



BNL-104628-2014-TECH

AGS/AD/Tech Note No. 201;BNL-104628-2014-IR

## OPERATION NOTES BOUSSARD BEAM COMPENSATION

W. Frey

June 1984

Collider Accelerator Department  
**Brookhaven National Laboratory**

**U.S. Department of Energy**

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

## **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Accelerator Department  
BROOKHAVEN NATIONAL LABORATORY  
Associated Universities, Inc.  
Upton, New York 11973

AGS Division Technical Note  
No. 201

OPERATION NOTES  
BOUSSARD BEAM COMPENSATION

W. Frey

June 29, 1984

The AGS is presently operating with active beam compensation at injection and extraction. The circulating beam in the machine will induce a voltage at the accelerating gap due to the beam interacting with the impedance of the synchronously tuned cavities. The induced voltage will cause unwanted bunching of the beam at injection and extraction. The effective impedance of the cavity to the beam is reduced to zero by adding to the cavity drive a properly phase shifted signal proportional to the circulating AGS beam. The technique of using additional beam feedback to achieve beam cancellation at the AGS was proposed by D. Boussard of CERN in the summer of 1983. This note will describe the operation of the prototype Boussard Beam Compensation (BBC) equipment. The BBC, as presently implemented, does not permit phase shifting of the signal during the accelerating cycle (rf frequency slewing from 2.5 to 4.5 MHz). The BBC is used only when the beam frequency is constant, i.e. injection or extraction.

Figure 1 is a simplified block diagram of the BBC. Figure 2 is a timing diagram of the BBC. The numbers in circles on Figure 1 refer to the timing signals in Figure 2.

The normal beam pick up at E20 feeds the Low Level RF (LLRF) as before. The output (2VP-P) of the LLRF is split into two channels. One output is the main channel input to the BBC. The other output goes to the RF Building, as before, to provide frequency-tuning current information to the Main Tuning Servo (MTS).

A second beam pickup at G7 provides a beam reference signal (amplitude and phase) to the BBC. Figure 3 is a block diagram of the

BBC unit. The beam pickup signal, which is proportional to the beam induced signal at the cavities is split four ways. A low-pass filter is used to remove the higher harmonics from the beam pickup. Three of the four signals feed phase shifting modules, while the fourth is used as a test port. The three phase-shifting modules are identical except for the input low-pass filter. This filter is used to suppress second and higher harmonics of the frequency being shifted. At present only two of the modules are being used, injection  $f \approx 2.50$  MHz and extraction  $f \approx 4.450$  MHz. The third module is for future use.

There is  $180^\circ$  of continuous phase shift control from the MCR. In addition, a switch on the module will provide fixed increments of  $0^\circ$ ,  $\pi/2$ ,  $\pi$ , and  $-\pi/2$  to insure smooth phase adjustment at any operating phase. Presently, the prototype has provision for  $0^\circ$  on  $\pi$  switching.

After the phase shifting, an adjustable gain amplifier is used to set the magnitude of the phase shifted feedback signal. The 45 db of gain adjust is computer controlled from the MCR. Input and output gating is used to prevent unwanted signal leakage at times other than the desired compensation time. The output of the phase shifters is added to the main channel signal. Signal 16 of Figure 2 illustrates the time superposition of the injection and extraction signals in the normal rf drive to the HLRF system.

The main channel signal is gain controlled for proper bunching and acceleration of the beam. An AGC amplifier compares the sum of the 10 cavities with the desired energy gain function and adjusts the gain of the main channel accordingly. The gain of the HLRF is fixed such that a 3 V PP input will drive the output of the 10 power amplifier outputs to 120 kW.

Figure 4 is a block diagram of the trigger generator for the BBC. Figure 5 illustrates the BBC modules and typical signals at the test ports of the modules.

mvh

Distribution: A.D. S&P Staff

5/4/84

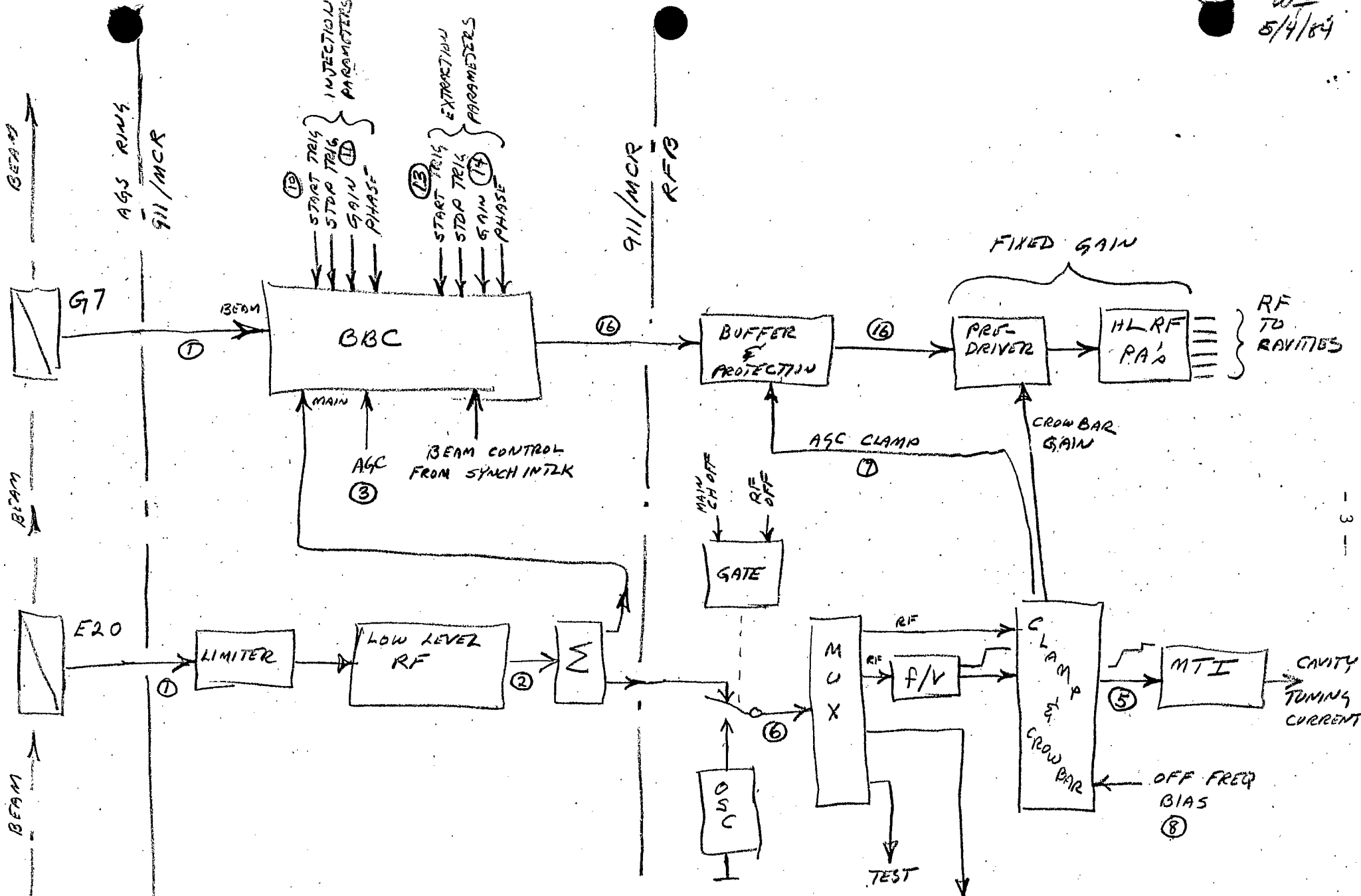
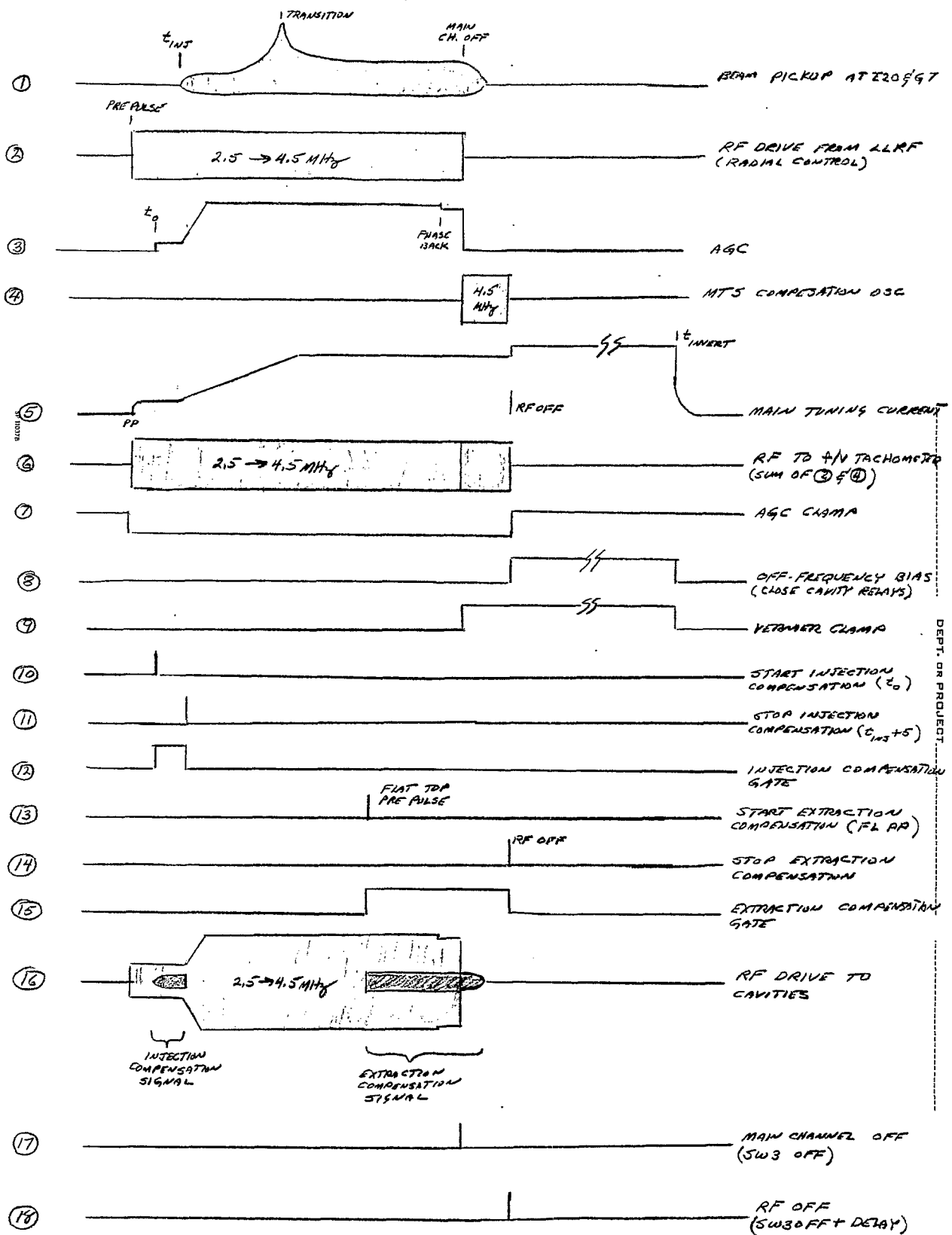


Figure 1 RF SYSTEM - BEAM COMPENSATION BLOCK DIAGRAM



BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHKD. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 SUBJECT \_\_\_\_\_  
 DEPT. OR PROJECT \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

BROOKHAVEN NATIONAL LABORATORY

FIGURE 2  
 BBC TIMING DIAGRAM

BROOKHAVEN NATIONAL LABORATORY

BY \_\_\_\_\_ DATE \_\_\_\_\_ SUBJECT BEAM COMPENSATION SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CHKD. BY \_\_\_\_\_ DATE \_\_\_\_\_ BLOCK DIAGRAM JOB NO. \_\_\_\_\_  
 DEPT. OR PROJECT LLRF BNC 74

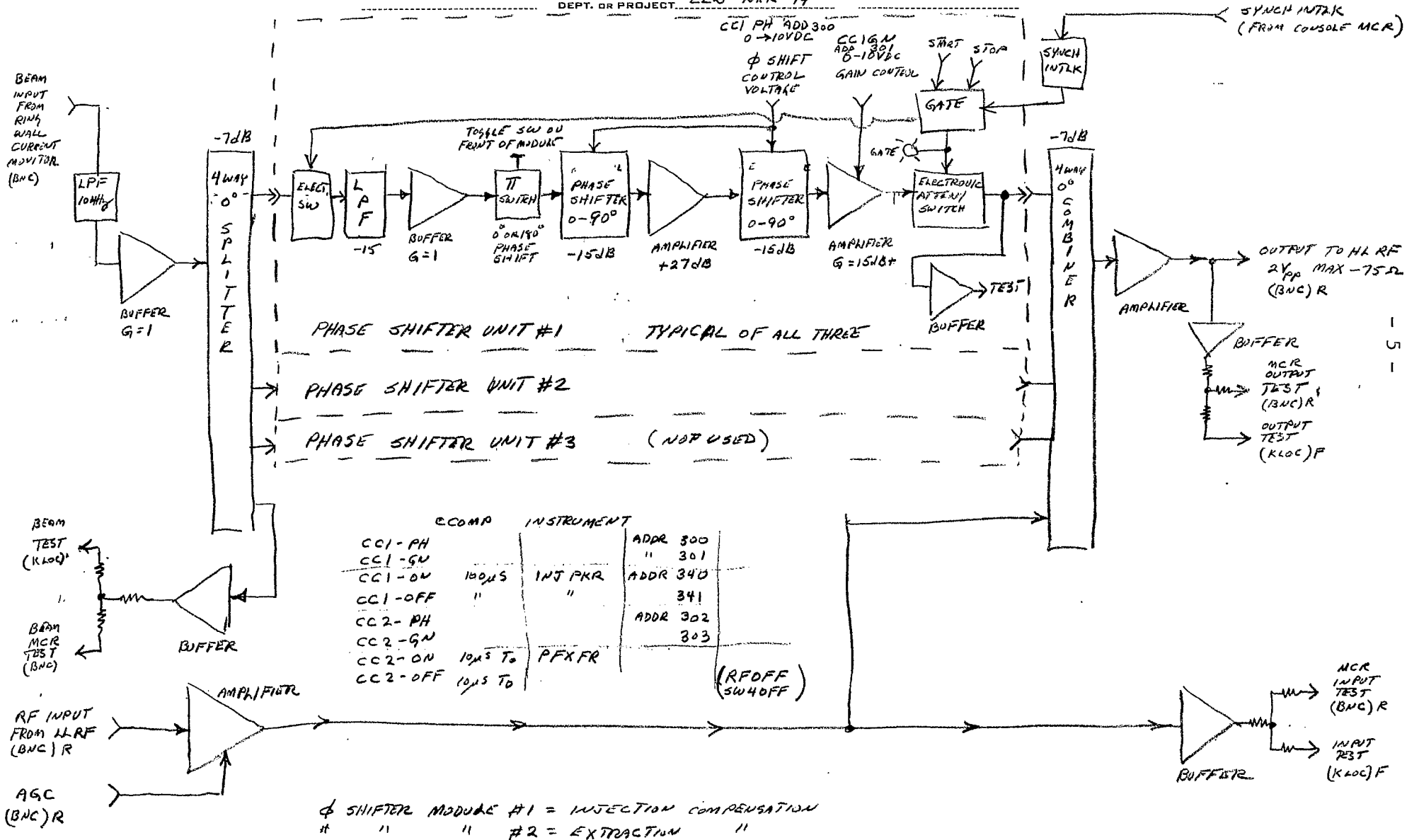


FIGURE 3  
 BLOCK DIAGRAM - BBC UNIT

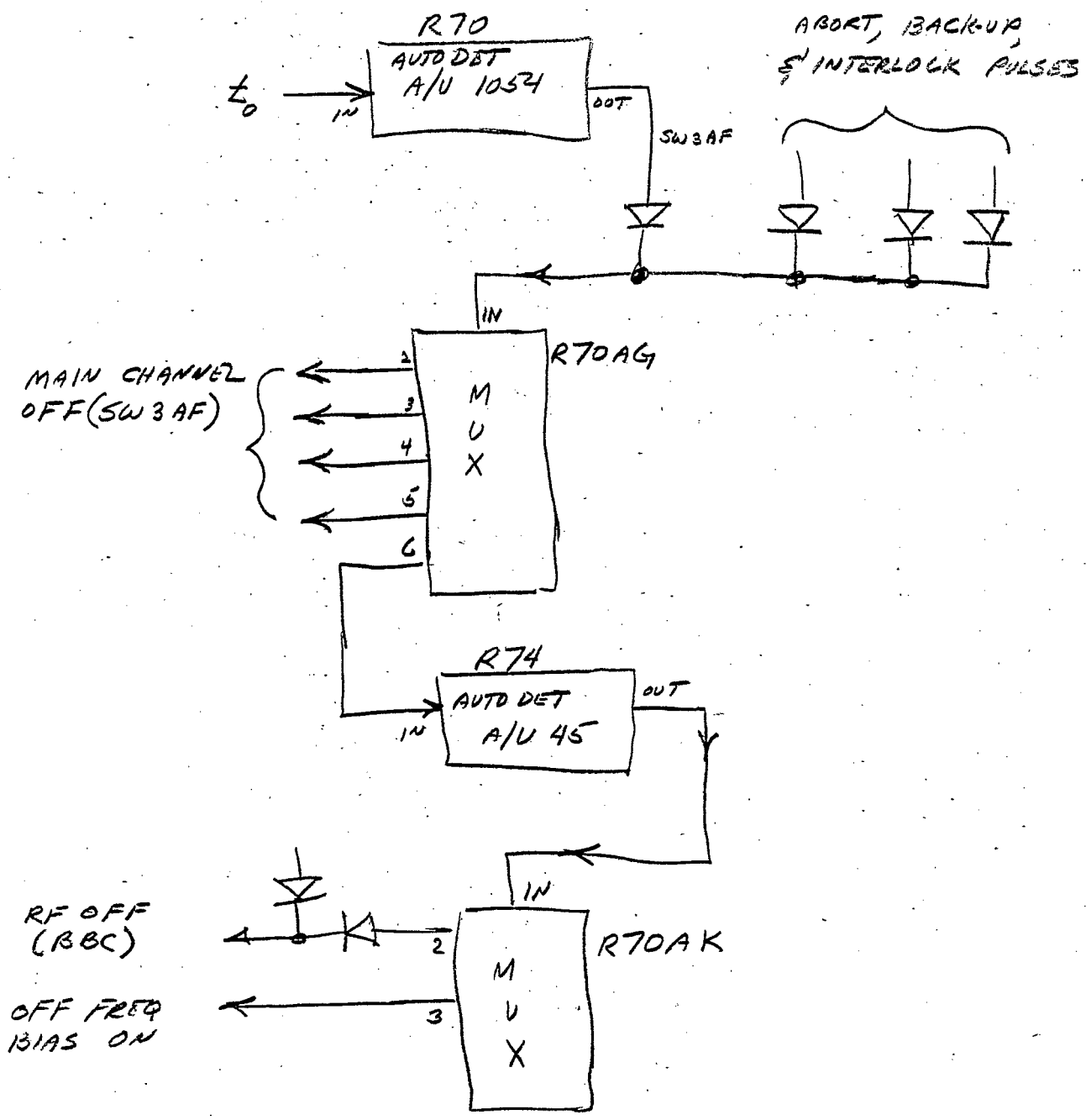
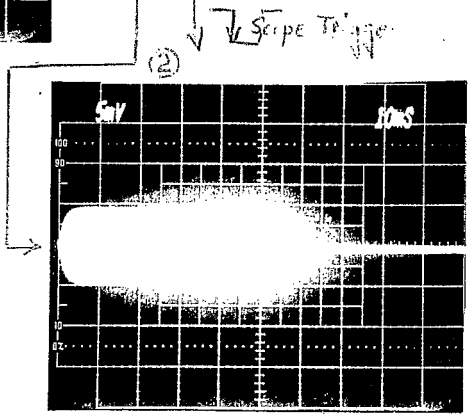
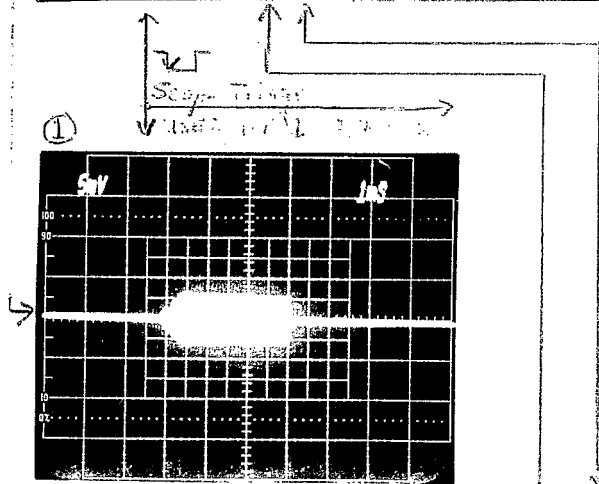
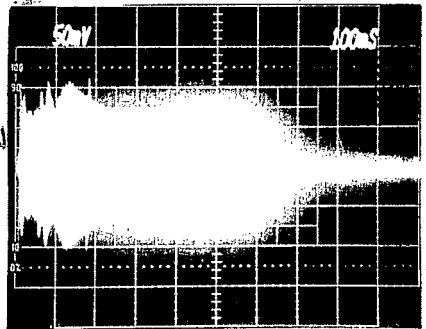
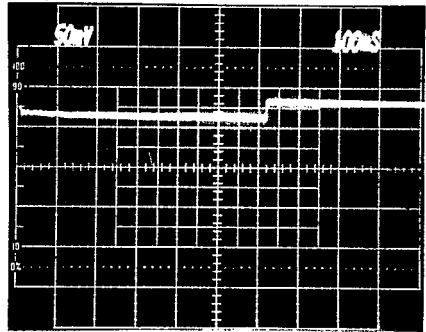
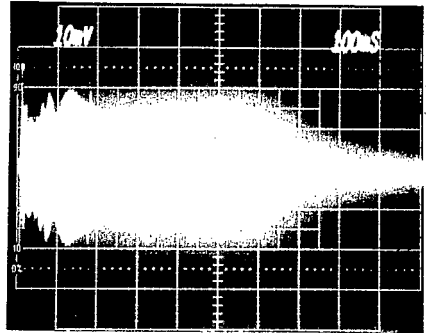
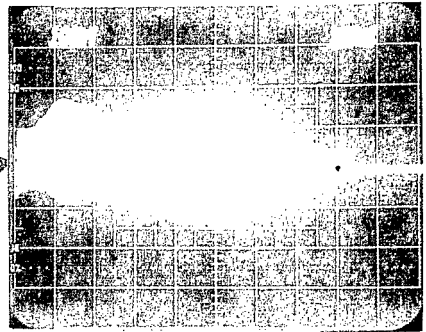
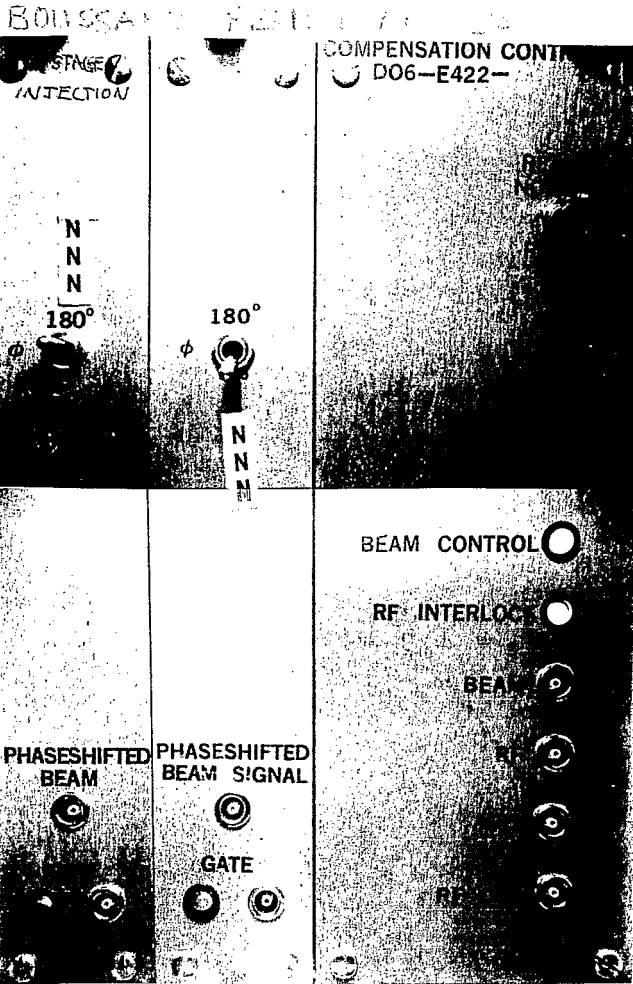


Figure 4  
TRIGGER SOURCE  
DIAGRAM



FIGURE 5



ALL SIGNALS TRIGGERED BY 6-2, 100μs Terminator