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RF Note #43

April 9, 1979
R. Gress

REPORT ON A STUDY OF AVAILABLE COMMERCIAL SYNTHESIZERS

Introduction

A commercial synthesizer must be acquired to serve as a primary signal source for the RF system. This synthesizer will feed mixing circuits to derive the appropriate signals for phase detection etc. (See Fig. 1). As an aid to this acquisition, a fact-finding study was undertaken to evaluate units presently on the market, and the following is the result of that study.

Synthesizer Specifications

Synthesizer specifications fall into four general catagories: resolution (settability); spectral purity; stability, and programability. Following consultation with various persons here at the lab, a set of kep specifications was identified. Performance-wise there seemed to be three pivotal specs: resolution, stability, and programability. Acceptable values were decided upon and each unit was examined in the light of these requirements. To enable one to develop a hand-shaking familiarity with how these specs are defined and interpreted, they will be discussed in the paragraphs to follow.

Frequency resolution, or settability, is defined to be the smallest output frequency increment generated in the synthesizer. The minimum resolution desired was taken as 100 Hz. This is a very relaxed value since 1 Hz settability is fairly standard. It is not uncommon for units to offer resolutions of .1 Hz, and in fact, a few boast 1 millihertz specs. In cases where resolution was optional, a value of 10 Hz was chosen. This is a comfortable margin and not significantly more expensive than 100 Hz.

Frequencyprogramability is standard on most units. Remote programming is accomplished by one or more of the following: IEEE bus, parallel GCD/TTL, or contact closures. In general, units with frequency programming are also equipped with output level programming. Associated with this is a quotation of switching speed or settling time. This is usually quoted as time required to be within a given Δf of the final frequency. However, some manufacturers fail to specify this Δf.

The range of common settling time values is 10μS to 5 Msec. a reason for this wide range will be discussed in section III.

Consideration of settling time transients may be appropriate for the instance of frequency touch-up with RF applied. At this writing, it is uncertain whether the new system will better tolerate phase transients due to fast or slow switching speeds. The longest settling time of the acceptable units is 40 M Sec.

Spectral purity, in general, is a measure of the frequency domain composition of the output signal. A general consideration involves dealing with the complete RF spectrum, which is actually the sum of two spectra, one due to amplitude variations, the other due to phase fluctuations. Commonly included under this spec are harmonic, subharmonic, and spurious frequency levels; residual AM; residual FM, and Phase noise. These latter two items are more properly considered measures of short term stability which is the topic of the next section. Although spectral purity was not considered one of the critical specs, the following values are offered as guidelines. Harmonic (and subharmonic) levels should be at least 25-30 dB below the fundamental. The majority of synthesizers meet this, and in fact, it is difficult to achieve a better value. Spurious frequencies, on the other hand, are much easier to suppress and should be down by at least 70 dB. AM noise may be quoted either as residual AM or integrated AM noise, but in either case, this level should be at least 70 to 80 dB below the fundamental. These methods of specifying AM noise are analogous to the residual FM and integrated phase noise discussed in the next section.

Frequency stability, perhaps the most crucial specification, is also the most difficult to pin down. To date, no official standard measure has been chosen by either IEEE or the National Bureau of Standards. As early as 1964, NASA and the IEEE jointly sponsored a symposium on short-term stability. Following this, the IEEE Subcommittee on Frequency Stability was formed and charged with defining this measurement. Since then, many papers have been written attempting to eliminate the uncertainty. The large diversity of definitions and measurement methods causes problems. Measurements are made both in the frequency and time domains. It is also natural to divide this specification into long and short-term stability. Here again, a problem arises in defining long-term and short-term. Deterministic effects on stability, such as power line fluctuations and crystal oscillator ageing are considered long-term effects. Statistical effect, such as those based on noise, are classified as short-term instabilities. A common long-term measurement is the simple fractional frequency fluctuation, usually quoted a ppm/day. Short-term stability, however, is measured in a variety of ways. These methods are residual FM, phase noise spectral density, integrated phase noise, frequency spectral density and the variance of fractional frequency fluctuations. Of these, only the first three are quoted by manufacturers. Although there is no standard officially decided upon, one is tacitly assumed. Phase noise spectral density is the preferred frequency domain measure, and the frequency variance the preferred time domain method. of the three measures quoted by manufacturers, residual FM and phase noise spectral density are most frequently given. Since makers often specify only one or the other measure, the question arises as to how to compare units described so differently.

While the means is not necessarily obvious, one can calculate an equivalent residual FM given a phase noise density. Appendix I defines these quantities completely and given the details of this conversion. Here it is sufficient to say that residual or incidental FM and the phase noise spectral density (signal to phase noise ratio) are actually interchangable and to state how manufacturers quote each of these. A phase noise spectrum is a distribution of signal to phase noise ratio, in dB, on a per Hertz basis. Usually a graph of this ratio, in dB versus frequency distance from the fundamental, is included on the spec sheet. At the least, several points off such a cruve will be given. Residual FM noise is the equivalent RMS frequency deviation required to produce a sideband of specified amplitude, at a specified frequency offset from the fundamental. The specified frequency is taken to be the sinusoidal modulation signal causing the deviation. A common quotation will state the RMS or peak deviation in Hertz or ppm, and the measurement band width (usually 3 kHz). An offset (modulation) frequency should also begiven, but usually it is not. Such measurements are the less useful integrated residual FM type.

At this point, we need to find a good value for this spec. We can get a lower bound on possible values by considering a standard reference oscillator.

The typical phase noise density for a high stability crystal oscillator has a value of about -136 dB, 100 Hz removed from the fundamental. This translates into a residual FM frequency deviation of .002 Hz in a 3 kHz bandwidth. We may consider this the best obtainable value, since super stable crystal oscillators are only slightly better. Now then, what is a reasonable upper limit? It was decided that the output frequency should never deviate more than $\pm$ 2 ppm from the chosen value. This places the most stringent limitation ($\pm$ 18 Hz) on 9 MHz. Using this peak Δf value, the example is Appendix I calculates -56 dB is the required signal to phase noise ratio at 100 Hz from the fundamental. Obviously this is a very relaxed value, since most units involved in this study quote sideband ratios of -90 dB or better with a 100 Hz offset (See table 4).

For completeness, the third method of specifying stability should be mentioned. Integrated phase noise is a signal to phase noise ratio given by :

$$\frac{ESB\ (30\ kHz)}{Ec} \Big/ \ dB$$

Where ESB(30KHz) is the RMS value of the total phase noise sidebands in a 30 KHz B.W centered on the carrier (excluding $\pm$ 1 Hz). Such values are usually only quoted in addition to the phase noise spectral density.

To sum up, we can now completely define the synthesizer performance required to meet our needs.

Required Specifications:

1. Resolution: 100 Hz
2. Remote Programmability
   a. Type: Preferably TTL/parallel BCD
   b. Switching time: unspecified
3. Spectral Purity
   a. Harmonics (Subharmonics): -25 dB
   b. Spurious: -70 dB
   c. AM noise: -70 dB
4. Stability
   a. Long term: ± 2 ppm/day
   b. Short term
      1) Residual FM: 18 Hz @ 100 Hz offset, measured in a 3 KHz B.W.
      2) Phase noise spectral density: -56 dB signal to phase noise ratio @ 100 Hz offset, in a 1 Hz B.W.

Following are the tabulated results of the study. Table 1 lists manufacturers considered, and in Tables 2 and 4 acceptable units are compared in the light of the above specs. Table 3 lists unacceptable units and the basis for rejection.

Table 1

MANUFACTURERS CONSIDERED

Adret	Rohde & Schwarz
Fluke	Boonton
Rockland	Systron-Donner
Hewlett-Packard	Marconi
General Radio	Wavetek
Racal-Dana	Ailtech

Table 2

ACCEPTABLE UNITS

MFR	MODEL	FREQ RANGE	PRICE	PROG	TUNING METHOD	SERVICE NOTES
Adret	6101B	.4 - 600 MHz	$12.9K	P	Rotary Dec. Switches	1
"	7100A	.3 - 650 MHz	10.0K	P	Main + Vernier Knob	1
Fluke	6160B	1 - 160 MHz	6.3K	P	Rotary Decade SW	2
Rockland	5600-23	.1 - 160 MHz	5.2K	P	"	3
HP	3335A	0 - 80 MHz	7.0K	P	Single Knob	4
"	8660A	1 -1300 MHz	16.1K	P	Thumbwheel Switches	4
Rohde & Schwarz	SMS	.4 - 520 MHz	7.3K	P	Pushbutton Switches	6
Ailtech	360	0 - 180 MHz	8.7K	P	Pushbutton Dec Switches	5

Table 3

UNACCEPTABLE UNITS

MFR	MODEL	FREQ RANGE	PRICE	PROG	BASIS FOR UNACCEPTABILITY
Wavetek	3001	1-520 MHz	$3.0K	P	Resolution
Gen Rad	1062	.01-500 MHz	?	P	Discontinued
"	1061	0-160 MHz	8.0K	P	"
Marconi	2020	.05-520 MHz	25.8K	P	Price
Rohde & Schwarz	SMDS	10KHz-1GHz	46.7K	P	"
HP	8640B	.5-512 MHz	6.7K	NP	Resolution/Non Prog
Systron-Donner	1701	100Hz-1GHz	4.2K	P	Spurious/Resid. FM
Boonton	102D	.45-520 MHz	4.7K	NP	Non prog.
Racal-Dana	9081	5-520 MHz	5.0K	NP	"

Service Notes:

1. A board exchange exchange program is being set up for the 7100A only. The 6101B must be set back to the Freeport, N.Y. service cneter. Approx. 1 week repair time.

2. Units must be sent to Rolling Meadows, IL. service center. A Livonia service center is coming in about 1 year. Service time ≈ 30 da.

3. Policy has been no charge board exchange program for life of the unit. Service center: Rockleigh, N.J. 24 hr. board receipt time possible. Above policy is not in writing.

4. All units must be sent to Rolling Meadows, IL service center. For 3335A, cost varies with extent of damage. 8660A - standard calibration = $240, standard repair = $305, repair of oscillator or rectifier assembly -EXTRA. Service time ≈ 2 weeks.

5. Exchange with demo plug ins or main frame is possible while unit is repaired at RONKON KOMA, N.Y. factory.

6. Return unit to Fairfield, N.J.

TABLE 4

COMPARATIVE SPECIFICATIONS

	RESIDUAL FM (Hz) @ 100Hz	PHASE NOISE (dB) @ 100Hz	LONG TERM STABILITY (PPM)/da	RESOLUTION (Hz)	PROGRAMMING METHOD	SETTLING TIME (μS)	HARMONICS (dB)	SPURIOUS (dB)	METHOD OF SYN. I = INDIRECT D = DIRECT
ADRET 6101B	.006	-90	.02	1	BCD	2×10^3	-30	-80	?
" 7100	.02	-80	144 (3)	1	IEEE	10^5	-35	-100	?
FLUKE 6160B	6×10^{-4}	-110	.017	1	BCD	800	-30	-83	I
ROCKLAND 5600-23	.001	-105	.002	10	BCD	20	-40	-75	D
HP 3335A	1.6×10^{-4}	-122	.01	.001	IEEE	2×10^3	-40	-75	?
" 8660A	.006	-90	.03	1	BCD	5×10^3	-25	-50 (1)	?
R&S SMS	— (2)	— (2)	.03	100	IEEE	4×10^4	-30	-60	?
AILTECH 360	8×10^{-4}	-108	.03	1	BCD	20	-35	-94	D
REQ'D →	.32	-56	2	100	BCD	—	-25	-70	

(1) For +10 dBm output, -70dB for < 10 dBm output

(2) insufficient data available.

(3) vernier on.

Types of Synthesizers

There are two basic techniques of coherent frequency synthesis. These are the direct and indirect methods. The direct method generates frequencies by direct arithmetical operations on a reference signal, such as addition and subtraction (mixing), multiplication and division. Fig 2 shows the most widely used approach - add and divide. This scheme was developed circa 1949 at the Naval Research Lab, patented in 1958 and first commercially used by H.P. and Fluke in the early 1960s. Two advantages of this system are fast switching times (20 µSec) and a fail safe feature. This latter quality guarantees no output if any section of the system fails.

Indirect synthesis uses feedback to generate frequency increments via phase lock loops (PLLs). The output of a voltage controlled oscillator (VCO) is divided down, compared to a reference oscillator and the resulting error voltage controls the VCO frequency. While either analog or digital PLLs may be used, most modern units are designed around digital schemes. Many circuit variations of each type are possible, and Figs 3 and 4 show a typical diagram of each. In the past, the indirect method proved to be the less expensive design. However, today there seems to be little cost advantage to this method. Some of the more important and interesting performance characteristics of this system should be noted.

First, the PLL acts as a filter. As far as reference noise is concerned, it behaves as a low pass filter. It performs as a high pass filter for VCO noise. Thus, in the phase noise power spectrum, noise close to the output frequency is associated with reference oscillator noise, and noise far removed in frequency is due to the VCO(s). The advantage here is that noise from the potentially worst source is kept away from the output frequency. One of the severest problems associated with the digital PLL, is that caused by the frequency limit of integrated circuits used as variable ratio deviders. Low loop frequencies result in smaller frequency increments (high resolution). However, low frequencies here also mean slow VCO corrections hence an inability to remove residual FM due to systematic variations (e.g. vibration). Also, low loop frequencies are difficult to filter and could lead to possible phase modulation of the VCO. The result usually is a unit with a lower frequency limit and less resolution than a direct design. In terms of programmability, indirect synthesizers have switching speeds as slow as several milliseconds compared to 10-20 µS fordirect units. Also as noted previously, most indirect types are not fail safe as are the direct types. In case of circuit failure resulting in loss of phase lock, the output frequency becomes indeterminate due to a free running condition.

Synthesizer Frequency Range

Table 2 reflects quite a diversity in frequency coverage among the various units. we desire a synthesizer output in the range of 142 to 205 MHz. This is the scheme shown in Fig. 1. However, it is possible to use units with the lower frequency ranges (up to 160 MHz) as illustrated in Fig. 5. Originally, the main reason for going so high in frequency was to reduce the bandwidth such that signal processing circuits could perform better in the mixing scheme. The 7-70 MHz range with a frequency ratio of 10, becomes 142-205 MHz with a ratio of 1.56. Thus, one can shrink a decade of frequency to less than an octave. Using the lower frequency scheme (97-160 MHz), of Fig. 5, only slightly increases this ratio to 1.64. Since the 90 MHz XCO is already on hand, one 88 MHz oscillator would have to be purchased. Notch filters for 90 and 88 MHz should be added to the existing lowpass filters to take out the XCO frequencies. Only very minor component changes might have to be made to the amplifier and buffer circuits. These circuits would actually perform a bit better at the lower frequencies. Cost of this method would be about $200 over the cost of a 160 MHz unit alone.

Another method of utilizing a lower frequency synthesizer is that recommended by Fluke to double the frequency limit. This is illustrated in Fig. 6. Using devices recommended, the quoted harmonic specs are acceptable. Assuming all necessary components are purchased commercially, cost of this method is $6.7K versus $6.3K for the Fluke unit alone.

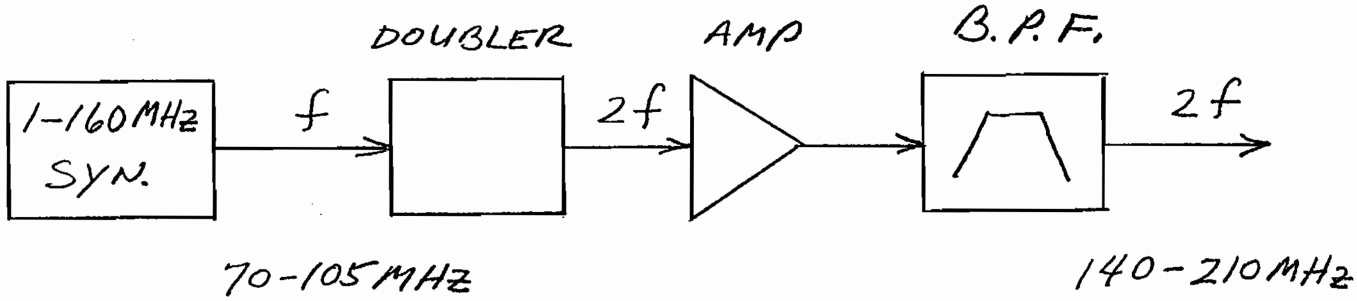


FIG 6

Rockland also recommends this method.

There is a reason for the 160 MHz limitation on several synthesizers. It turns out that this frequency is the comfortable limit for the ICs used.

Employing the HP 3335A is a somewhat different matter. The 0-80 MHz frequency range would have to be heterodyned up to the desired 142-205 MHz band. An additional mixer/filter combination would be required.

Additional Information - Acceptable Units

A few supplementary comments, concerning the manufacturing companies and their respective units, would be in order at this point.

Adret - A French company specializing in synthesizers, reportedly one of the world's largest, now allied in this country with Comstron - also a synthesizer manufacturer. At least two distributors dropped Adret for poor service in the past(units had to be returned to France). Apparently this has been solved by joining with Comstron. Demo units are available.

7100 A - Self diagnostic, defective board is identified. Composition of unit:

Basic Unit 7100 A	$7,500
Programmable frequency (option 4)	1,800
1 Hz resolution (option 5)	700
	$10,000

6000 - Composition of unit:

6101 Main frame without search	4,125
6315 .4 - 600 MHz plug in	8,745
	$12,870

Fluke - A venerable company with experience in 50 MHz synthesizers. Demos are available.

6160 - A five year old design.
Composition of unit:

Basic unit 6160 B	5,995
5 ppm/yr. TEXO reference	295
	$ 6,290

Rockland - Apparently, a much respected synthesizer company which in the past sold wholesale to H.P. Rockland equipment used by National Bureau of Standards and NASA. Demos available.

Up to date
5600-23-(a two year old design)

Basic unit 5600-23	$5,210

H.P. - Not much to add here.

3335 A -	
Basic unit 3335 A	$7,000
8660 A - Composition of unit:	
8660 A Main frame	7,400
86602B RF plug in	4,874
11661B frequency extension module	3,816
	$16,091

Rhode & Schwarz - Established German RF instrumentation firm. Seemed behind state-of-the-art until now. Demo available.

SMS - a new product with full decade to decade carry over	7,300

Ailtech - An RF instrumentation manufacturer. Has absorbed Singer (another RF instrument company). Both are well established firms. Demos available.

a four year old all BCD design	
360 - Composition of unit:	
main frame	4,850
.01 - 180 MHz RF plug in	3,830
	$ 8,680

For comparison (cont. Ailtech)

1 MHz - 1.8 GHz plug in	8,830
Main frame	4,850
	$13,680

Recommendations

As table 4 clearly shows, all the acceptable units compare quite closely. Since the performance specs are so similar, it seems justifiable to let cost become an important criterion for selection. For this reason, the HP 8660A may be eliminated. The Adret 7100A has a problem with long-term stability with the tuning vernier on. This vernier must must be on to achieve 100 Hz resolution, hence let us rule out this unit. Additional mixing is required to use the HP 3335A, so we may put it aside. The Rhode and Schwarz unit is interesting, however it is primarily a portable unit (not crucial) and it is a bit of an unknown in the stability department. So, we might delete this unit. This leaves four units to choose from. In order of preference, the low frequency units are:

Rockland	5600-23
Ailtech	360
Fluke	6160B

The obvious high frequency choice:

Adret 6101B

Should one of the low frequency units be chosen, the scheme of Fig 5 is recommended.

Also, it would be desirable to test all units chosen for demonstration with the auto correlation phase-noise-measurement setup described by Jack Riedel in RF Note #37.

Photos of the recommended units are attached.

Appendix I.

Short term frequency instability can be modeled as a carrier frequency modulated by a complex modulating sygnal.

Fig 7b is the residual FM noise (phase noise) power spectrum resulting from the modulating signal of Fig 7a. The modulated carrier has the equation:

1) $$V = E \sin(2\pi f_o t + \theta(t)) = E \sin(2\pi f_o t + \Delta\phi \sin 2\pi f_m t) = E \sin B$$

The instantaneous frequency is:

2) $$f = \frac{1}{2\pi}\frac{dB}{dt} = f_o + \Delta\phi \; f_m \cos 2\pi \; t_m t$$

1) expresses noise as phase noise.
2) expresses noise as residual FM noise.

$\Delta f = \Delta\phi \; fm$ — peak frequency deviation

$\Delta\phi = m = \frac{\Delta f}{fm}$ — modulation index = peak phase deviation

For M <<1, the only significant components of the Bessel expansion of 2) are the first upper and lower sidebands. Only the upper sideband of Fig 7b is considered for measurements (SSB phase noise). It is well known that the ratio of the amplitude of either sideband to the carrier is:

$$\frac{ESB}{Ec} = \frac{M}{2} \quad \text{or} \quad \left.\frac{ESB}{Ec}\right/_{dB} = 20 \log \frac{\Delta f}{2fm}$$

A typical phase noise spectral density given by manufacturers is shown in Fig 8. This may be measured with the autocorrelation set up of Fig 9.

Similarly, a residual FM density curve (Fig 10) may be obtained by the set up of Fig 11.

Integrated phase noise is the RMS sideband level over a 30 KHz band width centered on the carrier. A 1Hz band centered on the carrier is excluded. Similarly, residual FM is often quoted as an RMS Value of Δf obtained by integrating the curve of Fig 10 over the .5 Hz to 15 KHz bandwidth. However, these integrated values are not quoted by all manufacturers, and the conversion to SSB phase noise values is not straight-forward. Hence for comparison, the SSB phase noise density should be used for all units. There is also a simple conversion from the phase noise sideband value at a specified frequency, to an equivalent Δf (or vice versa).

Example: Calculate the phase noise-to-signal ratio, at 100 Hz offset, due to 2 ppm deviation on the 9 MHz carrier.

$$\left.\frac{E_{SB}}{E_C}\right|_{dB\,(3KHz)} = 20 \log \frac{18}{2(100)} = -21\ dB.$$

Assuming Δf = 18Hz is measured in the standard 3 KHz band width. However, the phase noise to signal ratio is quoted on a per Hz basis, and the conversion is made as follows:

$$\frac{E_{SB}(1Hz)}{E_{SB}(3KHz)} = \sqrt{\frac{1}{3000}} = .0183$$

OR

$$\frac{E_{SB}(1Hz)}{E_{SB}(3KHz)} = -35\ dB.$$

thus,

$$\left.\frac{E_{SB}}{E_C}\right|_{dB\,(1Hz)} = -21 - 35 = -56\ dB.$$

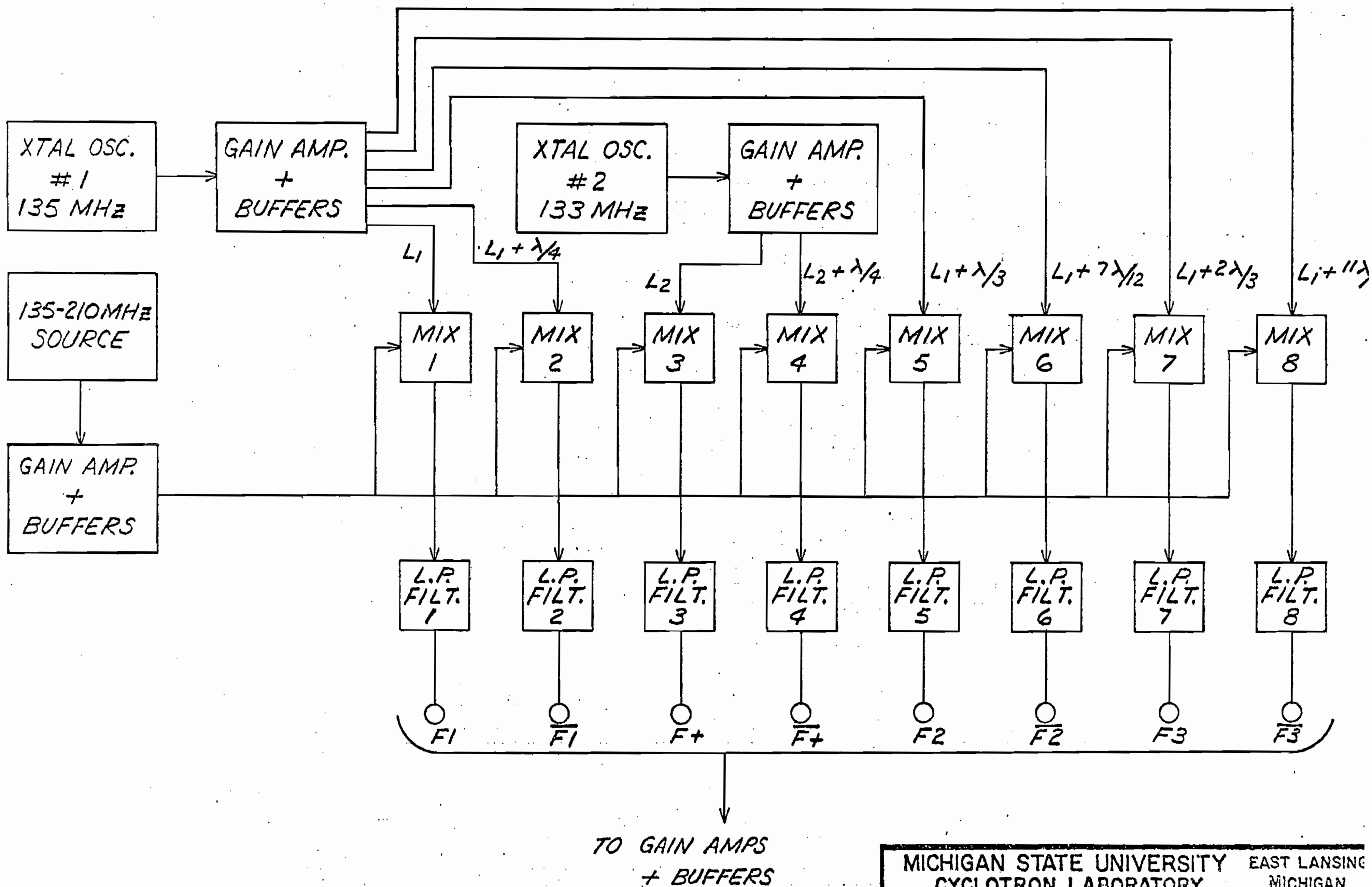


FIG 1

MICHIGAN STATE UNIVERSITY CYCLOTRON LABORATORY — EAST LANSING MICHIGAN

SCALE: — | DRN BY: WS | REV'D:

FREQUENCY SYNTHESIZER

DATE: 7-19-78 | APPR'D BY: | DRAWING NO.: 5-REK-1K-1-A | RE: 1

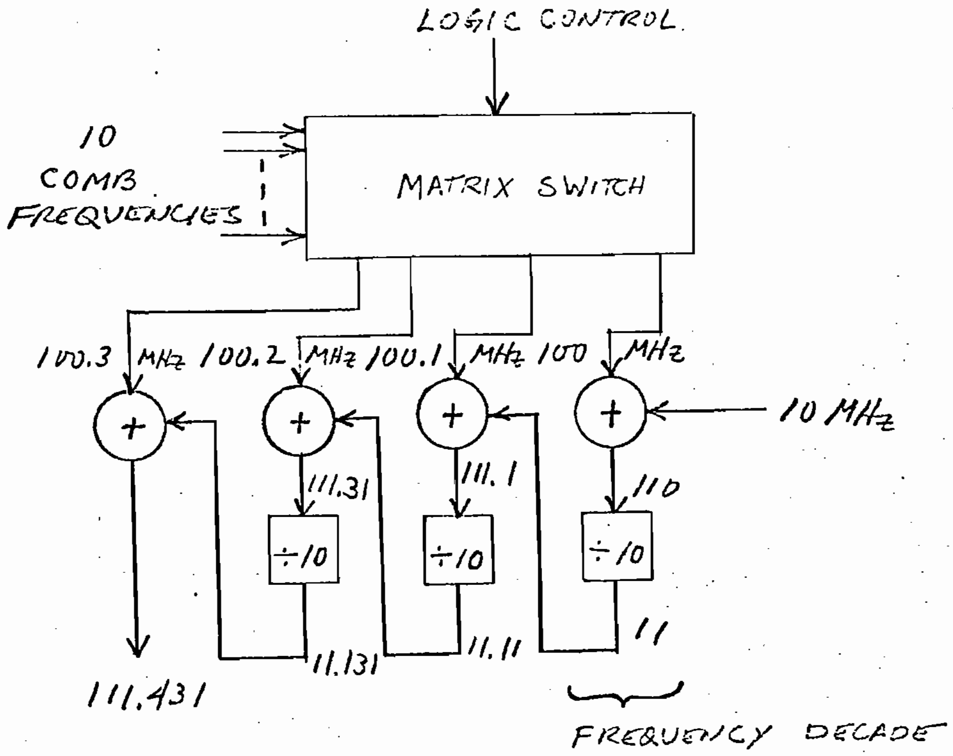


FIG 2 ADD & DIVIDE

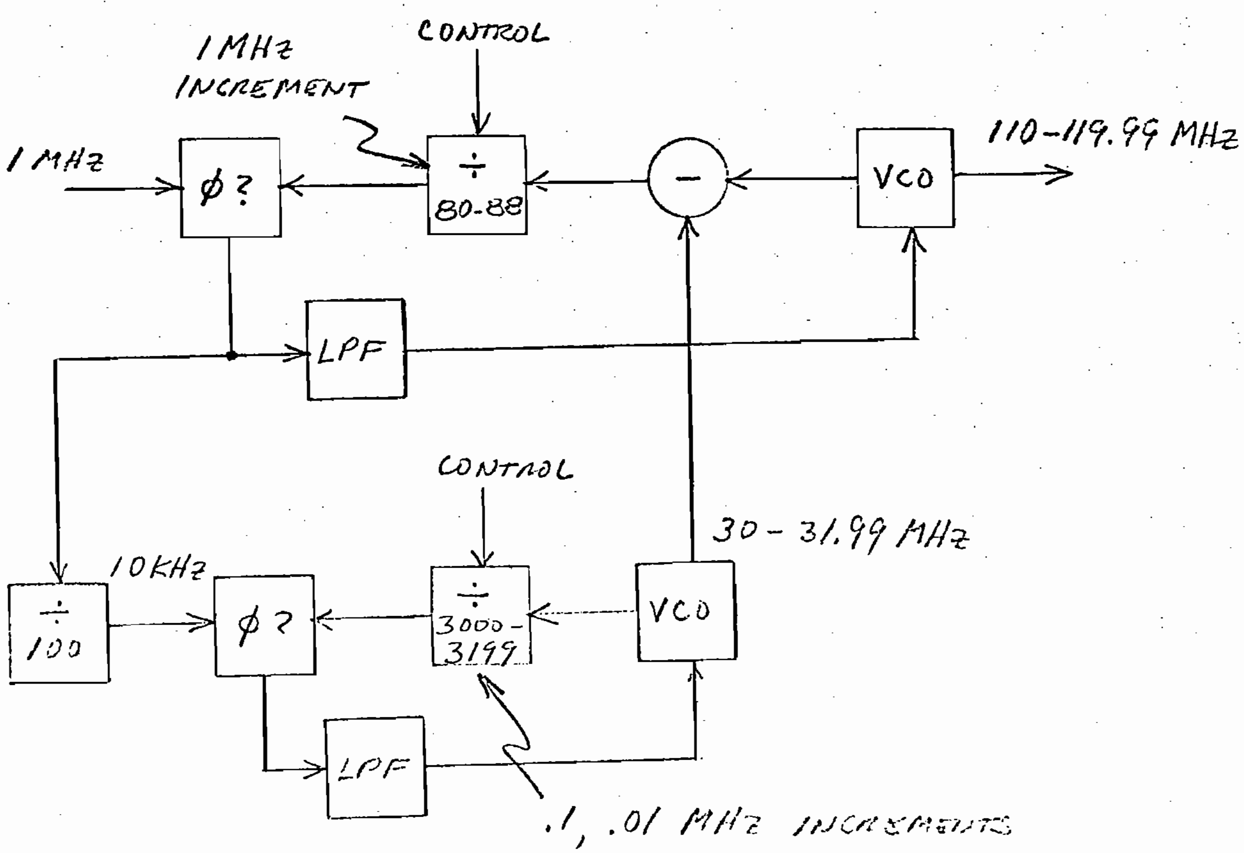


FIG 3 DIGITAL PLL

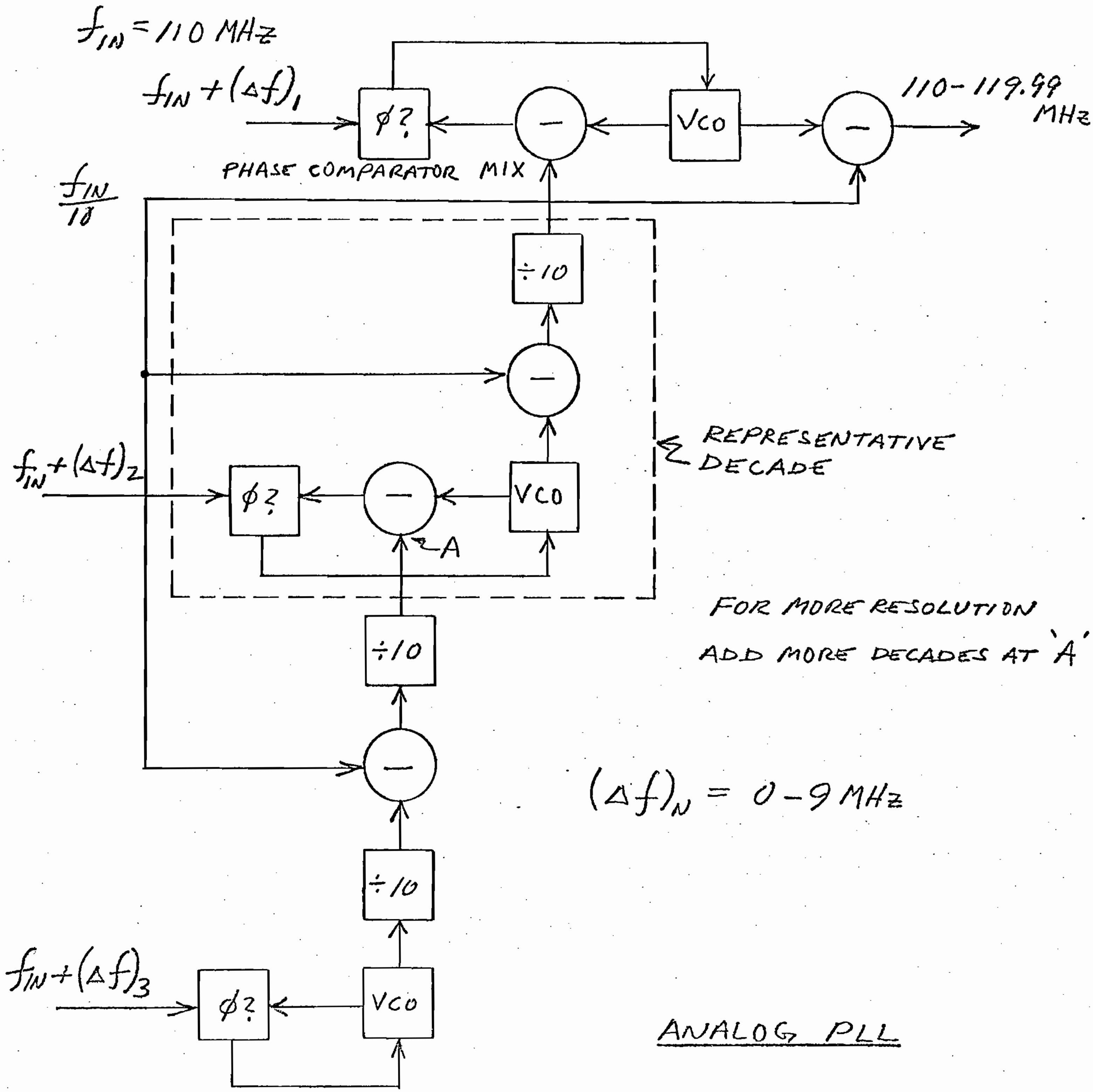

fIN = 110 MHz
fIN + (Δf)1
φ?
PHASE COMPARATOR
MIX
VCO
110 - 119.99 MHz
fIN/10
÷10
REPRESENTATIVE DECADE
fIN + (Δf)2
VCO
A
FOR MORE RESOLUTION
ADD MORE DECADES AT 'A'
(Δf)N = 0 - 9 MHz
fIN + (Δf)3
ANALOG PLL

FIG 4

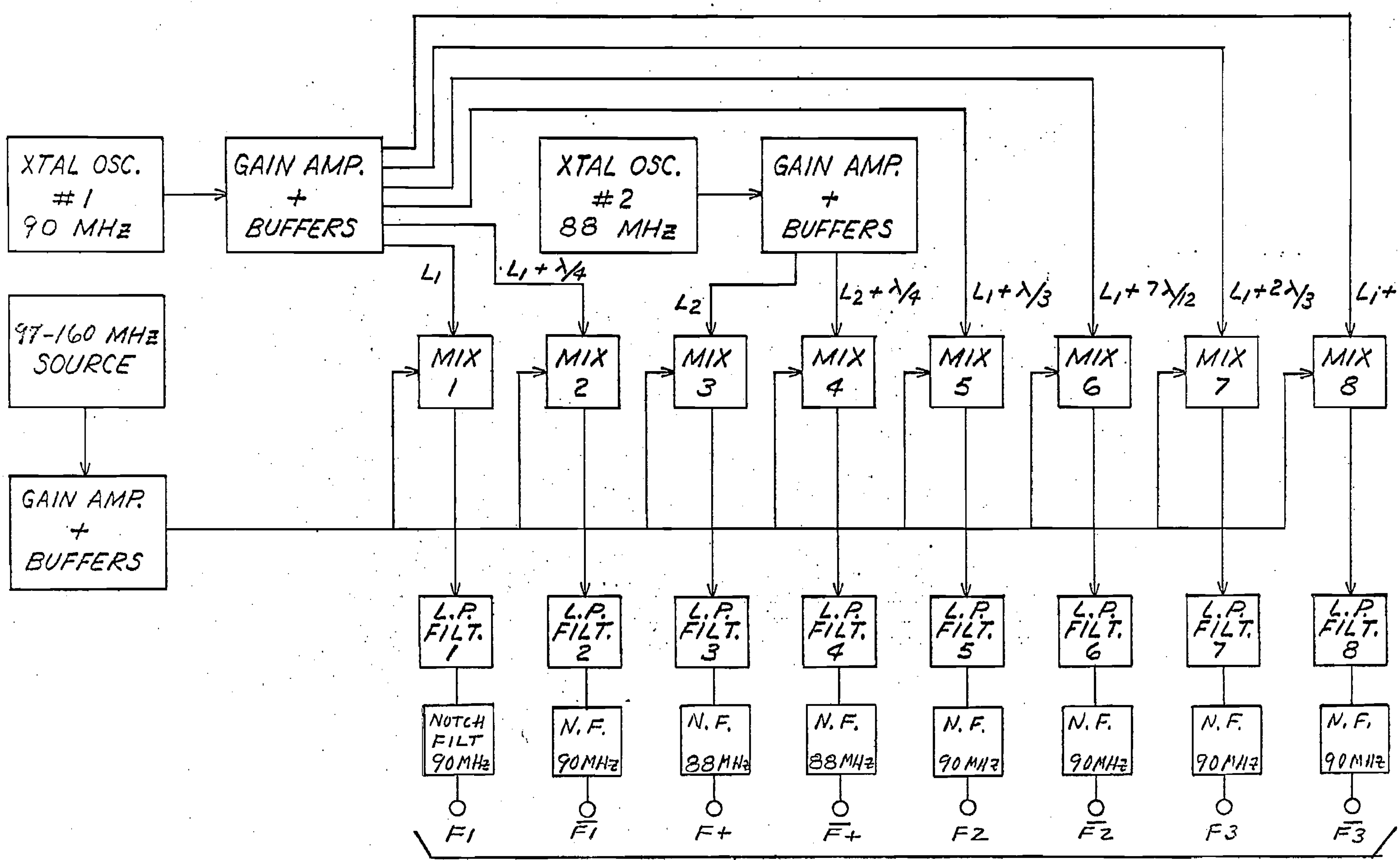


FIG 5

MICHIGAN STATE UNIVERSITY CYCLOTRON LABORATORY — EAST LANS MICHIGA

SCALE — | DRN BY WS | REV'D

FREQUENCY SYNTHESIZER

DATE | APPR'D BY | DRAWING NO.

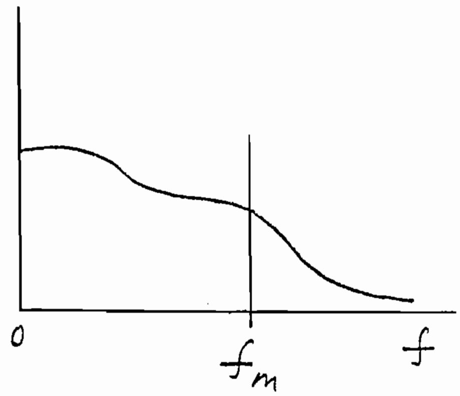


FIG 7a

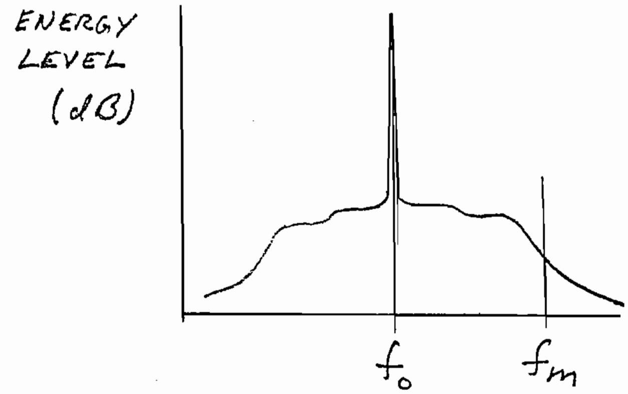


FIG 7b

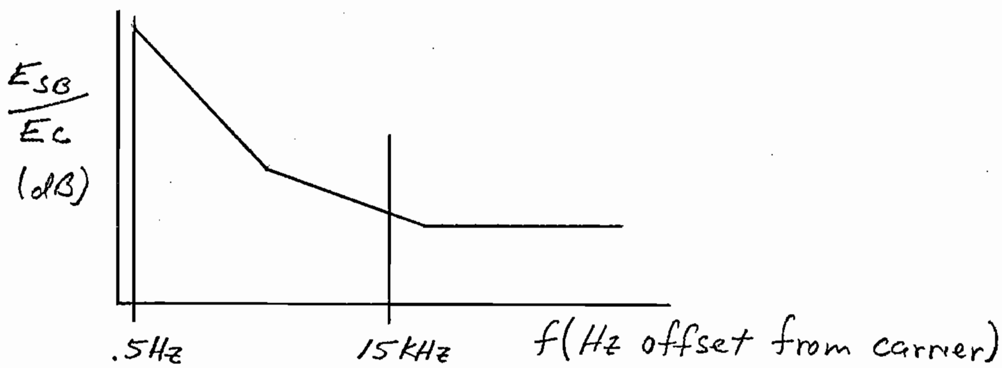


FIG 8

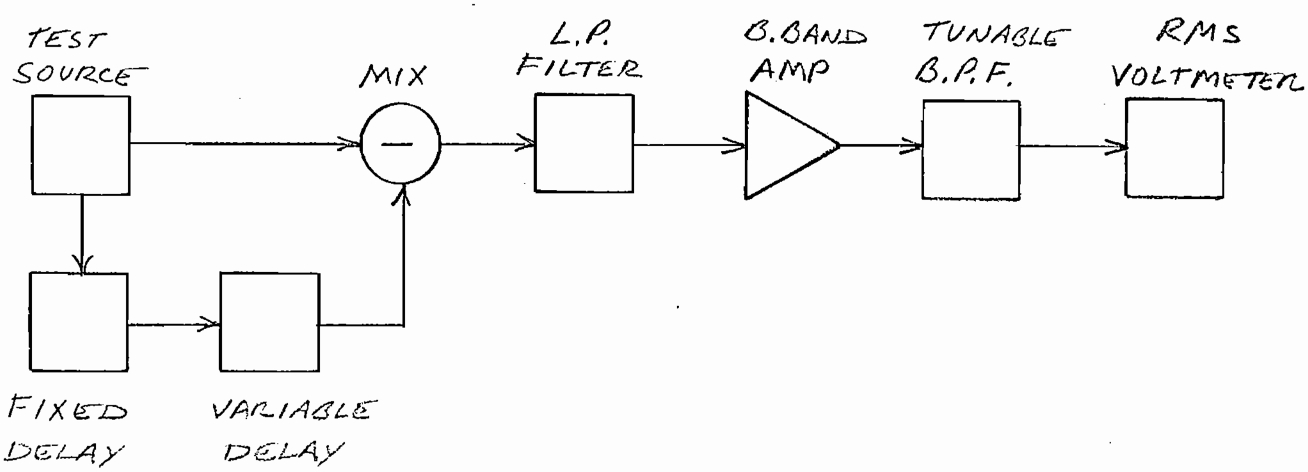
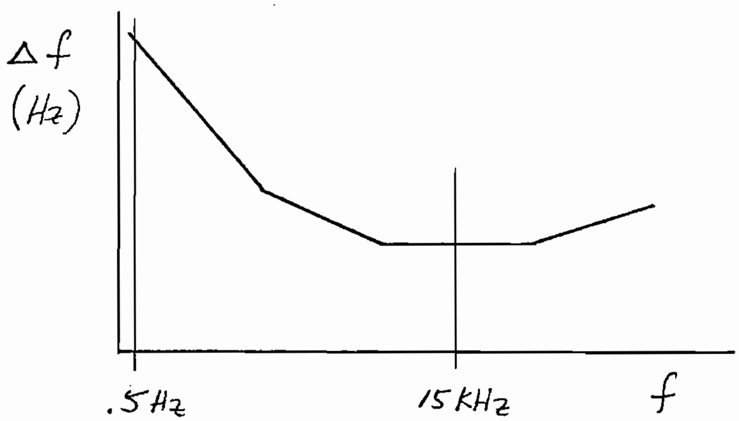
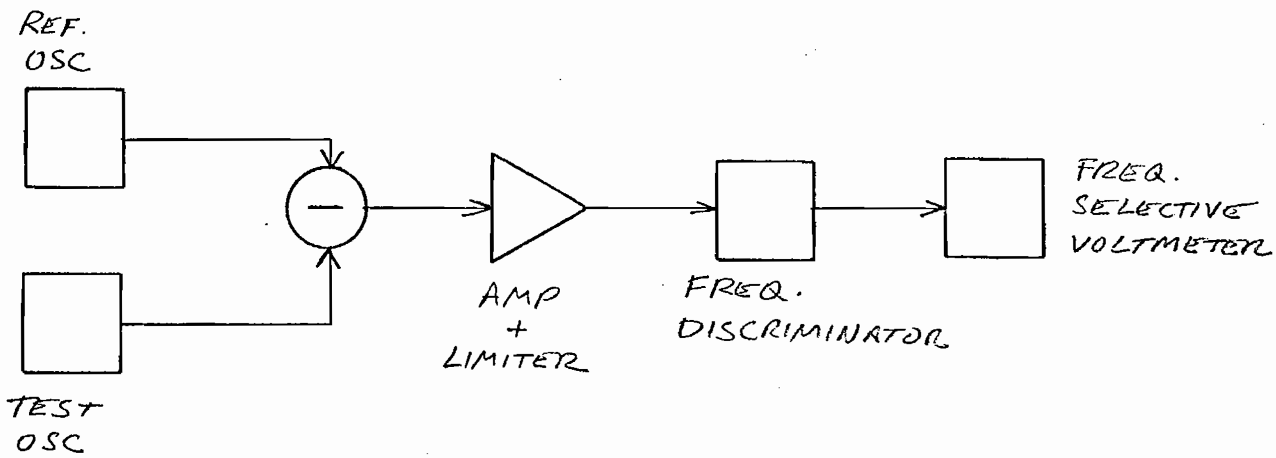


FIG 9



Δf
(Hz)
.5Hz
15KHz
f

FIG 10



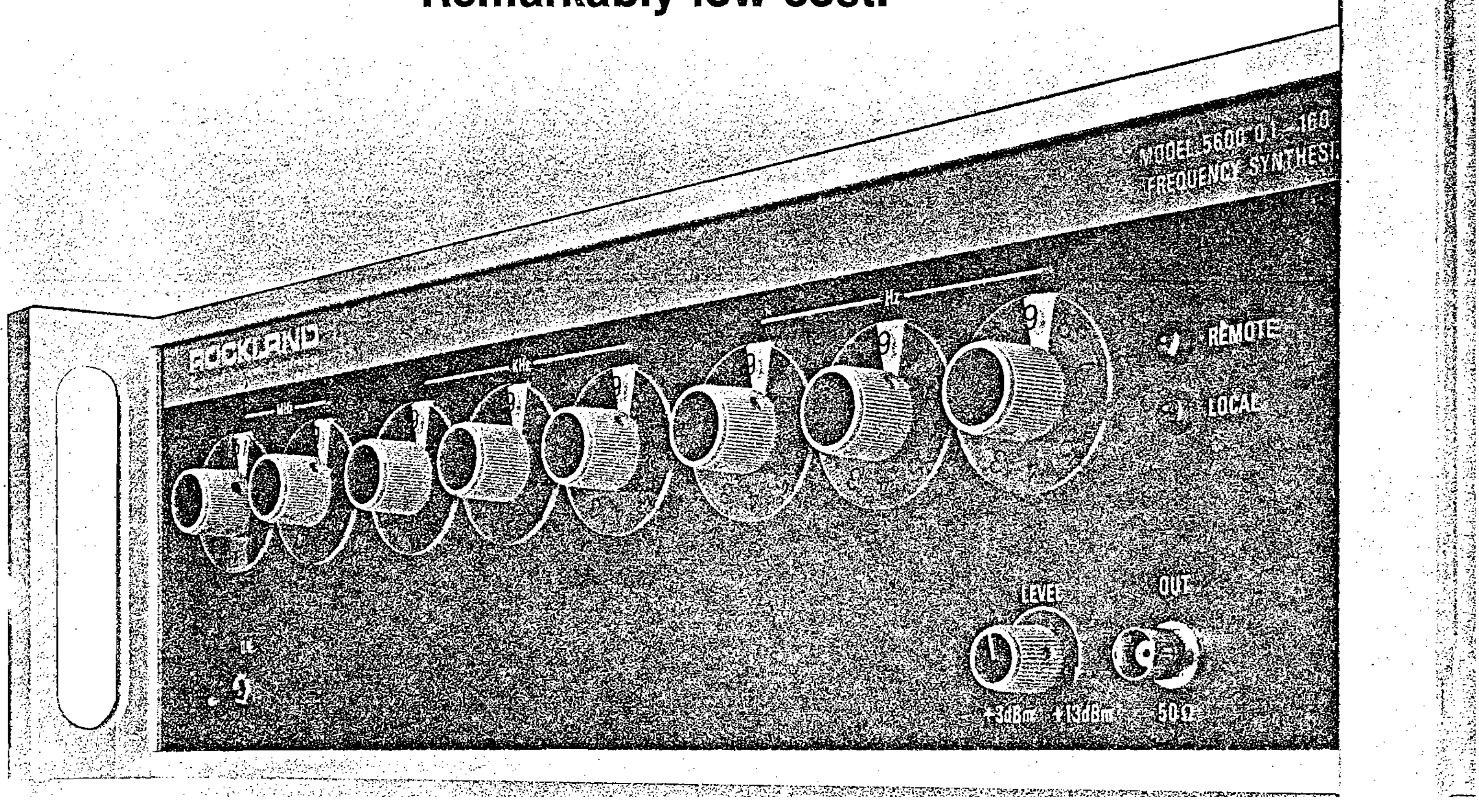
REF.
OSC
TEST
OSC
AMP
+
LIMITER
FREQ.
DISCRIMINATOR
FREQ.
SELECTIVE
VOLTMETER

FIG 11

ROCKLAND

MODELS 5600 & 5610A PROGRAMMABLE FREQUENCY SYNTHESIZERS

- 0.1 to 160 MHz
- Direct-Synthesis: no phase-lock loops
- Constant resolution: no range multipliers
- Remote-digital/front-panel programming
- Very fast switching: 20 μs
- High spectral purity: —70 dB SPURIOUS —35 dB HARMONIC —70 dB PHASE NOISE
- Excellent stability: $\pm 2 \times 10^{-9}$/day
- Leveled Output: ± 0.5 dB
- Remarkably low cost.



SYNTHESIZED SIGNAL GENERATOR

OPTIONS to 4000 MHz 20 μsec switching

180, 1800 and 2000 MHz RANGES

- LOW SPURIOUS —100 dBc
- LOW NOISE —138 dBc/Hz Floor
- HIGH-SPEED PROGRAMMABILITY 20 μsec switching
- VERSATILE Plug-in modularity

The 360 Direct Synthesis System for...

- Laboratory signal generation
- Computer-controlled test systems
- Electronic intelligence systems
- Frequency agile systems
- Communications systems

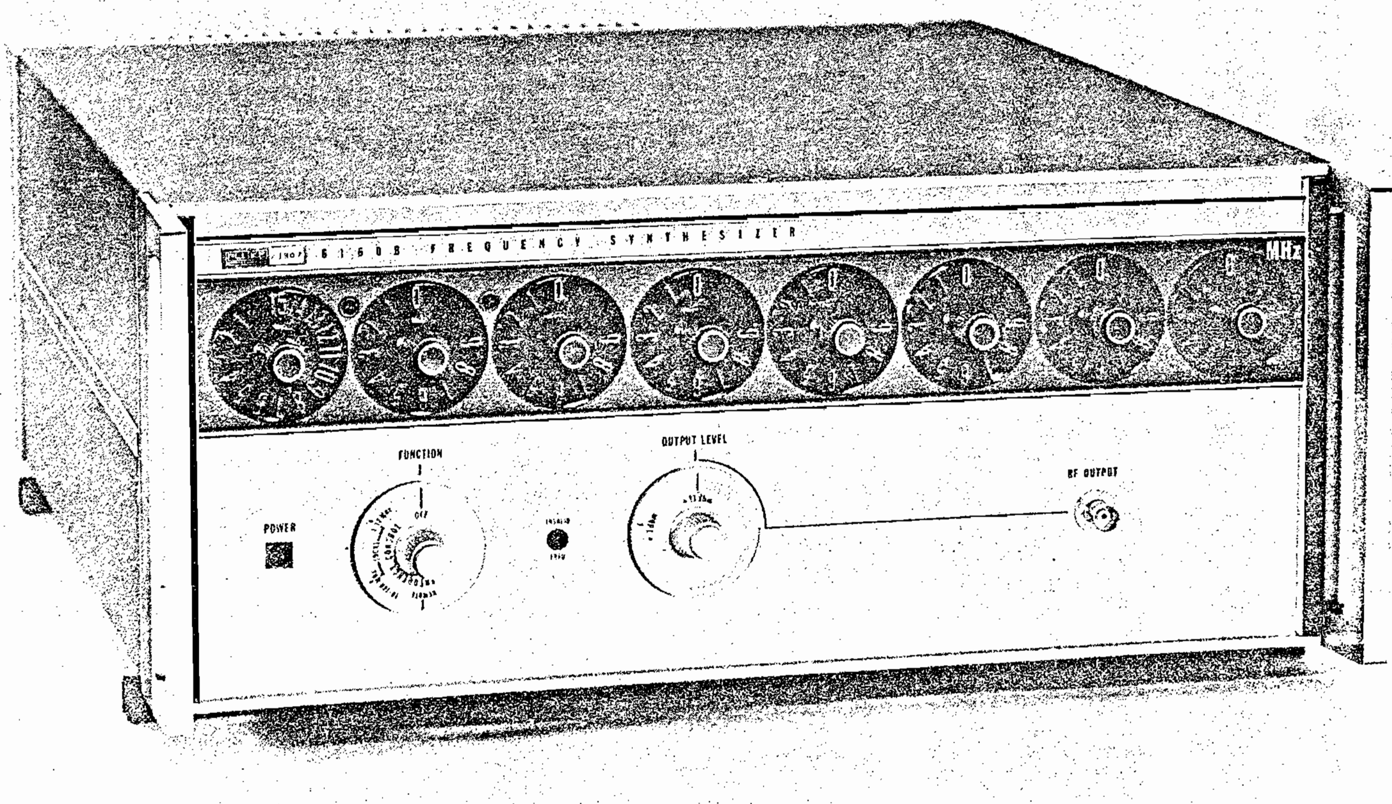
AILTECH
DIVISION CUTLER-HAMMER

Member of Cutler-Hammer Instruments and Systems Group

Frequency Synthesizer 6160B

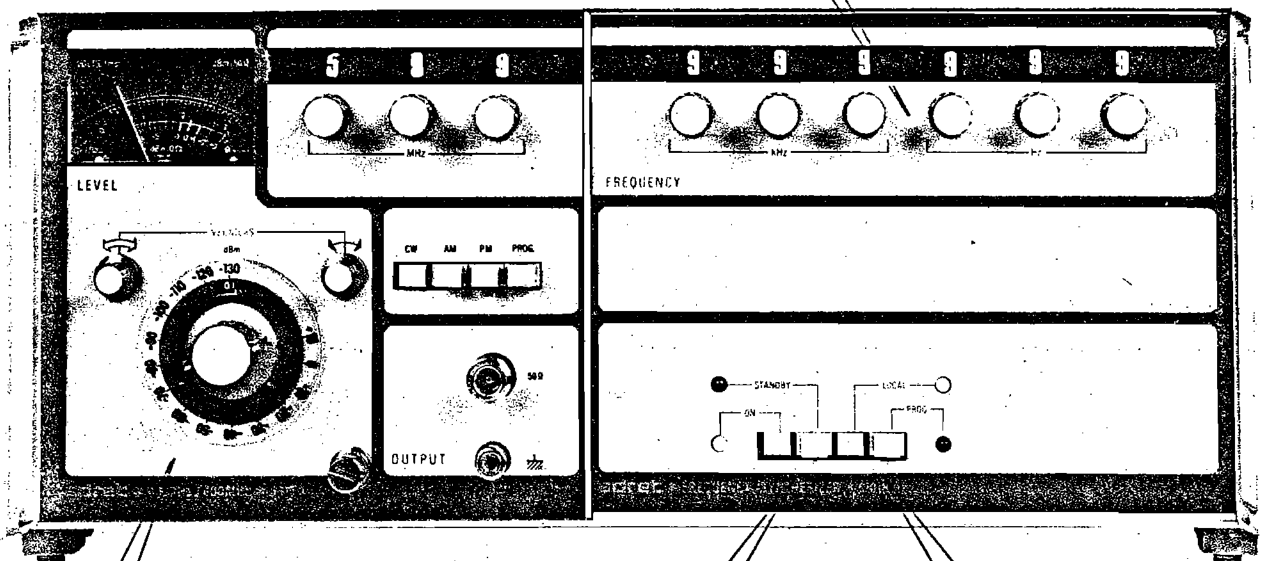
FEATURES:

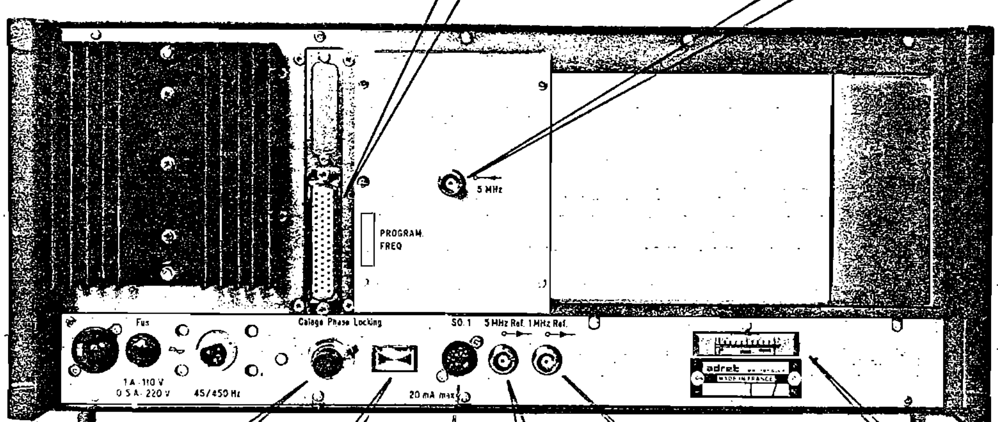
- Output Frequency 1 MHz - 160 MHz, 1 Hz Steps
- Non-Harmonic Spurious –83 dB to –100 dB
- Signal-To-Phase Noise Ratio 74 dB (Typical)
- Switching Speed Less than 0.8 ms
- Modular Design Adaptable to Special Applications
- BCD Programming - TTL Positive True Logic
- Stability to 2 Parts in 10^9/24 Hrs.



ADRET

6101 B MAINFRAME





Addendum to RF Note 43

Immediately following the completion of thisRF note, Bill Harder brought to my attention a spec sheet on the "ideal" synthesizer. Compare the following specs with those listed in tables 2 and 4.

Model: PTS 200
Freq. Range: 1-200 MHz
Price: $5K
Prog: BCD or IEEE
Tuning: Rotary Decade Switches
Risid FM: .001 Hz @100 Hz (1 Hz BW)
Phase Noise: -105 dB
Long Term Stability: .01 ppm/da
Resolution: 10 Hz
Settling Time: 20 μS
Harmonics: -35 dB
Spurious: -70 dB
Method of Synthesis: Direct

Obviously, the feature which sets this unit apart from the others recommended is the upper frequency limit. With this unit it is possible to obtain 65 MHz with the original mixing scheme (Fig 1).

The unit is completely modularized, and loaner modules are available for use during repair. Of course if necessary, the complete unit may be returned to the Acton, MA plant. A fourteen day repair turn-around would be unusually long. This includes shipping time. The repair rate is around 2 per cent of the units. A .1 to 160 MHz unit is available also, with specs identical to the Rockland unit. This is not surprising since Rockland bought the license for the design from PTS (Programmed Test Sources). The PTS 160 costs $4.3K. Another potentially useful feature is the provision for increasing resolution. Additional decade modules may be purchased and field installed in the unit. While the PTS 200 design is only two months old, it is essentially an extension of the old PTS 160 design. PTS is an established company which sells to most commercial NMR concerns and many universities.

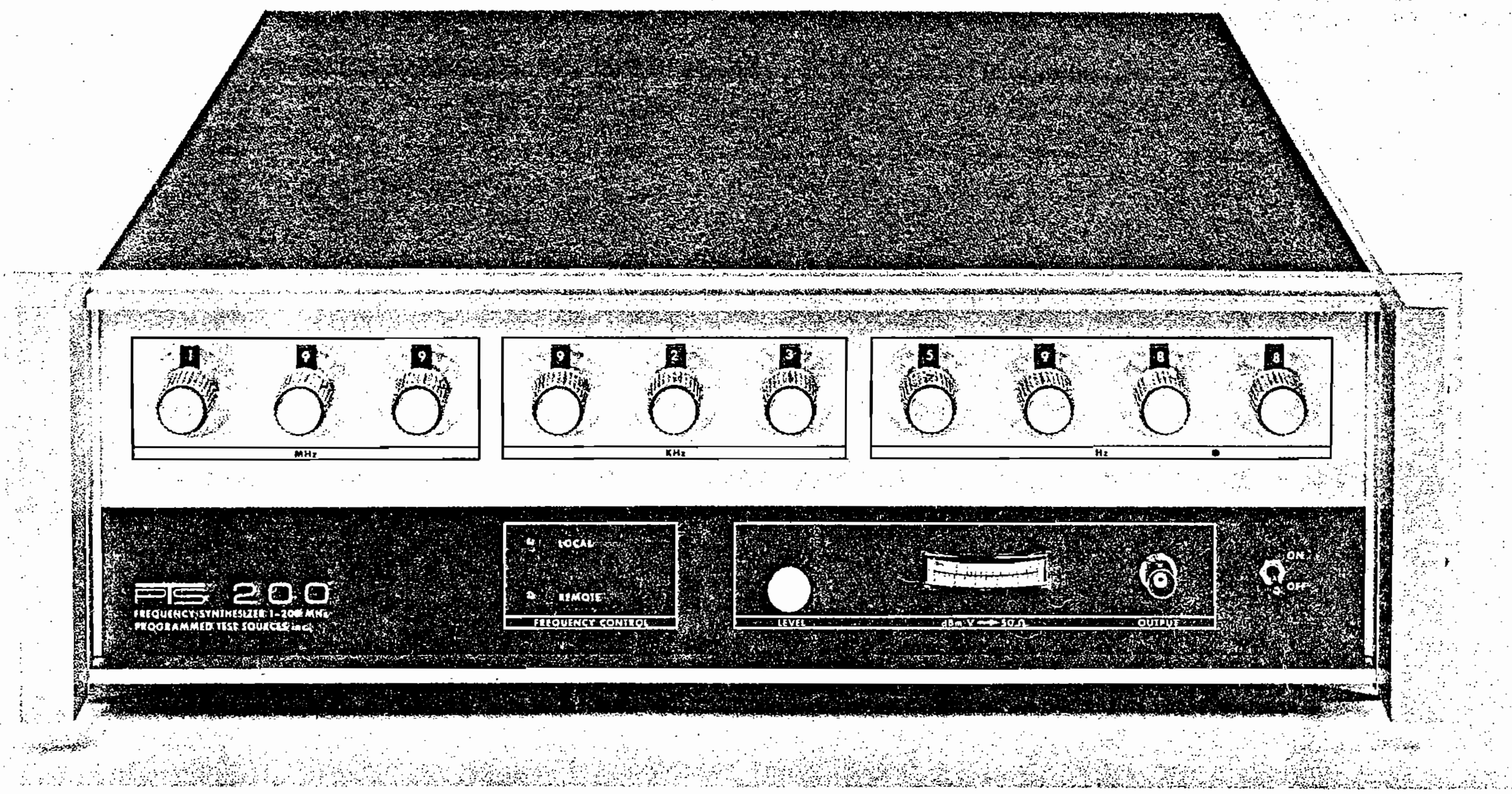
Thus, it seems the PTS 200 is the best buy of all recommended units.

200 MHz

PTS
FREQUENCY SYNTHESIZERS

HIGH PERFORMANCE

DIRECT SYNTHESIS



PTS 200 FREQUENCY SYNTHESIZER

- 1 - 200MHz
- +3 to +13dBm output
- choice of resolution
- low phase noise
- fast switching, 5-20 micro-sec.
- fully programmable, BCD or IEEE 488 BUS
- modular flexibility
- low power consumption, high reliability

TENTATIVE

The PTS 200 is a generator of precision frequencies. It transfers the accuracy and stability of a frequency standard (built-in or external) to any output frequency between 1MHz and 200 MHz. Steps as fine as 0.1Hz are available and all functions are remotely programmable.

The PTS 200 is a direct frequency synthesizer of novel design providing high performance for many demanding applications. With its low spurious outputs, fast switching, low phase noise and wide choice of resolution (finest step), it is suited for a range of uses from NMR to communications or ATE.

This new system of synthesis has drastically cut complexity and parts count. The attendant reduction of primary power input and dissipation (less than 50% of that of competitive designs) is a major factor in the reliability which is further enhanced by the use of ceramic ICs, all metal-can transistors and a packaging system maximizing mechanical integrity and stability while keeping weight low.. For ease of service most modules are identical and of plug-in design.

SPECIFICATIONS

FREQUENCY	Range:	1MHz to 200 MHz
	Resolution:	0.1Hz to 100 KHz steps (optional in decades)
	Control:	Local by 10-position switches. Remote by TTL-BCD, 1248, buffered or by IEEE 488 BUS. R/L transfer programmable.
	Switching Time:	20 micro-sec. (within 0.1rad at new frequency)
OUTPUT	Level:	+3 to +13dBm, (1V) into 50 ohms, metered in dBm and volt
	Flatness:	+, - 0.5dB
	Impedance:	50 ohms
	Control:	Manual by F/P-control, remote by voltage, (+0.63 to +2.00V)
	Settling Time:	20 micro-sec.
SPURIOUS OUTPUT	Discrete:	—70dB
	Harmonics:	—35dB at full output, (—40dB at lower level)
	Phase Noise:	—63dBc, (0.5Hz to 15KHz), incl. effects of int. standard
	L (1Hz):	100Hz/105dBc; 1KHz/115dBc; 10KHz/123dBc 100KHz/130dBc.
	Noise Floor:	—135dBc/Hz
FREQUENCY STANDARD	Internal:	3 x 10^{-9}day or 1 x 10^{-8}/day (optional)
	External Drive:	5.000 orr 10.000MHz, 0.5V into 300 ohms
	Aux. Output	10.000MHz, 0.4V into 50 ohms
	Oper. Ambient:	0 to 55°C, 95% R.H.
	Power:	105-125V, 50-400Hz, 45Watts
	Dimensions/Weight:	19 x 5¼ x 18" (Relay rack or bench cabinet, 35 lbs.)

PRICES (domestic)	Resolution:	100KHz	10KHz	1KHz	100Hz	10Hz	1Hz	0.1Hz
	$	4000.—	4200.—	4400.—	4600.—	4800.—	5000.—	5200.—

Freq. Standard: (Option)	3 x 10^{-9}/day, $450.— (oven)	1 x 10^{-8}/day, $200.— (TCXO)

PROGRAMMED TEST SOURCES, inc.

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69 HAYWARD ROAD • ACTON, MA 01720 • (617) 263-6467

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