State—Of—The—Art

RICHEY FINALLY DESIGNS A FREQUENCY COUNTER FOR CATV SYSTEMS

Back in the September 1976 CATJ we began a series on "do-it-yourself" CATV system test equipment. In the September issue we described a 'modulation stripper' or signal processor/limiter device with which a system could prepare a carrier for frequency counting with an external frequency counter. This is the 'other shoe' for that project; a newly developed (state-of-the-art) frequency counter designed to allow the system operator to make system carrier frequency measurements for perhaps less cost than would otherwise be possible.

The FCC rules, when we began this series, required *all* cable systems of any size (50 subscribers up) to perform *annual* measurements of the on-cable carrier frequencies for any carrier signals which have been frequency translated (i.e. converted) between the off-air frequency received and the cable frequency carried. To measure the frequency of a cable signal, one modulated with video information, requires that the system strip or eliminate the video modulation information from the carrier before measurement. The box or device to do the modulation-eliminating was described in the September CATJ (page 46). It was our intent at the time to come back in December with the designed-for-CATV frequency counter unit. As we got close to the point of buttoning up the counter along about early November, we were advised by parts suppliers of a whole new generation of counter/pre-scaler devices. The pre-scaler is the device that allows you to take a basically low(er) frequency frequency counter and drive it with higher (or VHF) frequency signals. The new "chip" looked so good we decided to start all over again with the counter; it simply meant that we would be eliminating about half the cost and an equivalent amount of circuit. That translates to dollars saved and time saved in the construction of the unit. *The opportunity was too good to pass up.*

And, in the interim the FCC has re-evaluated who must make annual frequency measurements and who could get by with "on-demand" frequency measurements. So maybe it is just as well we got sidetracked with new technology because now perhaps many CATV systems who would otherwise have felt compelled by FCC rules to acquire frequency measurement capabilities will have second thoughts about spending the dollars for a tool that may only be required once per year.

A Nifty Device

The counter described here is very much state-of-the-art. It utilizes the latest chip technology, which means that we have fewer parts and more counting capability for fewer dollars invested. Anyone who remembers the ten-year-ago frequency counters (they weighed about 150 pounds and required daily maintenance!) can appreciate just how small, compact, and relatively speaking component-simple the newest generation counters are. Perhaps someday the ultimate state-of-the-art frequency counter will read and display to 7 places (or 8) with a single "chip" and the whole device will fit into the palm of your hand. For now, the unit to be described here this month and next is about as compact and simple to construct as the art today allows.

The heart of a digital frequency counter is a decade counter. The decade counter takes an input signal and counts the signal pulses present. A signal pulse is one complete cycle or 1 Hz. One kilohertz is 1,000 complete cycles and one megahertz is 1,000,000 complete cycles. The basic decade counter counts to ten complete cycles (or 10 Hz) and then it "outputs" a 1 (i.e. it says "the 1 I am outputting tells you, the user, that I have just seen ten complete cycles go by"). As shown in diagram one, if we input to the decade counter a 16 Hz signal the first decade counter watches the first ten cycles zip by and then it kicks out a "1". This one goes to the next decade counter in line which says "Ok...there is '1 hertz/cycle to me'", and it displays a 1. Meanwhile back at the input decade counter the remaining 6 cycles zip by and

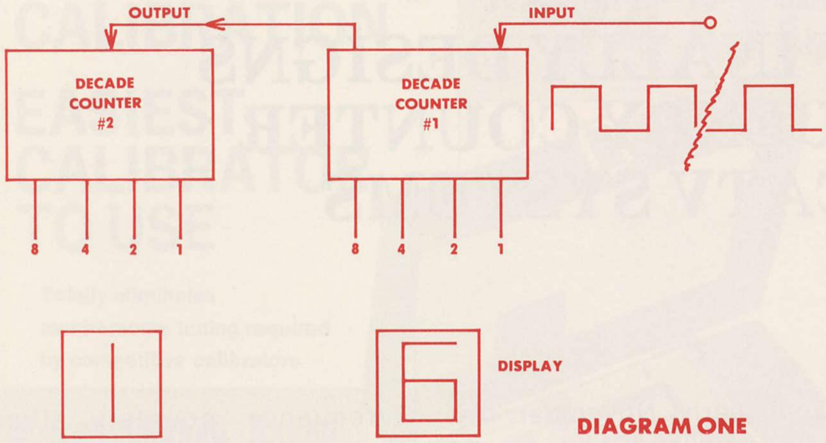


DIAGRAM ONE

there being no more cycles passing by, the first decade counter displays a 'partial count' of 6. With two decade counters and displays we can count cycles or hertz up to 99. If we want to go higher than this, we need to add another decade counter (to the left of the unit displaying a "1" in diagram 1). That would take us to 999. And so on, adding a new decade counter each time we want to increase the count capacity by ten times.

In a typical counter useful for CATV we would have an 8 decade count that would take us up to 99,999,999 hertz (or 99.999999 megahertz). This is an interesting exercise but it is not getting us to our goal. For if we kept feeding the hertz to the input of the unit, it would count up to its full capacity (whether 99, or 99,999,999) and then like your car speedometer it would return to 00 (or 00,000,000). So we are only part way to a frequency counter. What we have at this point is an "events counter" and while it may count very far and very fast. . .we need to do some more work to allow us to count and display frequency.

Remember that a carrier wave is self-calibrating at so-many cycles or hertz per second. So if we want to count the number of hertz or cycles represented by the carrier wave we need to develop a timing circuit that turns on the count mechanism at one point, keeps the counter-counting for a pre-determined period of time, and then turns off the mechanism. Well, if you think back into your theory, the carrier wave frequency is self-calibrating at so many hertz or cycles *per second.* In other words, when we glibly say channel two is 55.25 megahertz, what we are really saying is that *in one second of time* the channel two visual carrier signal will go through 55,250,000 complete cycles of RF. So it follows that if we want to count how many hertz are going through our counter and then translate that number into the *actual frequency* involved, we need to measure or open up our counter for *one second time.* So at the input to the counter device (i.e. the decade counters) we install a very fast and precisely controlled time "switch". We call this "switch" a gate and we call the signal that drives this switch a "gating signal". The gating switch *could be* controlled by internally looking at the 60 cycle AC power source and turning itself on for one complete cycle of AC (remember there are 60 cycles of AC per second). Therefore the AC cycle would provide the gating signal or time base for our "switch" (see diagram 2).

However, this is not such a good system (it has been found) so a better system has been developed, using a (typically) one megahertz *crystal* oscillator. If you take a 1 MHz precise-frequency oscillator and feed it into a series of dividers you can divide 1,000,000 hertz by 10 and get 100,000; and then divide that by 10 and get 100, and then divide that by 10 and get 10; and finally divide that by 10 and get the reference 1 Hz signal. One advantage to using a 1 MHz oscillator crystal for our reference signal is that we can feed the output of the 1 MHz oscillator to a shortwave communications receiver which we have tuned to the National Bureau of Standards signal at 5 or 10 or 15 MHz. By adjusting the 1 MHz oscillator circuit trimmer, we can bring the counter master gating oscillator into excact *"zero beat"* with the NBS precision shortwave signals and thereby *"calibrate"* our own counter gating oscillator signal.

Pre-Scaling

Most available decade counters will not work high enough in frequency to allow us to count much beyond 5 MHz or so (yes, there are high priced exceptions but we are trying to hold the cost down) so you have to put another electronic box *in front of* the basic counter unit to bring the frequency down to some range which the counter *will* accept. This box is called a "pre-scaler" and it is a cross between a frequency converter and a divider system.

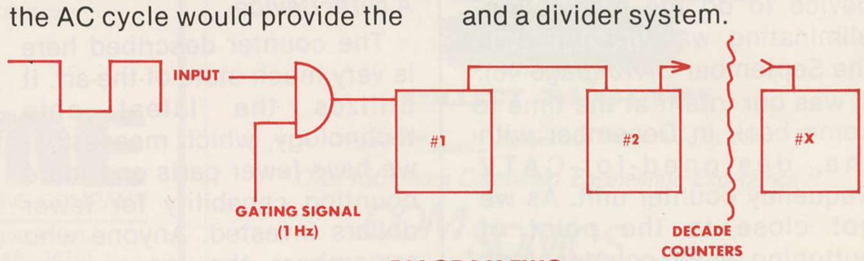


DIAGRAM TWO

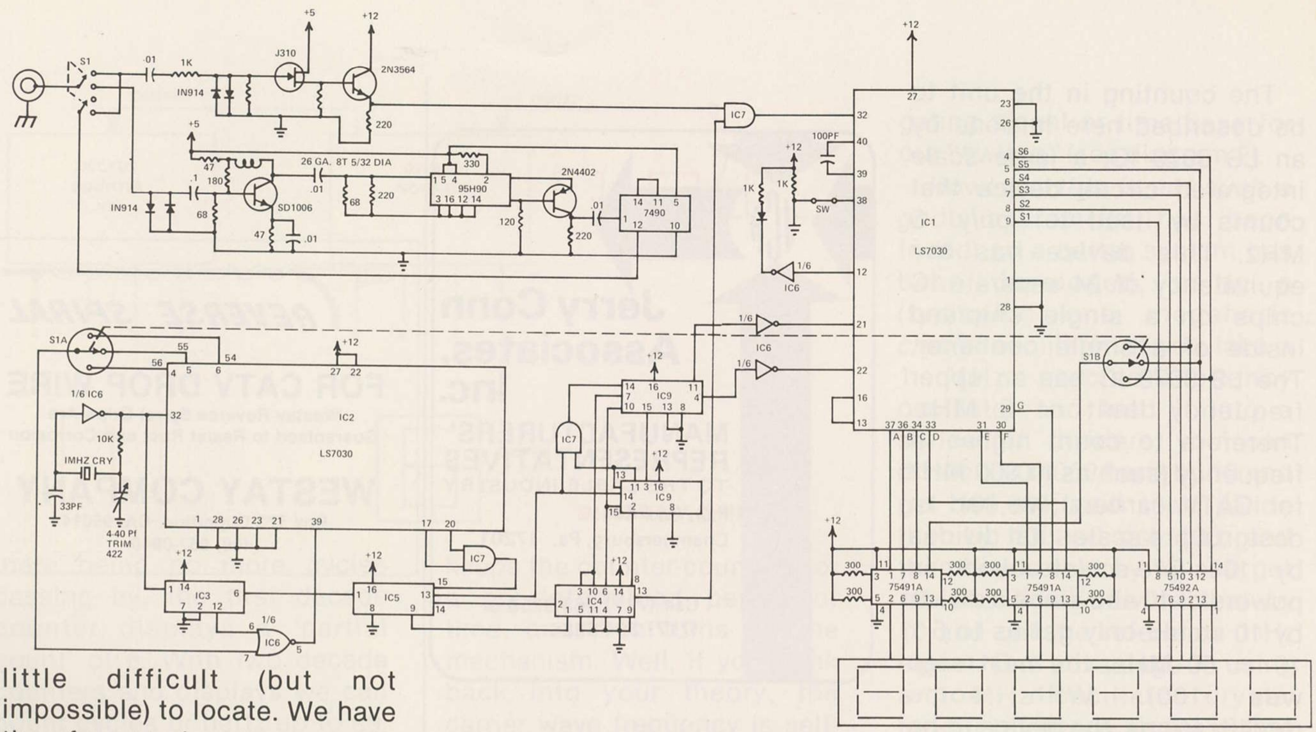
The counting in the unit to be described here is done by an LS 3070 IC; a large scale integrated circuit device that counts by itself to *"only"* 5 MHz. This device has the equivalency of 24 separate IC chips on a single chip/and inside of a single container. The LS 3070 IC has an upper frequency limit of 5 MHz. Therefore to count higher in frequency (such as to 300 MHz for CATV carriers) we had to design a pre-scaler that divides by 100 (pre-scalers work in powers of 10 and since a divide by 10 would only get us to 5 x 10 = 50 MHz, the next step was 100). With some modifications, the device to be described *might* well count to 450 MHz.

The pre-scaling is done by something called an *emitter coupled logic* (ECL) *chip.* This device accepts a signal up to 300 MHz at the input and then it outputs to exactly 1/10th of the input frequency. Which means that 300 MHz goes in and 30 MHz comes out. This is a 95H90 pre-scaler chip. The 30 MHz output from the 95H90 is then fed into a 7490 pre-scaler IC which *again* divides by 10, resulting in 30 MHz in and 3 MHz out.

Two Parts

The general discussion here is intended to acquaint you with the basic design problems associated with constructing a counter for CATV signal carriage measurements. The full schematic is also presented and the parts list. You can begin to gather parts and otherwise get oriented so that next month when we come back with the step-by-step construction of the unit you will be ready to roll. If you have no problem working directly from schematics, you are off and running at this point.

Because of the nature of the state-of-the-art approach, some of the parts may be a



little difficult (but not impossible) to locate. We have therefore made arrangements with a local outfit called Electronic Research and Development (see parts list) to supply those parts marked with an (a) as well as a complete circuit board for the unit. It is our belief, having priced all of the parts, that the total cost should come to between $100 and $115 for the complete package (including the PC board). If you have priced 300 megahertz counters recently, we think you will agree this is a pretty decent price, even if you do have to put it together in your own system shop.

One caution: Remember that as you start to accumulate parts that most of the IC devices are CMOS. *This means they must be handled with extreme care.* They come to you in protective cases. . . *leave them there* until you are ready to install them in the IC sockets. They are easily damaged when 'out in the open' by stray static charges, such as your body carries.

CATV COUNTER - PARTS LIST

Qty.	Item	Identification	Note
2	**LS7030**	IC # 1,2	(a)
1	4013	IC # 4	
1	4017	IC # 8	
1	4022	IC # 9	
1	4024	IC # 3	
1	4081	IC # 7	(a)
1	4572	IC # 6	
1	7490	IC # 10	
2	**75491A**	IC # 13,14	
1	75492A	IC # 12	
1	95H90	IC # 11	
1	7805UC	regulator	
1	7812UC	regulator	
1	2N3564	transistor	
1	2N4402	transistor	
1	SD1006	transistor	(a)
1	J310	FET	(a)
6	**FND500**	**LED display**	
1	1 MHz Xtal .01%		(a)
2	**47 ohm**	**resistors**	
2	**68 ohm**	**resistors**	
1	120 ohm	resistor	
1	180 ohm	resistor	
3	**220 ohm**	**resistors**	
8	**300 ohm**	**resistors**	
1	330 ohm	resistor	
3	**1K**	**resistors**	
1	4.7K	resistor	
1	10K	resistor	
1	1M	resistor	
4	**.01 MFD**	**capacitors**	
1	.1 MFD	capacitor	
1	33 pF	capacitor	
1	100 pF	capacitor	
1	422	trimmer cap	
1	SPST	switch	
1	DPST	switch	
1	2 pole, 3 pos. rotary switch		
1	PC board	main	(a)
1	PC board	display	(a)
2	**IC sockets 40 pin**		
4	**IC sockets 16 pin**		
4	**IC sockets 14 pin**		
1	enclosure	5.25 x 9.5 x 6.75 (")	
1	transformer		(a)
4	**2 amp diodes**		
1	line cord		
1	fuse holder		
1	5500 MFD, 25 v capacitor		

(a - a source for these parts is **Electronic Research & Development,** 5611 NW 37th, Oklahoma City, Oklahoma 73122.)

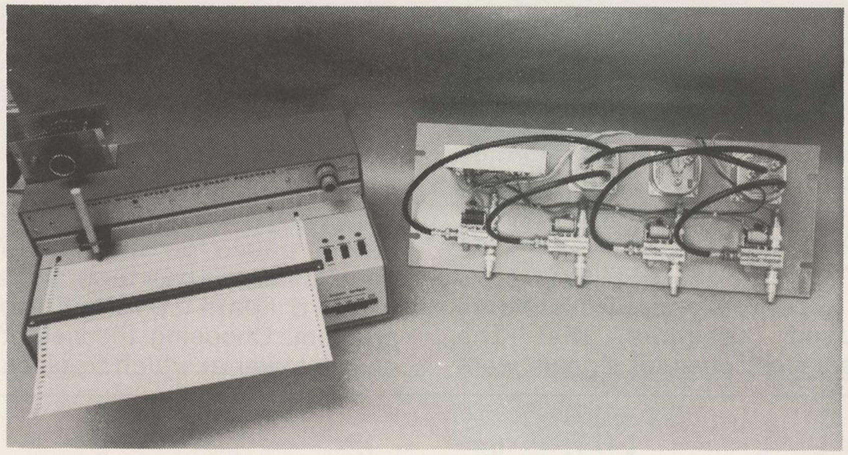
Is The Top Always Best?

SELECTING THE TOWER LOCATION FOR A UHF RECEIVING ANTENNA

In the process of engineering a four hop microwave system designed for the purpose of importing WTCG Atlanta into three Alabama cable communities, a combination signal-pick-up/microwave transmissions site was needed.

Economic considerations prevented the use of more than one microwave hop into the nearest system and, as a result, some compromises had to be made with respect of site selection. The resulting tower location was therefore selected primarily upon microwave path considerations, although a nearby cable operator indicated that reasonable quality reception of Channel 17 could be obtained. None-the-less, the pick up point was far from ideal since it was **90 miles** for channel 17 transmitter, and because there was an **adjacent channel 18** approximately 70 miles distant, and a two-removed channel 19-54 miles away.

Past experience had shown several things about long distance reception of UHF signals.



INEXPENSIVE HEATH IR-18M single channel recorder (kit) is turned into four channel recording device with analog read-out of recording channel using package shown right of recorder.

1. **Reception** at a distance of 80 miles or greater **can result in deep fading** under certain conditions.
2. **Adjacent channels** with signal strengths in the same order of magnitude of the desired signal can create interference that is sometimes **difficult to eliminate.**
3. **The height** of the receiving antenna is in some cases **critical.**

Note that the three statements are hedged considerably. The facts are that prediction of the result is difficult, thus no invariant statements have been made.

In the case at hand, the receive site was located as shown in diagram 1, with respect to the three signals noted.

Fortunately, for microwave purposes, it was possible to find a mountain top site. The site was about 10 feet below the crest of the mountain on the east side. A 160 foot tower was installed for the microwave and Channel 17 receiving antenna. Removal of adjacent channel interference was the first step after the tower was in place. Diagram 2 shows the technique that was used. The antenna signal was amplified by a low noise Channel 17 preamplifier. Following the preamp was a specially designed UHF band pass filter which attenuated the adjacent

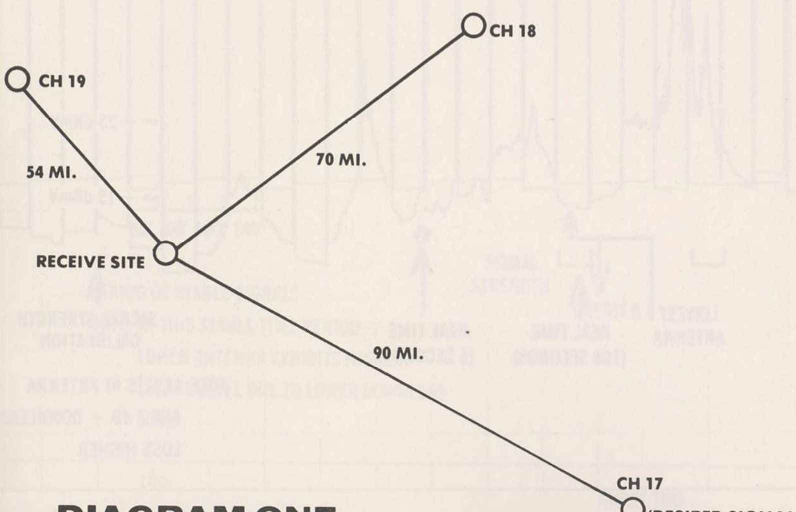


DIAGRAM ONE

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