(4) *Mid-States Model SLIM*
(5) *Sadelco Model FS3SB*

Additionally, in the January issue we will review the *Jerrold/Texscan Model VSM-1*, an instrument that lives in the "twilight zone" between field strength meters and spectrum analyzers. It is also our intention, in the January issue, to discuss field calibration of FSM instruments. We will review the *Delta-Benco Model FSM-C4* calibrator and the *Measurements Model 950* calibrator, and because calibration of *absolute voltage levels* is an important function, this calibration methodology will be explored in some detail.

One of the greatest dangers when reviewing a product is the terrible *temptation* to be a design engineer, or to try to second guess why the people who designed the product approached it exactly the way they did. If you have some designing and manufacturing background, your first thought often is "that is not the way I would do that". And if you allow yourself to think along these lines throughout the analysis of a specific product, you may end up *liking none of what you see*. The design-type person always thinks his concepts are better than others, at least until he is shown differently, and the fellow who designed the instrument is seldom there to defend his philosophies, so naturally the reviewer always wins the argument!

We are reminded of a letter from a CATJ reader who said, "*Why don't you guys review some equipment, and tell us in plain language what is good and what is bad. . . . don't pull any punches!*" That seems like a pretty reasonable suggestion, except many

(*3*) *Installer meters will be the subject of a later series in CATJ.*

POLICY ON EQUIPMENT REVIEWS

Reviewing equipment is filled with dangers. First we run the risk of making **CATJ** advertisers unhappy. For a publication that depends upon advertising to a large measure, for operating expenses, that alone is a significant danger.

Second, there is the danger of sounding pompous and know-it-all. That turns readers off, and aggravates design people who might one day be asked to **cooperate** with future equipment reviews by providing equipment for test and design data.

Third, there is the danger that if we don't point out real failings, readers who already own the particular piece of equipment and know about those failings will say "aha... they didn't even mention the backwards mounting whammy!".

The safest thing to do is to not review equipment, and say nothing at all about anything. This safest of all roads is also the dullest, and if, in fact, we know something that CATV operators would profit by also knowing, then this is also the most dishonest approach (in the vernacular of the times, "sandbagging") we could possibly take.

Our equipment review policy is straight forward, and it is bound to make some people unhappy sometimes.

(1) Tell it like it is;

(2) Be very careful to accentuate the positive features, because one really positive feature may well make the minor negative features not so very important afterall;

(3) Recognize that nobody has ever (yet) built a perfect anything (and that includes a perfect equipment review!);

(4) Finally, **provide ample and adequate opportunity** for the designer or manufacturer of any unit reviewed to respond to the review, at the earliest possible date (through the TECHNICAL TOPICS column here in CATJ).

Our **"equal opportunity to reply"** extends to **readers** as well. Your own comments and observations are welcomed. Please understand however that if you have information to contribute and it is new information covering some aspect of a product which we overlooked, that before we print any **new** "negative comments" we will ourselves check out the observation, and go over it with the manufacturer before rushing into print with your letter.

When all is said and done, our primary objective is to be objective, **and accurate**, in anything we report here. That is the only way we can gain and keep reader confidence and supplier support.

would have us compare the Sadelco FS3SB directly with the Mid-States SLIM. Yes, both are field strength meters, but there any possible direct comparison ends. Another CATJ reader wrote, *"I see you are going to review field strength meters.... I hope you will tell us which one is the best unit."* Best? Best for whom? Best for what use?

None of the five units we will be reviewing are even similar. Yet, they represent the bulk of the instruments available today in the industry with "full-range capabilities". A CATV system looking for *certain* specific functions will find the Mid-States SLIM "best" for them. Another system looking for other specific functions will choose the Jerrold 727. Systems looking for general all-around meter useage will choose the Blonder-Tongue FSM-2 or Delta-Benco FST-4. Systems concerned about size will choose the Sadelco FS3SB, or a similar Sadelco unit.

As we review each instrument in this series, we hope you will keep in mind the fact that *there are advantages and disadvantages to every in-*

BLONDER-TONGUE FSM-2 with auxiliary sub-band converter covers through 83

strument. There is no perfect, "do-everything" CATV FSM instrument on the market, simply because it would be so big, so heavy, and so complicated that it would not be useable on a pole or up on the tower (and would therefore no longer be "perfect"). Every instrument on the market today makes one or more *compromises.* If the compromise is in an area where you have little use for a function, or where accuracy is not important, the compromise means little to you.

In each individual review we will point out the positive things the meter does, as well as point out where the meter design compromises make it less desirable than another unit on the market. When you consider new meters for your own system, you should begin by making a list of the *exact uses* to which you will put the instrument and the percentage of total operating time you expect each function to take. Then you will be able to select the meter best suited to your own requirements.

REVIEW – BLONDER-TONGUE FSM-2

The *Blonder-Tongue FSM-2* meter was perhaps one of the most difficult instruments for CATJ to review in a standard format because of the multiple-functions found in the instrument. The meter offers features such as *peak or average detection,* VHF *and* UHF, and a pot controlled 0-20 db *i.f. attenuator* in a combination not found in any other instrument.

The general FSM-2 specifications are shown here. Like virtually all instruments in this series, the basic electronics range is -40 to -20 dbmv; 100 microvolts is a full scale reading with no pad attenuation switched-in. The full attenuation-in range is +70 dbmv full scale, or 3.2 volts.

The front panel (see photo) has four slide switches selecting attenuation in the input attenuator of 10/20/20/20 db (left to right) for a total of 70 db. Additionally, the i.f. attenuator is a variable control that adds an additional 20 db of attenuation (90 total). The 0-20 db i.f. range pot is a 100K control located in the emitter circuit of the first i.f. amplifier. *It is extremely important that when the operator advances the first full 20 db of attenuation into the instrument* (i.e. to read -20/0 dbmv) that this i.f. attenuator control be *the first attenuation inserted.* With it in the "in" position, the basic range of the unit becomes not the standard -40 to -20 dbmv, but a new -20 to 0 dbmv. Unless this control is switched into the full attenuate position (the control "clicks" and locks) the i.f. amplifier stages in the FSM desensitize and the i.f. selectivity decreases rapidly. If you are having trouble separating adjacent aural and visual carriers with an FSM-2, check first to see if the 0-20 db i.f. attenuator is in the "in" or "on" position (*clicked and locked*).

The FSM-2 has the following options:

(1) *Converter - Model 4132,* covering 5-54 MHz (see photo). This unit attaches to the top of the FSM-2 and extends the range of the FSM-2 to 5 MHz on the low end, making it continuous from 5-220 MHz, and 470-890 MHz.

(2) *Converter - Model 4728,* covering 220-280 MHz. Like Model

4132, this unit attaches to the top of the FSM-2.

(3) *Handle Kit - Model 4134*, provides a method of rapidly attaching the FSM-2 to a suspended aerial strand (i.e. messenger).

(4) *Cover Kit - Model 4135*, provides a cover to fit over the front of the instrument for use in rainy weather.

(5) *Factory Calibration* — The specified accuracy of the FSM-2 is +/— 1.5 db over the frequency range 54-216 and 470-890 MHz. For many years the FSM-2 came from the factory with factory calibration notations provided in the instruction manual (i.e. correction factors). Currently *this is a $35.00 factory option* and a factory calibrated unit has the designation *FSM-2C.*

MEASURING MODULATION

One of the unique features of the FSM-2 is the peak or average detector circuit. *All CATV measurements for signal levels are made in the peak detector position or mode.* Virtually all other instruments employ only peak reading detectors and when you see output levels of amplifiers, etc. specified, it is always in a *peak* mode.

By offering either peak *or* average detection, with the aid of a simple chart appearing in the FSM-2 manual, you can quite accurately set or check percentage of modulation on a video (RF) modulator.

(1) The FSM-2 is adjusted (through a combination of switchable pads and the variable linear 20 db i.f. attenuator control) to give a full scale reading of exactly +10 db (on the -10 to +10 scale) with the meter in the peak reading mode.

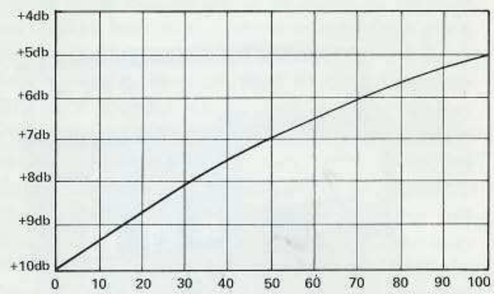


CHART TWO

(2) The detector selection is moved to the average position, and the drop in signal level noted. The *difference* between the peak read mode level and the average read mode level is found on a chart (see Chart Two) which gives you the modulation percentage.

Working backwards, it is an easy manner to set video drive to a modulator, or to set up the modulator "modulation control" to reach not more than 100% modulation peaks. By setting up modulators in this manner, you should be a little more assured that you are not driving the modulator into overmodulation and clipping sync pulses in the process.

NOTE: It must be emphasized that in normal CATV signal level measurements the meter *must be in the peak reading mode*, or all levels set by the operator may be *up to 5 db higher* than he thinks they are, with the result being cross mod or overload (from being that *far off* in plant amplifier level settings).

SETTING AUDIO CARRIER LEVELS

One of the more troublesome settings at a head end is setting the aural carrier level down the FCC specified 13 to 17 db below the visual carrier level for that channel. CATJ talked with several FSM-2 users who do it in this manner....

PEAK READING DETECTORS

Measuring the peak of sync tips is a challenging task. Peak detectors generally have **different efficiencies at different voltage levels.** With a 20 db scale range on the meter face, the peak detector **range** is 10 to 1. For the detector to remain at the same operating efficiency over a 10-1 voltage range is no easy trick. The inaccuracy of the peak reading detector is one of the major contributors to meter-scale-inaccuracies simply because the detected voltage fed from the detector to the meter amplifier and meter movement does not track true (as detector efficiency changes) over the 10 to 1 range.

By adjusting the visual carrier level to the proper output level, a reference for the aural carrier level is established. This is usually done at a fairly high level measurement point, and consequently the 0-20 db i.f. attenuator is "in" or "on". With the visual carrier level adjusted, the i.f. attenuator control is slowly turned from the full "in" position clockwise until the meter moves to full scale (+10 on the -10 to +10 meter scale). *Then the meter is tuned to the aural carrier and peaked.* Now the aural carrier level control (trap, etc.) is adjusted to read -3 db to -7 db on the -10 to +10 scale. The visual carrier reference was set to +10 with the i.f. attenuator pot and the only FSM control touched was the main tuning dial. Without changing any pads or switches, and without any mental computation, the same scale range is used to set the aural to the specified -13 to -17 below the visual.

This "trick" is made possible by the variable i.f. attenuator feature of the FSM-2. Anyone who has set aural levels and gone through the mental gymnastics of switching in or out 10/20 db of pad ("...let's see, +42 dbmv, switch out 10 db, I am looking for +29 dbmv, which will fall....") to set aural levels knows the frustrations involved.

However, there can be a problem with this technique. Recall in the first part of this series we pointed out that the basic meter movement normally has its *greatest degree of accuracy* in the 60-80% of full scale range, and its greatest degree of *inaccuracy* in the far left (-10 to 0) portion of the scale range. Thus when you crank in the i.f. attenuator to conveniently read +10 on the scale (full scale) and then tune to the aural carrier to look for a reading that is 13 to 17 db lower down, you are going to be right down there in the "most inaccurate region" of most meter scale/movements. When you add this inaccuracy potential to the +/— 1.5 db inaccuracy of the instrument itself, you might be 5 db or more off reading with the aural/visual carrier relationships.

UHF TUNER

The FSM-2 is one of the few instruments to provide UHF as a *standard feature* (i.e. you cannot buy the instrument without it). Blonder-Tongue builds in two separate "tuning heads": one for the standard VHF channels, and one for the standard UHF channels. A balancing network inserted between the VHF/UHF tuning heads and the input to the 40 MHz i.f. amplifier string provides a factory adjustment (R6, a 3K pot) to insure that the meter sensitivity (i.e. calibration) is the same on UHF as VHF.

The VHF and UHF tuning is accomplished with the same dial (knob). The user selects whether he is tuning for VHF or UHF with a slide switch on the front panel.

OTHER OPERATOR CONTROLS

In addition to the 10/20/20/20 db slide switches in the front end attenuator, the 0-20 db i.f. attenuator pot, the VHF or UHF selection switch, the detector switch (average or peak), and the frequency selection (tuning) knob, the user also has the following up front controls:

(1) Off / Battery / AC selection switch
(2) A mechanical-zero control screw for the meter
(3) An electrical meter-set control (compensates for changes in input operating voltage from AC or DC supplies)
(4) A detected video output jack

The detector output provides up to 2 volts peak to peak of detected (AC) signal, or 50 microamps of current (*across 500 ohms*). These are available at the front panel jack with full scale readings (i.e. +10 on the -10 to +10 scale), with the meter in the average detection position (mode). The 2 volts p/t/p sounds like it should drive a video monitor, but it won't. First, there is the problem of bandwidth (the 60 db down i.f. bandwidth of the FSM-2 is +/— 0.9 MHz). An adequate amount of video information simply does not get through the selective (reference selectivity of a TV receiver) FSM i.f. to provide *video plus sync* information to hold a monitor stable. Second is the mis-match problem. The 2 volts p/t/p is approximately 500 ohms and the transfer loss without a matching device is considerable (approximately 10 db). However, the *50 microamps is adequate to drive a chart recorder;* a subject to be discussed in greater detail in a later portion of this series.

CALIBRATION

Calibration is a double-edged sword. *First there is absolute calibration,* against a "standard" (i.e. being assured that +17 dbmv is in fact +17 dbmv, within the +/— 1.5 db factory specified accuracy); or in the case of the FSM-2C (factory calibrated model), within the tolerances specified.

Secondly there is the matter of meter-scale accuracy within any given 20 db scale range. All instruments to be reviewed by CATJ will include measurements made of the scale accuracy, and of the *apparent* absolute accuracy of the instrument itself.

Absolute accuracy is the area where people will be quickest to fault us, our equipment, and our techniques. All five instruments were measured at the same time, using the same calibrated source (*Measurements 950*). Measurements were made on channels 2, 6, 7, and 13 in the following manner:

(1) All instruments were set up per their instruction manuals for mechanical zero, electrical zero, tuner compensation, etc.;
(2) All instruments were operated from 110 VAC source(s);
(3) The standard (source) was first set up on channel 2. All instru-

CALIBRATE IN POSITION

Most meters require (or strongly suggest) the user set the mechanical zero of the meter before use. This is done with AC (or DC) power off against a meter-needle reference line usually imprinted on the meter face.

The purpose of this adjustment is to insure that the meter movement has a fighting chance of starting from zero-zero when power is applied. Meter movements are tension devices and subject to mechanical change as they age, get bounced about, or rest in an unusual position. The meter should always be used in one position (i.e. upright if so specified) and the mechanical meter zero control should be set with the meter (as specified by the manuel) with the meter in the recommended position.

Mechanical zeroing of the meter movement is usually accomplished by adjusting the meter movement front cover screw located at the base of the instrument needle.

Failure to mechanical-zero a meter as a part of the calibration procedure will result in even greater readout errors in the already compromised -10 to 0 db portion of the scale in particular.

ments (five FSM devices) were checked for their real indicated signal levels when the Measurements 950 was set to 0 dbmv output (actually +6 dbmv output with a precision Wavetek 7510 step pad inserted between the 950 output and FSM unit-under-test input);

(4) We waited 15 minutes and repeated the same series of tests on channel 2;

(5) We immediately moved to channel 6 and made the same tests, waited fifteen minutes and repeated;

(6) We immediately moved to channel 7 and made the same tests, waited fifteen minutes and repeated;

(7) We immediately moved to channel 13 and made the same tests, waited fifteen minutes and repeated.

Then we waited four hours, with all instruments operating on 110 VAC for that period, and repeated the tests exactly as noted above.

The numbers you will see in these reviews are the average readings measured, and worst-case readings. Where there were significant "cold-start" errors noted, the individual FSM reviews will indicate this. The *only purpose* of this test series is to measure the *accuracy of the instrument relative to our Measurements Corporation Model 950 "standard"*.

The matter of scale-range accuracy was checked in a separate test. The tests were repeated twice, once with the Measurements 950 as a +10 dbmv source, and then with a stable TV signal as the +10 dbmv source. Both tests were made on channel 9. The +10 level was chosen because on most of the meters checked, it is a "full scale" reading (on the Sadelco it is a near-full scale reading). We would be able to stay in the same meter-range (i.e. switch in no internal meter pads) to go down in external step attenuator 1 db steps and read the indicated meter change. We did this with both the Measurements 950 CW carrier and a real TV signal to detect the differences, which we suspected were there, between reading a CW (unmodulated, with sync pulses) carrier and one modulated with normal TV video and sync.

B-T FSM-2 ABSOLUTE LEVEL CHECKS

We experienced some difficulty in setting up our Blonder-Tongue supplied FSM-2 for electrical zero. The manual suggested that you first set mechanical zero with the meter off, and in the operating position. This we did. Then the manual suggests two ways to set "electrical zero":

(1) Place the 20 db i.f. attenuator "in" and disconnect any RF input;

(2) Turn on the electrical-zero screw on the front panel until the meter needle lines up with the *electrical-zero reference line* on the meter scale.

This we did.

Then they suggest a "better method" is to tune in a real TV signal with the 10 db slide switch attenuator "out" or "off", and obtain a reading of approximately 5 db on the -10 to +10 meter scale. Then:

(1) *Turn "out" i.f. attenuation* with the variable pot until the indicated level moves right *to a full scale +10 db reading;*

(2) Switch "in" the 10 db slide switch attenuator and note whether the meter needle *drops exactly 10 db* to the 0 db position on the scale;

(3) If it does not drop precisely 10 db, adjust the electrical-zero control and then the i.f. attenuator, back and forth (switching the 10 db slide switch attenuator "in" and "out") until you

have the electrical zero control set so that when 10 db of pad is taken "out", the meter drops from an indicated +10 on the scale to an indicated 0 on the scale.

On the meter B-T supplied us, the *best we could* do was an indicated +1.5 (or an 8.5 db indicated scale drop when 10 db of pad was switched "in"). While we had this best case going, when we disconnected any RF input from the meter the needle dropped not to -10, but *off scale* to the left of -10 to approximately the same resting place as meter-off *mechanical zero.*

We confirmed the 10 db slide switch pad was accurate with an external pad, and then tried the same procedure with another FSM-2. *We had no difficulty in making the second FSM-2 set up as the manual suggested;* only when we disconnected any RF from this second. FSM-2. The meter fell back and rested *not at -10, but at -8 db on the scale* (considerably up-scale from the normal no-signal condition). We have brought this to the attention of Blonder-Tongue and they have the opportunity to respond to our tests in our TECHNICAL TOPICS section of CATJ as soon as they wish.

Moving on to the absolute level tests, we used the instrument B-T supplied, adjusted to the best-case position for scale accuracy (as noted previously, this was an 8.5 db scale drop with a 10 db RF level drop), and here is what we found:

UNIT: Blonder-Tongue FSM-2
SPECIFIED ACCURACY: +/— 1.5 db
TEST INPUT LEVEL: 0 dbmv

Channel	Average	Worst Case
2	1.0 low	1.5 low
6	0.0	0.3 high
7	0.5 low	2.0 low
13	0.5 low	1.5 low

From a cold start, we found we needed approximately five minutes at room temperature for the tuning dial to stabilize (where we could set it and walk away, and come back and still find it was peaked on the carrier). The stability seemed independent of VHF channel being measured.

FSM-2 SCALE ACCURACY TESTS

Specified Accuracy: +/— 1.5 db
Test Input Level: +10 dbmv
Input Types: CW (unmodulated) carrier Modulated channel 9 carrier

Input Types:
CW (unmodulated) carrier
Modulated channel 9 carrier

Input Level (True)	CW Carrier Reading	Modulated TV Reading
+10	+10	+10
+ 9	+ 9.2	+ 9.5
+ 8	+ 8.5	+ 9.1
+ 7	+ 7.8	+ 8.3
+ 6	+ 7.0	+ 7.5
+ 5	+ 6.0	+ 6.9
+ 4	+ 5.1	+ 6.0
+ 3	+ 4.2	+ 5.0
+ 2	+ 3.2	+ 4.0
+ 1	+ 2.5	+ 3.5
0	+ 0.9	+ 1.8
— 1	— 1.8	+ 2.8
— 2	— 1.3	— 0.7
— 3	— 2.8	— 2.0
— 4	— 3.9	— 3.0
— 5	— 5.1	— 4.5
— 6	— 6.9	— 6.2
— 7	— 8.5	— 8.1
— 8	—10.0	—10.0
— 9	—10.0 +	—10.0 +
—10	—10.0 +	—10.0 +

B-T SCALE ACCURACY CHECKS

As noted previously, a methodology for checking individual 20 db scale range accuracy was devised, using both the Measurements 950 as an unmodulated CW source, and a modulated commercial TV signal on channel 9. The results appear here in table form.

The FSM-2 scale tracking errors are most apparent in the modulated TV signal tests, with worst case showing up around 11-14 on the 0-20 scale, and then again at the very low end (0-2). The meter (*contrary to many others*) tracks quite well in the -3 to -7 region.

BLONDER-TONGUE LABS, INC.

FSM-2

Frequency Range—VHF: 54-220 MHz
UHF: 470-890 MHz
Full Scale Sensitivity:
100 microvolts to 3.2 volts in 10 ranges
Input Impedance: 75 ohms
Selectivity:
at 3 db points, +/— 0.25 MHz;
at 60 db points, +/— 0.9 MHz
Accuracy: +/— 1.5 db
Temperature Range: -20 to +120 degrees F
Power Requirements:
105/130 VAC, 50-400 Hz
18 VDC (2-9 vdc, series)
Weight: 13 lbs. with batteries
Size: 12-5/8" x x 7-3/4" h x 7" d
Battery Drain: 15 mA
Minimum Battery Voltage Required:
13 volts
Price Range: $410.00

OTHER OBSERVED FEATURES

Any given instrument can have good, fair, or poor dial accuracy (an FSM is *not* a frequency meter). The FSM-2 tracked well through the low band range, but read slightly high in the high band range. The only problem this presents is being certain you are on 9A, rather than 10V, when you are reading aural and visual levels in a fully loaded system. By starting off with the lowest carrier present (i.e. channel 7 video) and working up, you should have no trouble keeping tabs on the one you want. Of course you can use an earphone and obtain audio from the detector jack to listen for either audio or sync buzz, depending upon the "type" of carrier you think you are after.

The 0-20 db i.f. attenuator in an FSM-2 can be custom calibrated by the user with an external 1 db step pad, and some type of marking machine, on the front panel. The black dots on the front panel (there are 11 total) should *not* be assumed to be 20 db divided by 11 indicator marks. However, once calibrated, you should go back whenever you do a full meter calibration and re-check your custom calibration marks.

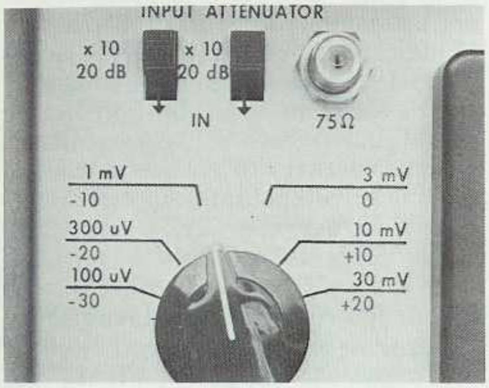
Some users try to use this i.f. control as a tuner compensator *to correct for errors* across the VHF (or UHF) bands. This is probably a mistake, since even with accurate calibration of the i.f. control, you are still subject to meter-scale errors. The accuracy of the compensation, as applied at i.f., *will only be good for the particular portion of the meter scale originally used* in calibration.

Finally, users are cautioned always to check whether the meter is in the average, or peak detector position. One user we spoke with liked the meter "for the first six months" but "lately it has been reading low". After chatting awhile, we happened to ask whether he had ever used the average detector for modulation checks. "Yes, once, about two months ago" was the response. "And how long has the meter been reading low?", we asked. "About two months", he noted.

Yes, he had never *returned the switch* to the peak position (and had not checked the volt set) in the two month period.

REVIEW—DELTA ELECTRONICS FST-4

The Delta-Benco Electronics FST-4 meter is a completely solid state instrument that can be powered from either AC mains, or internal battery (DC) supply. The user automatically switches, with no actual manual switching, from DC to AC operation (or AC to DC operation) by inserting (or unplugging) the AC line cord from the outlet. Thus, if the instrument is operating from AC mains and the power goes off, the unit will continue to function by internally switching to DC operation.



DELTA-BENCO FST-4 10 db step attenuator simplifies read out interpretation

The unit employs the standard format discussed previously in this series (October CATJ). A switched front-end attenuator works in 10 db steps and the front panel is calibrated, around the rotary attenuator switch, in the ranges you are utilizing. There are a total of six 10 db rotary step positions, and two additional 20 db slide switch attenuators.

The meter is commonly used in the following ranges:

-40/-20 range (-30 dbmv mid-scale)
-30/-10 range (-20 dbmv mid-scale)
-20/0 range (-10 dbmv mid-scale)
-10/+10 range (0 dbmv mid-scale)
0/+20 range (+10 dbmv mid-scale)
+10/+30 range (+20 dbmv mid-scale)

Then for a +30/+50 range, one of the 20 db switchable pads is brought "in". For the +50/+70 range, the second 20 db switchable pad is brought "in". Because of the 10 db steps in the rotary ranges, the first 20 db switch can be brought "in" at any point, as well as at the end.

The straight-forward rotary attenuator in 10 db steps makes getting used to the meter's calibration ranges quite simple. The rotary switch tells you the exact range you are in (up to the +30 dbmv range, after which you bring in the first 20 db slide switch pad), and this keeps human error to a minimum.

As the photo of the front panel of the unit shows, the panel includes a tuning compensator for adjustment to the absolute value calibration scales. This compensation factor is affixed to the front panel with a special ink. It will wash off with some moderate pressure and a detergent, but it should stay in place for years of normal use.

The power on/off switch includes a battery-check position, although the checking consists of measuring the supply voltage from the regulator. The power supply, in addition to including a circuit that automatically switches from AC to DC (or vice versa) when AC is taken away (or initially supplied), includes a protection circuit to insure that damage to the unit cannot occur should battery polarity be reversed.

Range tuning in one continuous band from 54 to 250 MHz is accomplished by employing the time-tested Mallory Inductuner, which has been around in one form or another about as long as television. This makes for a very stable tuning system, and in reasonable environments, frequency drift is practically eliminated, due to the mechanical construction of the tuner.

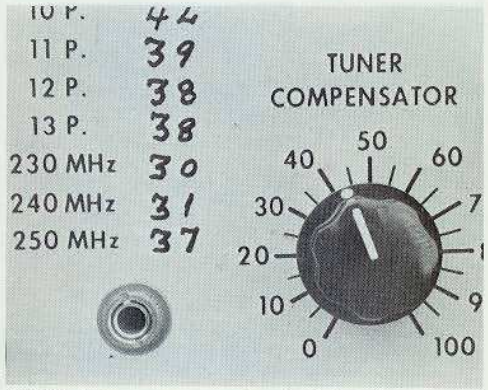
The FST-4 has separate video and audio output jacks. The video output is approximately 0.75 volts peak to peak through a standard F fitting. The audio output has its own audio amplifier out-

DELTA-BENCO FST-4 is completely self-contained with AC/DC supply put stage, and a small earphone is provided.

Apparently, the everyday use of this meter by Canadian operators, in an environment which frequently gets much colder than that experienced by stateside operators, has caused the "spec writer" for the instrument to think twice. As the small table inset at the beginning of this review notes, the accuracy of the meter is specified as "settable to" +/— 0.5 db. Delta mentions they calibrate meters with a Hewlett Packard type 431B power meter and a 8402A calibrator. Their manual covers re-calibration with their own FSM/C-4 calibrator simply enough so that most anyone, who has modest experience, can do the job. The specification for meter accuracy to an absolute standard reads "overall accuracy from 0 degrees F to +120 degrees F is +/— 2.0 db". But they note, "...the final calibration and testing holds the accuracy of each unit to a figure of +/— 0.5 db." Of course, a great deal of the *real accuracy* depends upon the care with which one sets the tuner compensator

DELTA ELECTRONICS FST-4

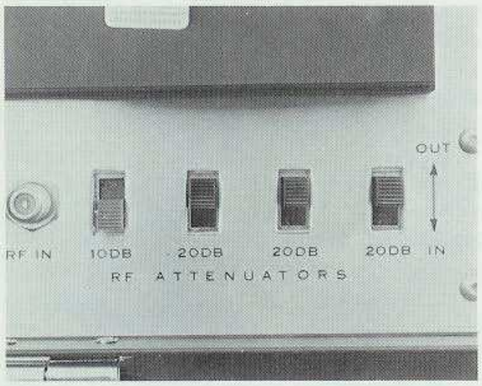
Frequency Range:
54-250 MHz, continuous
Full Scale Sensitivity:
100 microvolts to 3.2 volts in 10 ranges
Input Impedance: 75 ohms
Selectivity:
at 3 db points, +/— 0.25 MHz
Accuracy: +/— 2.0 db (*)
(*—Settable to +/— 0.5 db accuracy)
Temperature Range: 0-120 degrees F
Power Requirements:
105/130 VAC, 60 Hz
18 VDC (2-9 vdc, series)
Weight: 8 lbs with batteries
Size: 10-5/8" w, 8" h, 6"d
Battery Drain: 13 mA
Minimum Battery Voltage Required:
11 volts
Price Range: $345.00



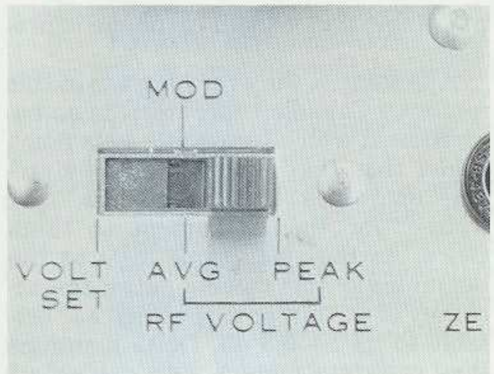
FST-4 tuner compensator includes front panel compensation settings

control, and the care with which the initial compensation values were set and noted on the front panel. When we ran our absolute accuracy analysis with the Measurements 950 calibrator, we found the accuracy to be within the +/— 2.0 db range specified, but also found that for very little effort we could correct it to the same accuracy as the Measurements 950 (one tracked the other) within the +/— 0.5 db range. More about that shortly...

The manual with the FST-4 is not elaborate, but its detail is to be commended. There is just the right amount of circuit designer theory and a nice, readable amount of "what to do in case of trouble" data to keep the meter in *your* hands most of the time, and out of the factory repair depot. Many, many problems can be corrected by the average technician, *if* he is given just a few basic design and operating facts with which to work. We feel instrument manufacturers who attempt to keep the user in the dark about the mysteries of the black box, only end up hurting themselves. The straight-forward approach of Delta in their manual is a step in the right direction. If the manual were expanded just a tad to include several inside-of-case photographs, with call-outs of the various important sections and stages, as a guide to locating measurement points within the meter, it would be about as



BLONDER-TONGUE FSM-2 front end attenuators are slide switched



BLONDER TONGUE FSM-2 operational switch includes battery check

complete as any CATV tech or engineer could want.

We took the FST-4 with us for a week of tramping around on mountain tops and muddy head ends. We used it to chart record an off-the-air signal one night for a fellow who wondered how far down (and up) his signal wandered for a particularly difficult 110 mile path, and we got into the "trenches" of a buried plant to help set up a series of trunk and extender amplifiers. In short, we used it quite hard for that length of time. Our major complaint is with the dial which reads out the channel or frequency to which you are tuned. It tracks very, very well, but mechanically it has a few problems. We actually had two FST-4 units—one with a small knob inset within the side of the case (a good idea to keep you from busting off an extended knob), and another with a (protruding) geared extension knob and drive. Both units were almost identical electrically (i.e. accuracy). The only difference was in the mechanical knob. We felt the geared drive moved too slowly. Getting from 2 to 13 simply took too long. *Both units had a similar problem* with the imprinted channel/frequency *calibration sheet* that is glued (or somehow implanted) onto the rotating drum that turns behind the window. The imprinted strip is flat when it begins, and it is affixed to a circular drum. This means there are two natural ends to the strip. On both units, the *end* of the imprinted strip on the low frequency end (channel 2) came loose very quickly. As you operate the unit, the flyaway end rattled and banged around; we suspect, sooner or later, the entire imprinted sheet would come loose. Repairing it is no big deal. We simply think it should not have come loose in the first place. And since it did on both units, we suggest Delta re-check the way they affix these strips to the drum!

FST-4 ABSOLUTE LEVEL CHECKS

Because there is a tuner compensator on the front panel of the FST-4, we were obliged to include setting this compensator to the correct position with the mechanical checks specified in the manual, before proceeding to reference the FST-4 absolute level measurements against the Measurements 950 standard we used for all of these meter checks.

The FST-4 had no worst case and best case differences in measurements on any channel; *it always checked the same.* So, that showing will be eliminated in this report section.

UNIT: Delta Electronics FST-4
SPECIFIED ACCURACY: +/— 2 db (*)
Test Input Level: 0 dbmv

FST-4 SCALE ACCURACY TESTS

Specified Accuracy: +/— 2.0 db (*)
Test Input Level: +10 dbmv
Input Types:
CW (unmodulated) carrier
Modulated channel 9 carrier
(*—settable to +/— 0.5 db)

Input Level (True)	CW Carrier Reading	Modulated TV Reading
+10	+10	+10
+ 9	+ 9.1	+ 9.2
+ 8	+ 8.2	+ 8.2
+ 7	+ 7.2	+ 7.1
+ 6	+ 6.2	+ 6.0
+ 5	+ 5.3	+ 5.0
+ 4	+ 4.4	+ 4.2
+ 3	+ 3.5	+ 3.1
+ 2	+ 2.6	+ 2.1
+ 1	+ 2.0	+ 1.1
0	+ 0.8	+ 0.1
— 1	0.0	— 1.0
— 2	— 1.1	— 2.0
— 3	— 2.0	— 3.0
— 4	— 2.9	— 3.9
— 5	— 3.9	— 4.9
— 6	— 5.0	— 6.4
— 7	— 6.2	— 7.5
— 8	— 7.0	— 8.8
— 9	— 8.0	— 9.8
—10	— 9.1	—10.0 +

(* 0-120 degrees F; settable to +/— 0.5 db)

Channel	Level	TC Spec	TC R/S
2	+1.0	77	68
6	+0.8	70	64
7	+1.9	34	15
13	+2.0	38	18

In the above tabulation, the "level" is the indicated level when the Measurements 950 was set to 0 dbmv output. The "TC Spec" column is the tuner compensation setting specified on the FST-4. The "TC R/S" column is the re-adjusted tuner compensation value to match the 0 dbmv output of the Measurements 950 with a 0 dbmv indicated level on the FST-4.

FST-4 SCALE ACCURACY CHECKS

The same technique for checking FST-4 scale reading accuracy was employed with the B-T FSM-2 (see previous description in this report). FST-4 results appear here in table form.

The FST-4 tracked exceedingly well through the ranges from 20 (+10) down to 5 (-5), falling apart (*relatively* speaking) only in the lower few db on the far left-hand portion of the scale. Interestingly, the peak detector tracked sync signals *better than the CW carrier* for the full range. The accuracy of the scaling was better on tracking sync tips, than on an unmodulated carrier all across the range, *except* at 18-20 (+8/+10).

OTHER OBSERVATIONS

For a small, lightweight, relatively inexpensive meter, the FST-4 has a great deal of accuracy and (we suspect) dependability going for it. It is not a fancy instrument. It is a basic, frills-cut frequency selective voltmeter.

Anything you might want to add would result in greater weight, perhaps greater bulk (although there is plenty of room left in the innards of the case), and more money. The most obvious feature missing is a UHF tuning head. UHF has come to Canadian telecasting only recently, and we suspect that some arrangement for use of existing FST-4 instruments for UHF cannot be far behind. There is in fact a UHF entry line on the tuning compensator, and an entry on that line for compensation of the tuner when used for "UHF", which are not explained in the manual.

However, by *leaving* UHF out of the basic instrument, Delta has been able to concentrate on providing a quality VHF instrument which they adequately explain in their manual. We suspect many technicians already appreciate this instrument.

SYNOPSIS

This series will continue with Part Three in the December issue of CATJ. At that time we will review the Sadelco FS3SB (with super band), the Jerrold 727, and the Mid-States Model SLIM.