Fermilab/AD/TEV
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Tevatron Beam Position Monitor (BPM) Upgrade

Filter Card Test Report

Ken Treptow, Vince Pavlicek, Bill Haynes

Introduction

This document contains the results of the testing of the Analog Filter Card in satisfaction of the requirements needed to release the design to production. The Filter Card provides the following signal conditioning and diagnostics functions:

1. Band pass filtering with closely matched pairs of channels.
2. Signal attenuation adjustable with a default of 20 dB for proton and 10 dB for anti proton signals.
3. Diagnostic signal injecting.

The Tevatron Filter board conditions the signals from the Tevatron BPM sensors for input to the Echotek DSR Module. It also provides for injecting a diagnostic signal back into the sensor, into the Echotek Module, or both. The Filter Card has eight channels so that one module is required for each Echotek Module. Each channel (Figure 1) consists of an attenuator network, a band pass filter, and two relays. The BPM signals enter and exit via SMB connectors on the front panel.

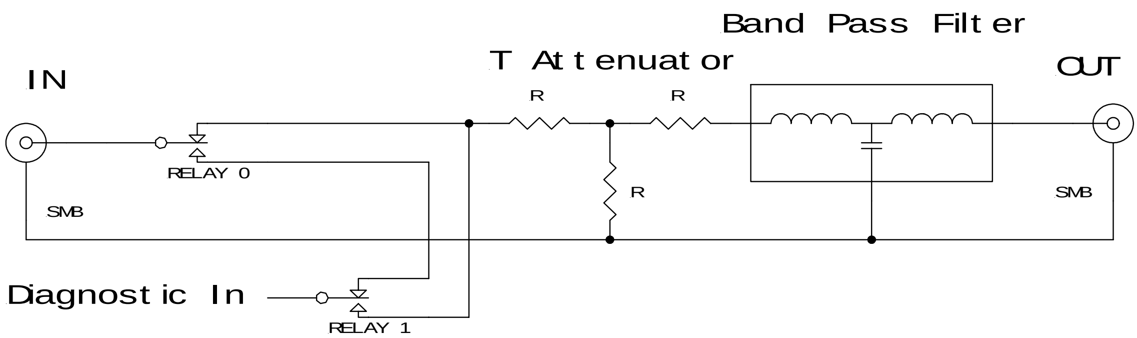

Figure 1 Single Channel

Test Plan

Analog Sections: The default for the below tests are that all Analog channel-under-test inputs and outputs are terminated at 50 ohms. The tested channels have the default attenuator resistors installed and where that becomes part of the measurement, it is noted in the results. Acceptance specs are based on the BPM system requirements and the BPM filter requirements on the assumption that the analog board itself does not contribute any additional signal effects beyond the channel attenuation.

1. Measure the return loss (S11) in a 10 MHz frequency range around a 53.104 center frequency with the relays in their default states so the signal travels through the entire channel on the module. The return loss must be less than -15 db.
    a. Plot the return loss for a representative channel of the module.
    b. Repeat the measurement for all eight channels looking for differences between channels. Differences between channels should be less than 3 db of loss.
2. Measure the insertion loss (S21) in a 10 MHz frequency range around a 53.104 center frequency with the relays in their default states. The insertion loss must be less than ½ db.
    a. Plot the insertion loss for a representative channel of the module.
    b. Repeat the measurement for all eight channels looking for differences between channels. Differences between channels should less than 0.2 db.
3. Measure cross talk by repeating 2 above after modifying the test set-up. Inject the signal into one channel and monitor the output of the neighbor channel(s), maintaining the correct termination at unused inputs and outputs. The crosstalk between adjacent channels should be less than -45 db.
    a. Plot the cross talk as insertion loss for the neighbor channels of a representative channel.
    b. Repeat the measurement for all eight channels looking for differences between the measurements. Differences between measurements must be less than 10 db.
4. Measure channel pair matching by repeating the insertion loss measurement #2 above comparing channel 1 & 2, 3 & 4, 5 & 6, and 7 & 8. The difference between channels should be less than 0.1 db.
    a. Plot the insertion loss for a representative channel pair.
    b. Repeat the measurement for all four pairs looking for differences between channels that are greater than 0.1 db. Any large differences should be understood and repaired if possible.
5. Measure the distortion of the channels by inserting a clean 53.104 MHz signal into the normal input and recording the distortion on the output. Record as distortion percent (less than 2% required) or as spectral plots of the input and output demonstrating that no noticeable (-40db) additional signals are added to the input signal by the board.
6. Measure the spectrum of the diagnostic signal from the timing card at the input and output of the module. Look at the channel inputs with the diagnostic signal sent to the input only and to both the input and output. 90% of the signal should be available in the first test and 75% at each connector in the second. Compare the signal at the output port with the input in two conditions; with the diagnostic signal to the output only (the input connector should have -40db signal level) and with the signal to both the input and output (the signals should have less than 3 db

difference). Compare the relative amplitudes of the eight channels to confirm there is approximately the same signal level (~3 db) in each channel. This test is looking for connectivity and not absolute signal levels.

Digital Section:

Initialize the Filter Card from the timing module. Exercise all relays on one module confirming relay activation with an ohmmeter. Misaddress the module and confirm that the relays do not activate.

Test results

The detailed results are contained in the spreadsheets in the file ProtoTests.xls. This is in the AD document database as Document #1384. Representative results and summaries are provided here. The result index numbers are the same as the test plan index numbers. The test boards are complete and, unless noted, the signal test measurements are made at the input and output connectors.

1. Return loss measurements are less than –34 dB on all channels in a 10 MHz band centered at 53.104 MHz. See typical plot in Figure 2 below.

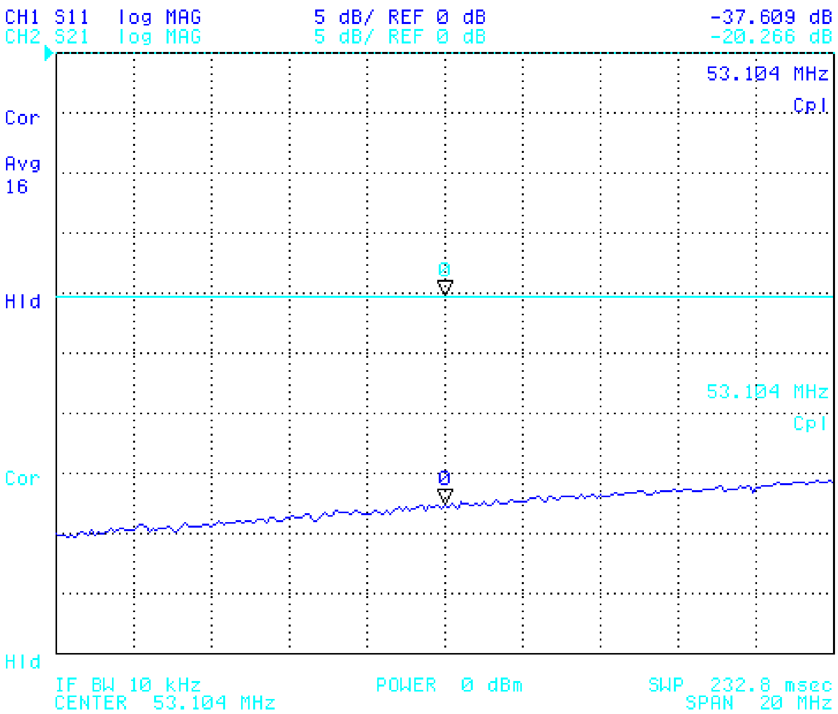

Figure 2. Reflected Energy and Transfer Loss

2. Transfer loss measurements are between 10.27 – 10.28 dB for 10 dB channels and 20.33 – 20.36 on 20 dB channels at 53.104 MHz. Thus the Filter board adds less than .5 db of signal loss to each channel. See typical plot in Figure 2 above.

3. Cross talk is less than 80 dB on all channels. See a typical plot in Figure 3 below.

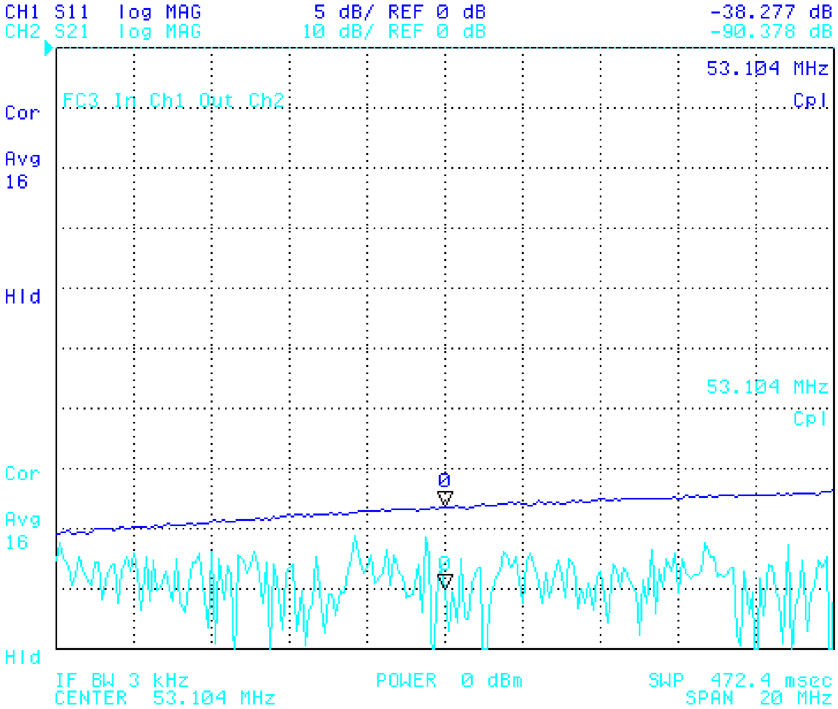

Figure 3. Cross Talk

4. Signal matching between channel pairs is less than 0.5 dB for return loss and less than 0.1 dB for transfer loss. See Figure 4 for a typical plot.

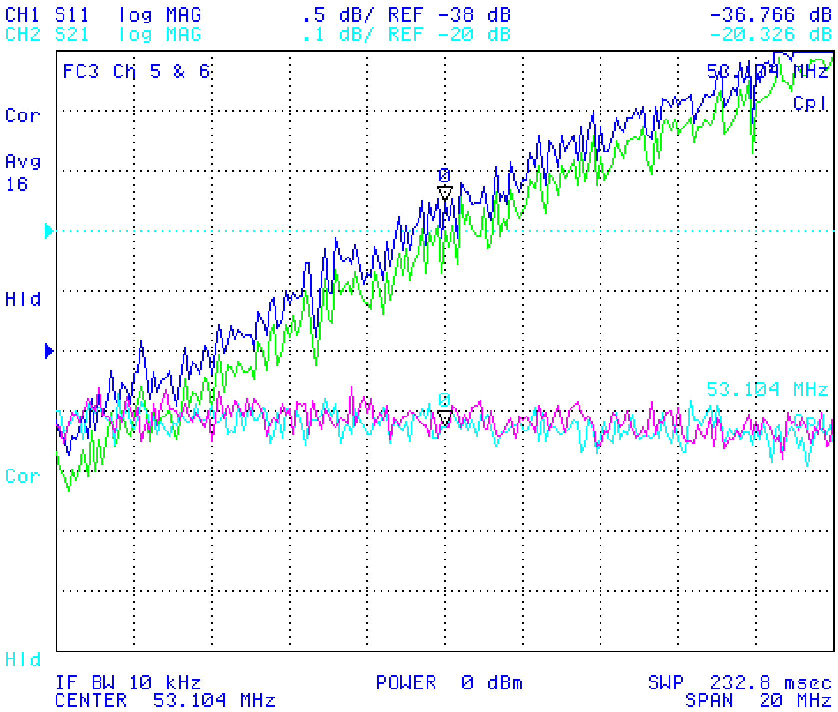

Figure 4. Channel Pair Differences

5. Spectrum plots showed good signal purity. See a typical plot in Figure 5.
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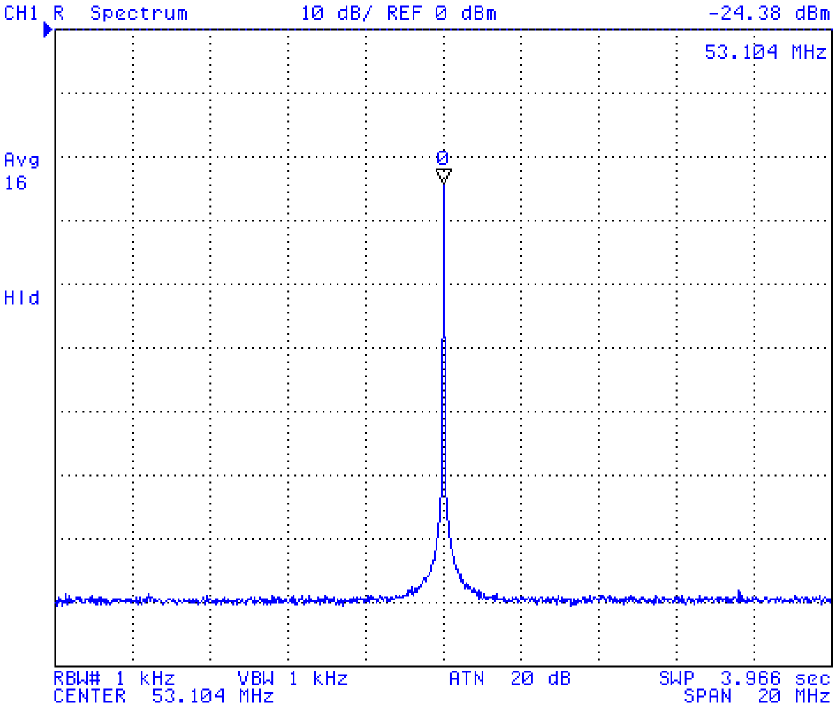

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Figure 5. Spectral Energy

6. The diagnostic signal has injected using all possible relay settings under the control of the Timing Generator Fanout Module. Spectrum plots showed all side bands within +/- 10 MHz of 53.104 to be less than – 40 dB of the test signal. See Figure 6 for a typical plot.
7. No specific tests were done for the mechanical relays used to switch the BPM and diagnostic signals. The manufacturer's specifications and test results are provided as the file rk_ relay.pdf and it is associated with this document in the document database. The part is designed for RF signal systems, is designed to maintain 50 ohm impedance on the signal connections and is specified to have an electrical lifetime of 300,000 operations. The manufacturer specifications show a plot (figure 4-3) of contact reliability over the mechanical lifetime of ten million operations. The BPM use of these relays should accumulate less than 3000 operations per year.

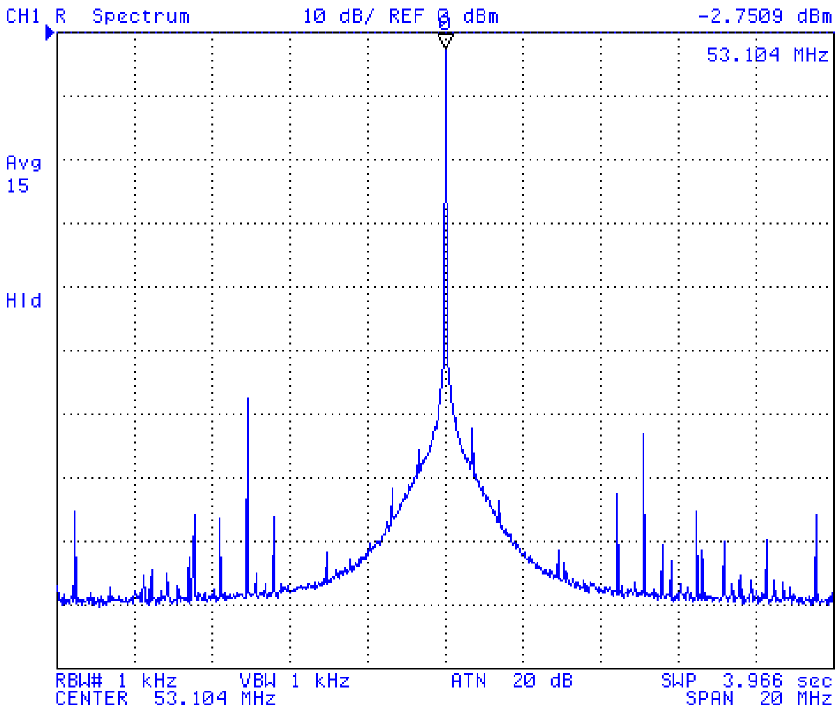

Figure 6 Diagnostic Signal Spectrum

Conclusion

The connectivity requirements for inputs, outputs and within the board have been demonstrated. The test plan shows the boards will satisfy the system requirements. All relay operations and digital communication where tested using the Timing Generator Fanout module. See Beams-doc-1384 for the complete test data for FC SN P3.

Five pilot boards have been assembled and 3 have been through detailed testing as of 30 September 2004.

Change Log

Version	Issue Date	Description of Change
1.0	30 Sept 2004	Original KRT
2.0	8 Oct 2004	Modifications suggested by reviewers

Concurrence

Following persons reviewed and concurred with the content of this document.

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Steve Wolbers, Project Manager (date)

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Bob Webber, Deputy Project Manager (date)

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Jim Steimel, Technical Coordinator (date)

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Vince Pavlicek, Subsystem manager (date)

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Margaret Votava, Subsystem manager (date)