CALIBRATION SYSTEM FOR SLC 476MHZ TO 2856MHZ MULTIPLIERS

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Abstract

The two mile long Main Drive Line (MDL) distributes 476MHz at each of the 31 sectors along its length. Each of the 31 sectors has a six times multiplier which drives the 2856MHz phase reference system for that sector. This system is used to set and maintain phase of the accelerator structures over time. During previous runs significant down time resulted from sector phasing which was required after multiplier replacement. A system was designed to calibrate the phase of the 476MHz input to the phase of the 2856MHz output of the multiplier units. This enabled multipliers to be replaced without rephasing sectors.

1 INTRODUCTION

The phase distribution system of the 2 mile long Stanford Linear Accelerator consist of a Main Drive Line (MDL) which distributes 476MHz to each of 31 subbooster stations, reference [1]. At each subbooster station there is a 19 inch rack mount chassis which takes the 476MHz from the MDL multiplies it by 6 to 2856MHz. The chassis is referred to as the SubBooster Drive Unit (SBDU). The 2856MHz in the SBDU is amplified and split to drive the Phase Reference Line (PRL) and the subbooster klystron. Electronics for control of the phase and amplitude of the subbooster klystron are also in this chassis. The SBDU is temperature controlled by a water regulated mounting plate.

The phase of each of the klystrons in a sector is set based on the phase of the PRL. During the 1994 to 1995 Stanford Linear Collider (SLC) run several SBDU were replaced for various modes of failure. The replacement of the unit takes about 1 hour but setting the phase of the 8 klystron sector had taken significantly more time. This recovery time was a significant portion of RF related down time. It was desired by the Accelerator Operations Department that the units all have the same phase length for the phase reference system output. This would allow the unit to be replaced without having to rephase a sector. Since the unit multiplies the RF from 476MHz to 2856MHz the calibration could not be easily done with standard test equipment.

†Work Supported by the Department of Energy
Contract DE-AC03-76SF00515

2 CALIBRATION SYSTEM

In order to calibrate the phase of the SBDU's a calibration unit was built figure 1. With this unit all SBDU were calibrated to the same phase length from the -0.2dbm of 476 MHz in to the 1.3W of 2856MHz out to drive the Phase Reference Line (PRL).

The SubBooster Drive Calibration Unit (SBDCU) consist of a 3 dB hybrid to split the 476MHz input power. One side of the hybrid output goes to the DUT and the other side goes to a six times multiplier. The output of the multiplier, 2856MHz, is passed through a phase trimmer, used for calibration of the unit, an isolator, and then into the LO port of a mixer used as a phase monitor. The PRL output of the DUT goes to into 20 dB coupler with a termination. The -20dB coupled out is further attenuated, passed through a phase trimmer and isolator, and into the RF port of the phase monitor mixer. The output of the phase monitor mixer is on a front panel BNC for viewing with a DVM. All internal phase critical units are mounted to a temperature stabilized plate. The controller with temperature readout is on the front panel.

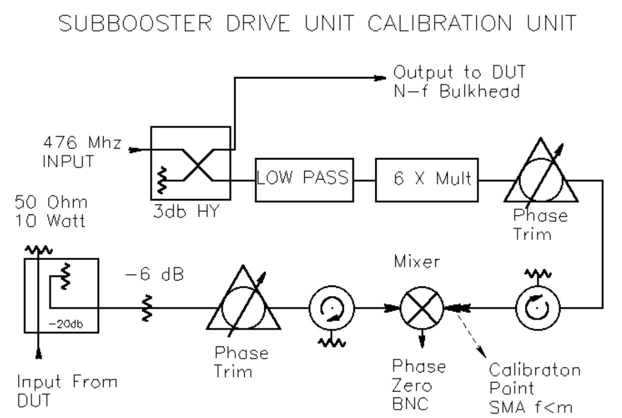

Figure: 1 SubBooster Drive Unit Calibration Unit

2.1 Calibration of the Calibration Unit

Since the SBDU were calibrated against the SBDCU, the SBDCU needed to be calibrated. Calibration of the unit was done in two steps.

Step 1 calibrates the phase of the 476 MHz on the output port to the DUT, to the phase of the 2856 MHz on the SMA male connector to the mixer. The calibration uses a HP54120A 20Ghz sampling scope, a phase shifter, a 476 MHz phase stable source, a 476 MHz 10dB directional coupler, power meter, the calibration adapter (N-male to SMA-male) and RF test cables. The only above item which directly effects calibration is the calibration adapter. The same adapter is used for all calibrations of this unit and is stored inside the SBDCU. The channels of the scope are first cross calibrated using the phase shifter to make sure the phase delay from the input of the cables to the scope screen is the same for channel 1 and 2. Since the phase through a step recovery diode multiplier is power dependent all measurements must be done at the operational power levels. The positive going zero crossings of the 476MHz from the DUT output port to the 2856MHz mixer input is lined up to within 1picosecond using the phase trimmer.

Step 2 of the calibration consists of zeroing the mixer when the phase at the Input from DUT port is equal to the phase at the input to the mixer on the 6 x multiplier output side. Equipment used is a network analyzer, 10 dB directional coupler, 33dB - 2W amp with isolator at output, 30dB directional coupler with 10 watt load at output used as high powered 30dB attenuator, power meter, phase shifter, calibration adapter (N-male to SMA-female), DVM, and test cables. The calibration adapter used effects calibration. The adapter used is stored inside the SBDCU. The power from the analyzer is split and one side amplified. The two cables, one with 1.3 Watts and the other with 3mW, are adjusted to the same phase length and then used to zero the mixer, see figure 2.

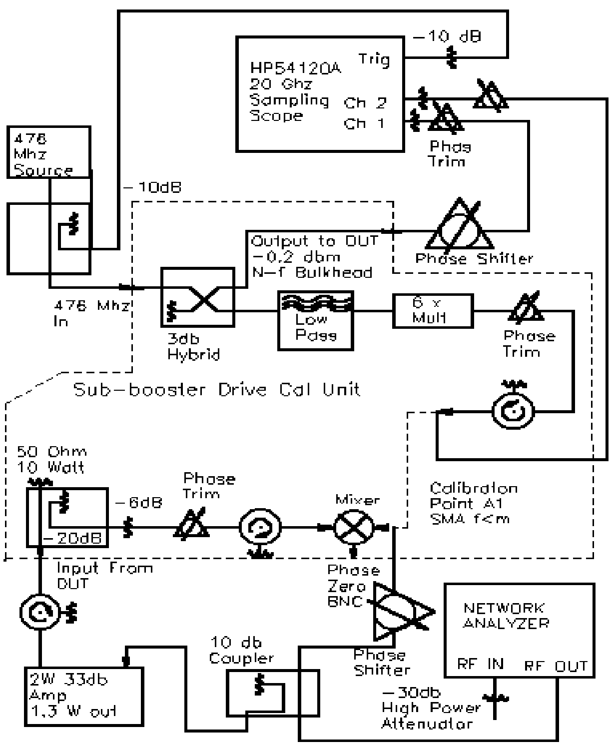

Figure 2 SubBooster Drive Calibration Unit Cal.

2.2 SBDU Calibration

The calibration setup requires a 476 MHz phase stable source, a phase shifter, a network analyzer, power meter, the SubBooster Drive Calibration Unit (SBDCU), three N type test cables and a temperature stabilized water system. Temperature stability is reached in the SBDCU about an hour after turn on. The SBDU is turned on with water temperature stabilized flow for 1/2 hour before measurement.

The phase length of the external phase shifter with a cable on each end is matched to the third cable on a network analyzer. The phase shifter and cable assembly connects the SBDCU output to the SBDU 476MHz input, figure 3. The remaining cable connects the 2856MHz 1.3Watt PRL output of the SBDU to the input of the SBDCU. A phase trimmer installed in the SBDU is then adjusted to zero the mixer, aligning the phase.

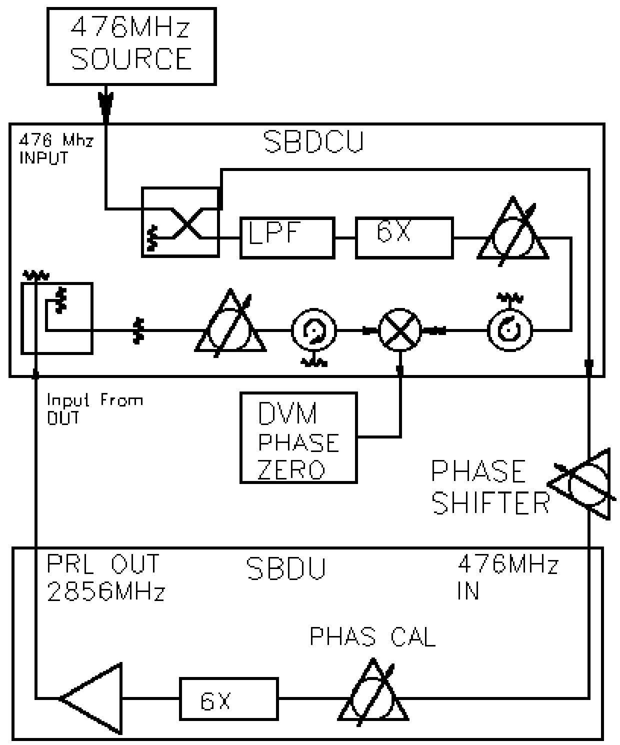

Figure 3 Calibration of Subbooster Drive Unit

3 CALIBRATION PERFORMANCE

Since the upgrade several units have been replaced with no time lost due to rephasing sectors. Figure 4 is a graph of a phase monitor of which the SBDU in sector 19 is in its phase loop. On the 23 of September, 1995, the SBDU was replaced. The spike in the plot is due to RF being removed during replacement. After replacement the phase returned to within 1° @ 2856MHz.

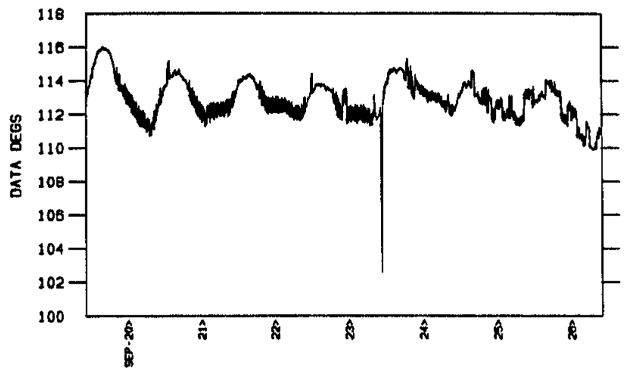

Figure 4 Phase of Sector 19 PRL

3.1 SBDU Calibration Data

During calibration of the SBDU, data was taken on the effects of temperature and amplitude on phase length. A summary of the results are given in Table 1. Phase is measured in °S which is degrees at 2856MHz.

	°S/dB	°S/°C
MIN	-9.98	-2.71
MAX	4.71	4.17
AVG	-2.39	-2.71
STD	2.92	4.17

Table 1. SBDU Phase Characteristic

The temperature of the SBDUs are held to within ±1°C and in most cases is within ±0.5°C. The 476MHz drive amplitude varies diurnally with temperature of the Main Drive Line. At Sector 30 where the variations are the greatest the power levels stay within ±0.5dB.

4 COMMENTS

The calibration of the SBDUs will save many hours of beam time in phasing of sectors. The data collected on the SBDUs will also help in understanding diurnal variations in the linac.

5 ACKNOWLEDGMENTS

We would like to thank K. Jobe, R. Koontz, M. Ross, and H. Schwarz for the fruitful discussions and support of this project.

REFERENCES

[1] `RF Phase Distribution Systems at the SLC', R.K. Jobe and H. D. Schwarz, Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309, USA. SLAC-PUB-4893 April 1989