CONF-870498--3

RECENT ELECTRONIC IMPROVEMENTS TO THE OAK RIDGE 25URC ACCELERATOR*

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CONF-870498--3

DE87 008799

ABSTRACT

A new chopper-buncher system has been installed in the 25URC accelerator injection line. The buncher is similar to the one used previously, but incorporates several significant improvements. The chopper is a new device to provide beam pulses for time-of-flight experiments. The accelerator charging system has been modified to increase reliability and improve chain monitoring. A display unit for beam profile monitors (BPM) is being developed. The display will allow the operator to observe four BPM traces simultaneously.

INTRODUCTION

A new chopper-buncher system has been installed on the 25URC accelerator. It replaces a buncher system which was used for several years.[1,2] The new system utilizes a chopper to eliminate beam background between bunches, a feature which is necessary for time-of-flight experiments. In addition, it incorporates a much-improved control system which has been integrated into the accelerator control system.

*Research sponsored by the Division of Basic Energy Sciences, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

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The charging system for the accelerator has been improved to increase reliability and provide additional monitoring. Shielded high-voltage cables connecting charge pick-off wheels and inductors in the terminal have proven to be very reliable. Circuitry has been added to the chain-charge pick-up in the column base to provide readily available information about chain speed and up- and down-charge. Additional pick-ups in the terminal and a dead section are being considered to aid in diagnosing charging problems.

A multi-trace beam profile monitor (BPM) display has been developed and will be installed during the year. The circuit allows the operator to observe four BPM signals on a single CRT display.

CHOPPER-BUNCHER SYSTEM

A new chopper-buncher system was installed and tested on the tandem accelerator during 1986. The new system provides beam pulses for time-of-flight experiments as well as pulses for injection into the ORIC.[3] Pulses are 1 to 5 ns wide and with the chopper operating, there is essentially zero background between pulses. For time-of-flight work, the pulse repetition rate is either 1 or 4 Mpps, and the chopper plates are driven at either 0.5 or 2.0 Mhz. Buncher frequency for this mode is fixed at 4.0 Mhz. For injection into ORIC, the chopper is not required. The new buncher is similar to the original system in being a double-drift harmonic type.[4] The tuning range has been expanded to cover 4 to 16 Mhz, and three buncher tube lengths are now available to cover a wider range of ion velocities. Controls for the buncher have been integrated into the accelerator control system, resulting in more convenient operation.

A simplified schematic of the chopper-buncher system is shown in Fig. 1. The buncher is very similar to the previous system except for details. Three plug-in coils provide a frequency range of 4 to 16 Mhz. Coil #1 is tunable over the 4 to 8 Mhz range; coil #2 is tunable over 8 to 16 Mhz; coil #3 is tunable over 16 to 32 Mhz. For buncher operation in the 4 to 8 Mhz range, coil #1 is used in the 1f resonator and coil #2 is used in the 2f resonator. For operation in the 8 to 16 Mhz range, coil #2 is used in the 1f resonator and coil #3 is used in the 2f resonator. The previous buncher with fixed coils covered a frequency range of 5 to 14.5 Mhz. The new buncher system also employs selectable buncher tube lengths of 9, 6 and 4 cm for the 1f buncher and half these lengths for the 2f buncher. This allows the system to bunch a wider range of ions. Another significant improvement in the new buncher involves the phase shifters. In the previous system, continuously adjustable delay lines were used as wide-range phase shifters; however the sliding contacts occasionally failed, resulting in unreliable operation. The new system employs binary-coded stepped delay lines with maximum delays of 235 ns and resolution of 5 ns. A novel continuously adjustable phase shifter was developed for the new buncher; a circuit diagram is presented in Fig. 2. This circuit provides a phase adjustment of about 30° at 4 Mhz and 60° at 16 Mhz, values which are more than adequate with the 5 ns resolution of the stepped delay line.

The beam chopper consists of deflection plates in the beam line preceding the buncher connected to a balanced resonator outside the vacuum system. The deflector plates are separated by 3.8 cm and have a length of 15.2 cm along the beam line. Beam defining slits are located 155 cm from the deflector. The resonator coil is a commercial unit having an inductance of 105 microhenries and a Q of 600 at 2 Mhz. It is tuned by a 100 pf vacuum variable capacitor from each end to ground. Adjustment of the resonator frequency to 0.5 Mhz is achieved by switching a 950 pf ceramic capacitor across the coil. Maximum voltage and power are required at 0.5 Mhz. For 4kV across the coil, the power required is about 65 watts.

Other improvements incorporated in the new buncher include tuner servos with reduced dead-zone and optimized coupling loops which require no adjustment over the frequency range. Although the previous buncher was controlled through a CAMAC system, it was not coupled to the accelerator control system. Control of the new buncher has been integrated with the accelerator control system.[5]

CHARGING SYSTEM

High-voltage cables connecting pick-off wheels and inductors in the terminal of the 25URC accelerator have been a source of trouble over the years. They were occasionally punctured by surges resulting in loss of charging and sometimes a tank opening. Most punctures occurred at points where the cable contacted a corner of the sheave support structure. Shielded cables were installed about one year ago in an effort to reduce the gradient on the surface of the cables. This appears to have alleviated the problem since no breakdowns have occurred in the past year.

The chain charge monitoring system[6] for the 25URC accelerator was augmented last year as indicated by the schematic diagram in Fig. 3. Pellet frequency and voltage signals have been produced which are being added to the accelerator CAMAC monitoring system. These will then be readily available to the operator. Additional charge pickups in the terminal and a dead section are being considered. The AC signal from these devices would be rectified and transmitted to the console. Information from the additional pickups should aid in locating causes of chain charge loss.

BPM DISPLAY

The simultaneous display of beam profiles along the beam path of an accelerator would be very helpful to the operator in "tuning" beam to the target. Last year a goal of displaying four BPM signals simultaneously was established. Initially, it was thought to be a rather simple task, but it soon became obvious that this was not the case since the four signals were not synchronized. The period of our BPM's is about 50 ms, but the differences in period are such that the display of four stationary traces would be impossible by usual means. One obvious solution is the use of four separate oscilloscopes to display the signals. The problems with this approach are that a large panel space is required and the traces are not easily viewed simultaneously. Although oscilloscopes with four vertical channels are available, the trigger for each trace is derived from only one of the channels. Unsynchronized signals then appear to move across the screen, and only one trace would be stationary. A solution to this situation would be to operate the oscilloscope in the "alternate sweep" mode and switch triggers externally. This should result in stationary traces, but with a sweep length of 50 ms, each trace would probably occur only three times per second. This scheme would be practical with a variable persistence storage CRT, but flicker would be a problem with common CRTs. Digital storage of the BPM signals was also considered. This appeared to be feasible, but a large amount of circuitry was required. The solution finally chosen is shown schematically in Fig. 4. This circuit operates in the "chopped", or sampling, mode. The BPM (vertical) signal, the sweep (horizontal) signal, and the fiducial (Z-axis) signal are sampled simultaneously for each channel. The sample length is about 12 microseconds. During the next 12 microseconds, the signals from the second channel are sampled and so on. In effect, a point is plotted on the CRT every 12 microseconds having a Y value determined by a BPM collector signal and an X value determined by the sweep signal for that same BPM. The sweeps are then completely independent, and stationary displays can be achieved of signals having widely different sweep intervals. A photograph of two BPM traces displayed with the subject circuit is shown in Fig. 5. Four channels were being sampled, but only two BPM signals were available.

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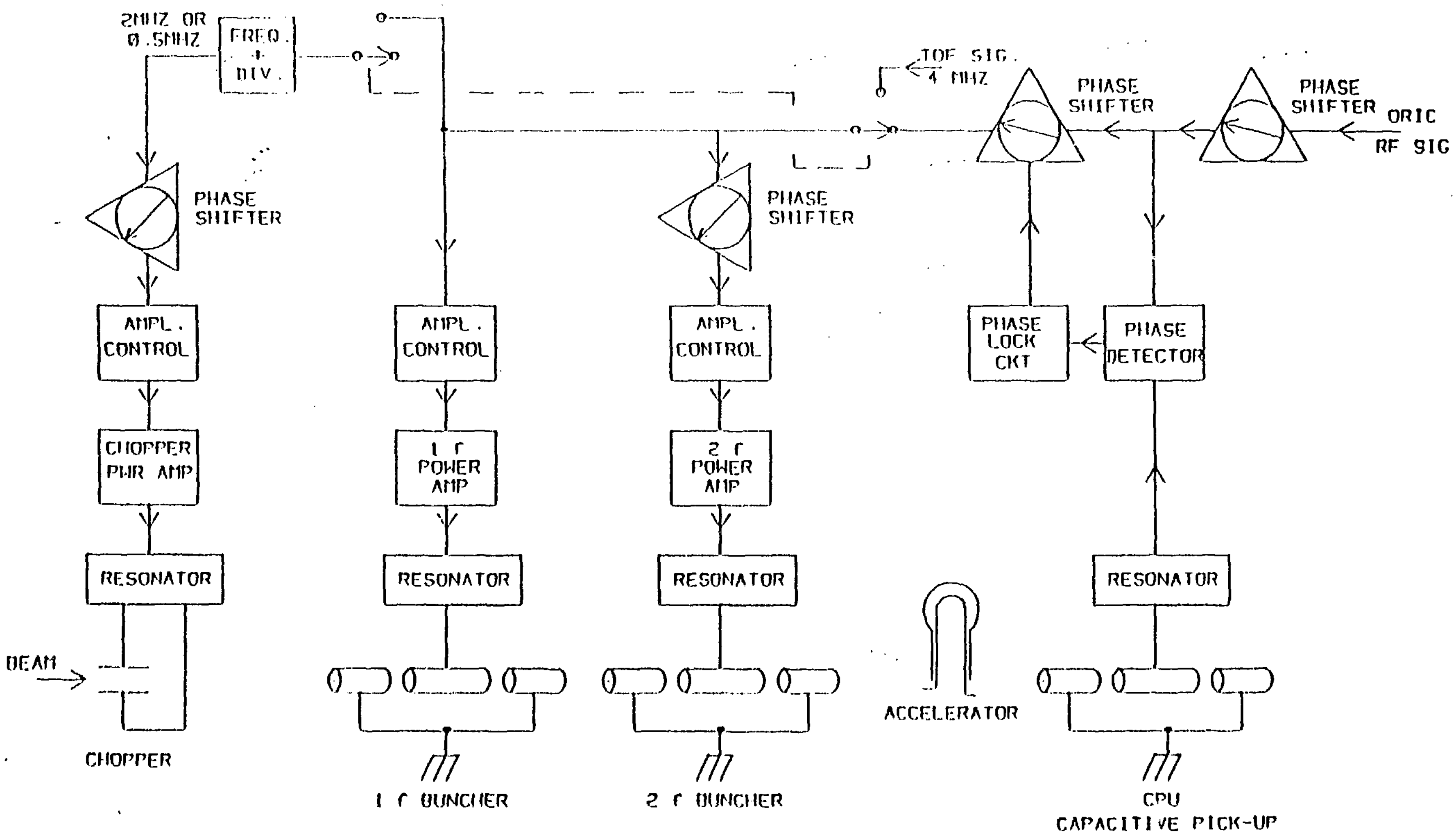
FIGURE CAPTIONS

1. Chopper-buncher system schematic diagram.
2. Variable phase shifter.
3. Chain monitoring system schematic diagram.
4. Schematic diagram of multiple-trace BPM display.
5. Display of two BPM traces.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CONTROL
PHASE
LOCK
CKT
PHASE
DETECTOR
CHOPPER
PWR AMP
1 f
POWER
AMP
2 f
POWER
AMP
RESONATOR
RESONATOR
RESONATOR
RESONATOR
BEAM
CHOPPER
1 f BUNCHER
2 f BUNCHER
ACCELERATOR
CPU
CAPACITIVE PICK-UP

Figure 1

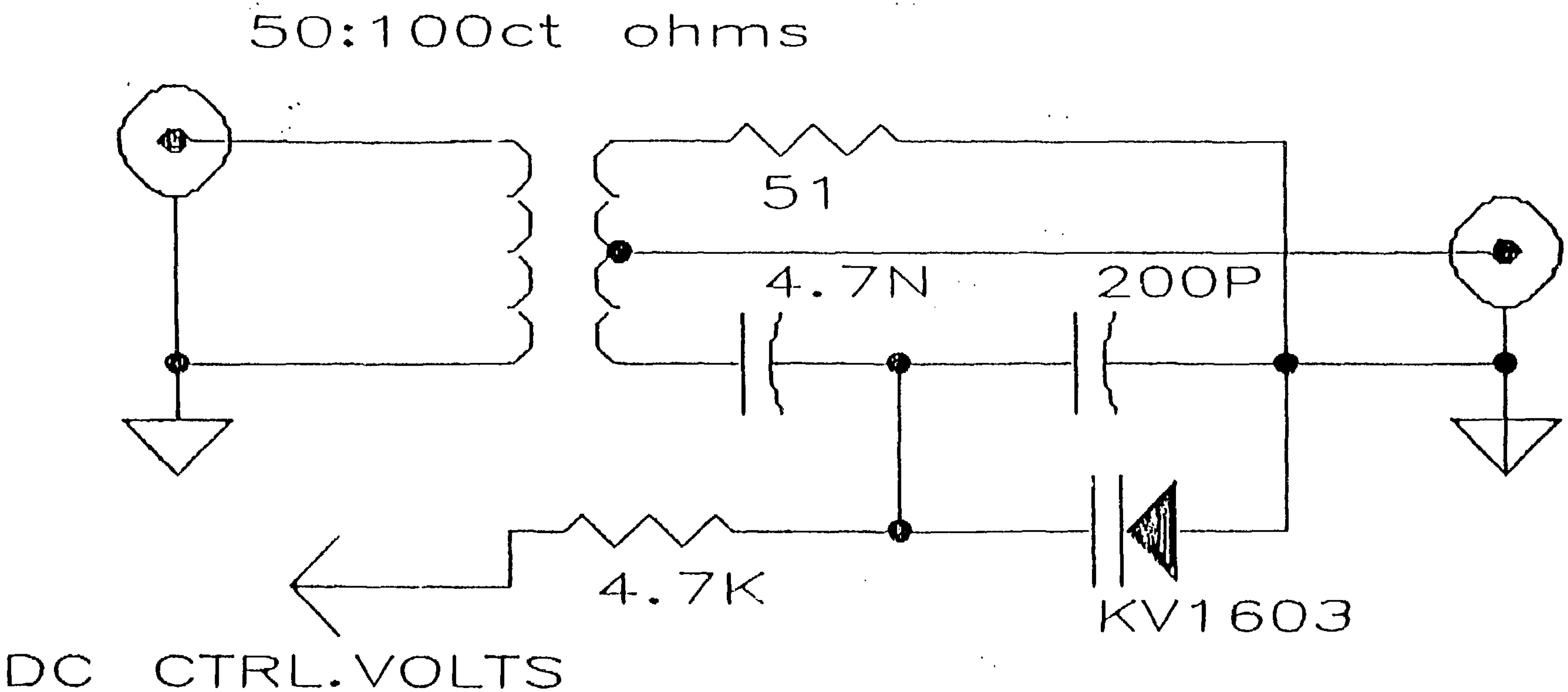
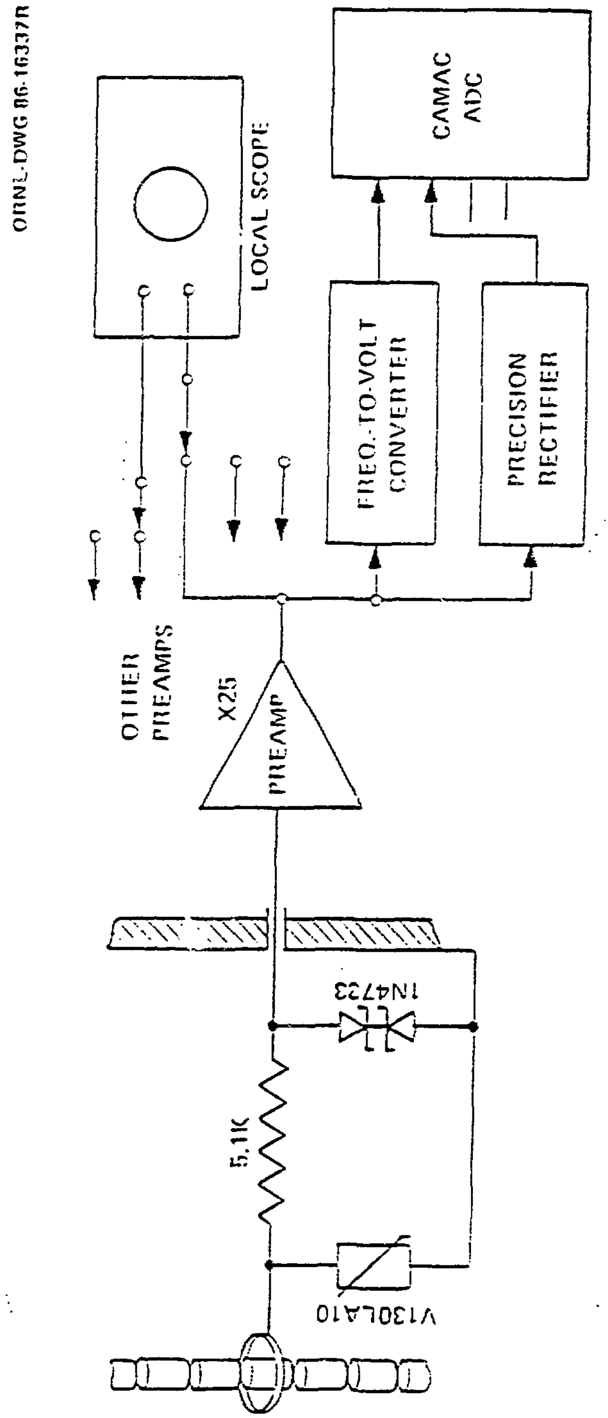


Figure 2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ADC
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RECTIFIER
OTHER
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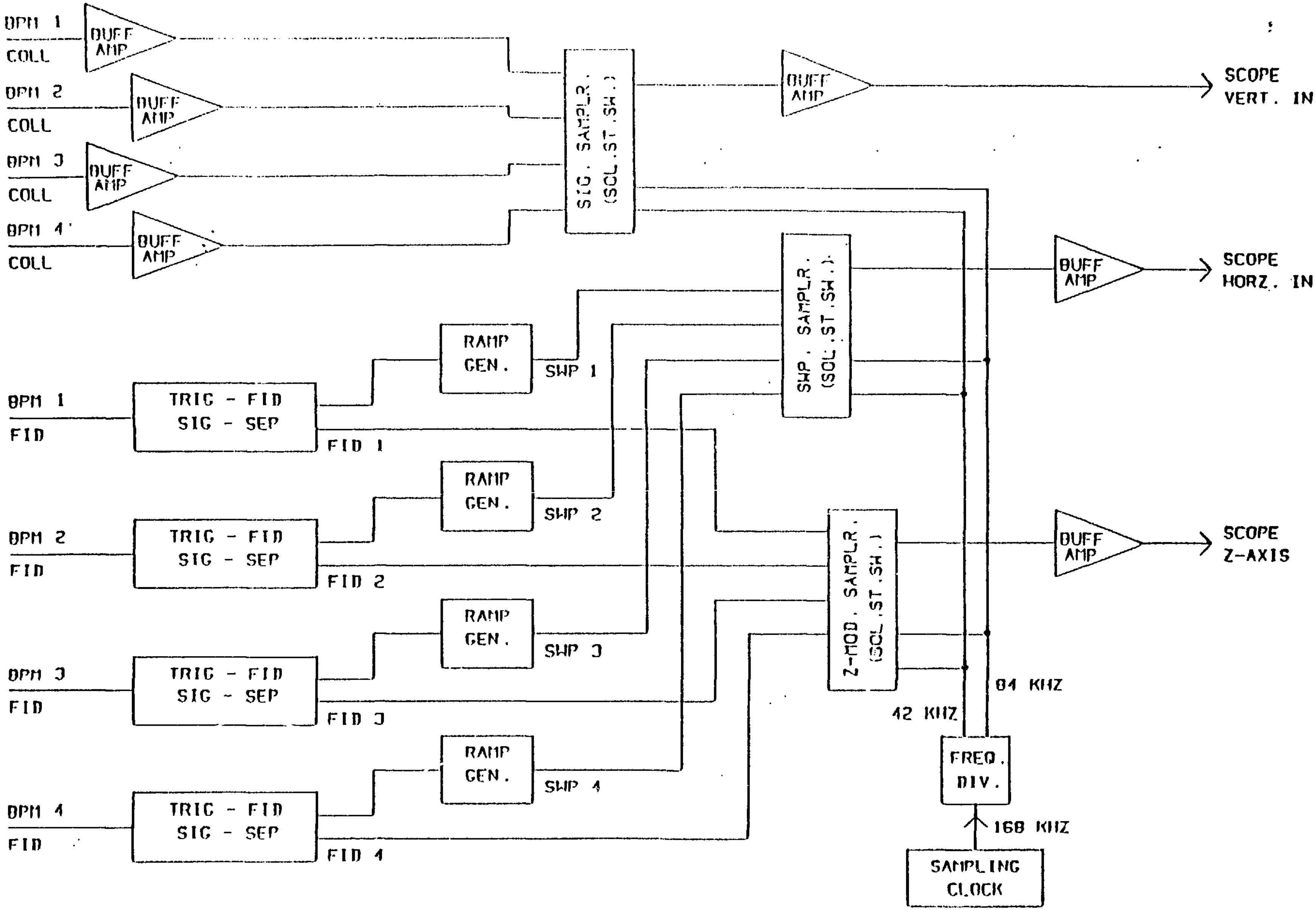
V130LA10

Figure 3



BPM 1
COLL
BUFF AMP
BPM 2
COLL
BUFF AMP
BPM 3
COLL
BUFF AMP
BPM 4
COLL
BUFF AMP
SIG. SAMPLR. (SCL.ST.SH.)
BUFF AMP
SCOPE VERT. IN
SWP. SAMPLR. (SCL.ST.SH.)
BUFF AMP
SCOPE HORZ. IN
RAMP GEN.
SWP 1
BPM 1
FID
TRIG - FID SIG - SEP
FID 1
RAMP GEN.
SWP 2
BPM 2
FID
TRIG - FID SIG - SEP
FID 2
Z-MOD. SAMPLR. (SCL.ST.SH.)
BUFF AMP
SCOPE Z-AXIS
RAMP GEN.
SWP 3
BPM 3
FID
TRIG - FID SIG - SEP
FID 3
84 KHZ
42 KHZ
FREQ. DIV.
RAMP GEN.
SWP 4
BPM 4
FID
TRIG - FID SIG - SEP
FID 4
168 KHZ
SAMPLING CLOCK

Figure 4

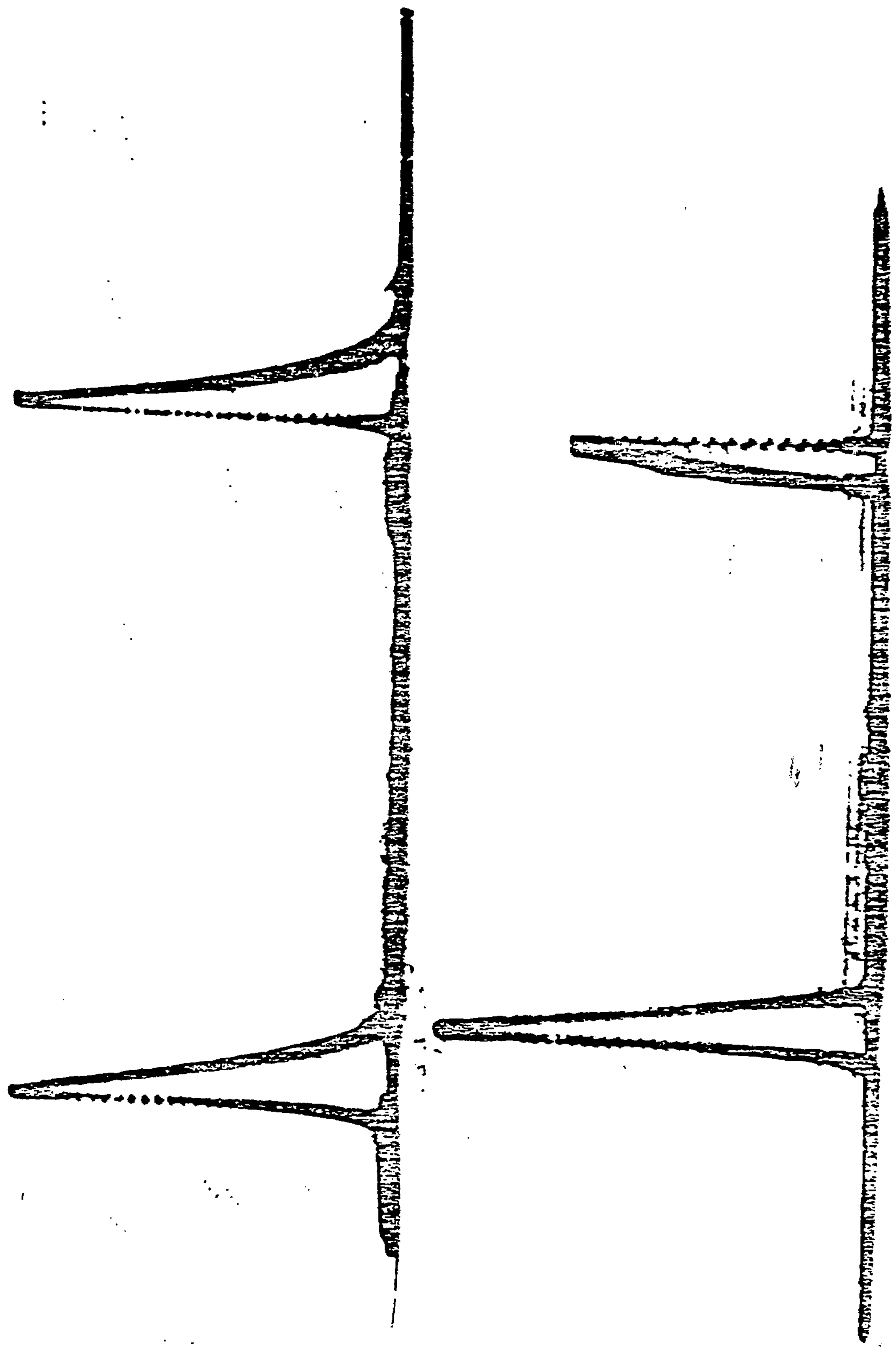


Figure 5