

DEVELOPMENT OF A DIGITAL CONTROL INTERFACE CARD WITH A LABVIEW CONTROL PROGRAM FOR TLS CORRECTOR MAGNET POWER SUPPLY

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Abstract

This paper presents an implementation of a virtual instrument control program and a digitally controlled interface card for Taiwan Light Source (TLS) corrector magnet power supplies (MPS). Eight pieces of corrector MPS converter modules are monitored and controlled by the digitally controlled interface card with delimit boundary of ± 10 voltage. The digitally controlled interface card was implemented with an ADS1278 24-bits multi-channel analog-to-digital converter, a DAC8718 16-bits multi-channel digital-to-analog converter and the TMS320F28335 digital signal processor. There are two control modes of the virtual instrument control program, which are 1) local control mode by RS-232, 2) the remote control mode by MiiNePort_E1 TCP/IP protocol; with the developed Labview control interface program, the user can choose which mode to communicate with the corrector magnet power supplies depending on the working environment.

INTRODUCTION

In TLS, the corrector magnet power converters under operation are Bira's MCOR30A modules, and these modules are controlled by a MCOR 12/30A single ended analog signal interface card. If Bira's MCOR30A modules should be remote controlled, there should be a bi-directional analog to digital converter card embedded in a computer system. In this paper, a digitally controlled interface card with a virtual instrument control program is implemented to replace MCOR 12/30A single ended interface card and remotely control the TLS corrector MPS without a bi-directional analog to digital converter card, that could reduce the instrument cost and manpower.

A homemade digitally controlled interface card includes a Texas Instruments TMS320F28335, a multi-channel analog-to-digital ADC1278 and a multi-channel digital-to-analog converter DAC8718 EVM board. With a virtual instrument control program in NI LabVIEW, the Bira MCOR30As could be totally monitored and controlled through the digitally controlled interface card.

The program for the digitally controlled interface card could be roughly divided into five functional sections: the control core unit/ the data transfer and receive unit/ the current signal capture/communication control modes and the virtual instrument control interface.

THE STRUCTURE OF DIGITALLY CONTROLLED INTERFACE CARD

The digitally controlled interface card could be roughly divided into five functional blocks, Bira MCOR12/30A power converter and Crate2513 / the ADS1278 24-bits multi-channel analog-to-digital converter / a DAC8718 16-bits multi-channel digital-to-analog converter / the virtual instrument control program in NI LabVIEW / a high performance DSP TMS320F28335 controller and RS232 Ethernet and McBSP transmission interface, as shown at Fig. 1.

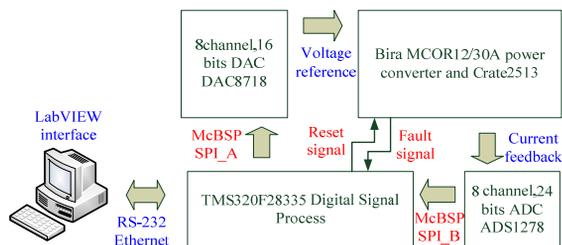


Figure 1: The structure of digital control interface card and the LabVIEW control program.

DSP COMMUNICATION METHOD

The DSP is programmed into three kinds of communication route. The first route is the McBSP protocol, the eight current commands are transferred from DSP to the DAC8718EVM and eight current feedback signals receive by the ADS1278EVM are transferred to DSP. The second route is a 12bits AD converter of DSP and TTL I/O signals, which could capture the fault signal of MCOR30As and reset MCOR30As. The third route is RS-232 or Ethernet ports, the user could choose which mode to communicate between DSP and the corrector magnet power supplies depending on the working environment by the developed LabVIEW control program. There are two ports inside of the McBSP, the port A of McBSP transfers current reference data to the DAC8718, and the port B of McBSP receives current feedback data from the ADS1278EVM data converter, as shown at figure 2.

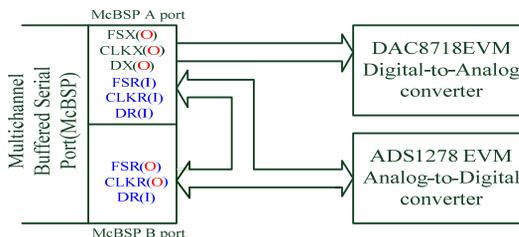


Figure 2: The McBSP protocol for data converter.

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DATA CONVERTER TIMING

The MsBSP with 27MHz system clock and 52.73kHz sample time, could program interruptive events to acquire current feedback signal from the multi-channel analog-to-digital converter ADS1278EVM and transfer current command signal to the multi-channel digital-to-analogy converter board DAC8718EVM.

Figure 3 is the state flow chart between the McBSP and the ADS1278. There are two interrupt events applied in the timing of the McBSP. The first interrupt event is set by port A of McBSP to capture 8 single-channel's 24bits data information of output current from the ADS1278, the second interrupt event is set by port B of McBSP to complete the capture of total 192bits data of eight channels. Figure 4 is the capture timing diagram between the McBSP and ADS1278 data converter for eight-channels.

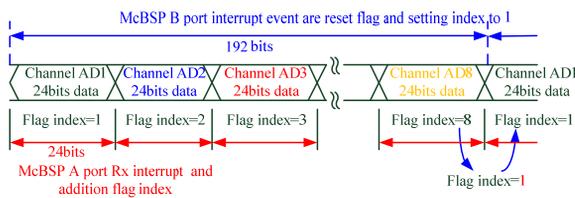


Figure 3: The MsBSP timing state for ADS1278 data converter.

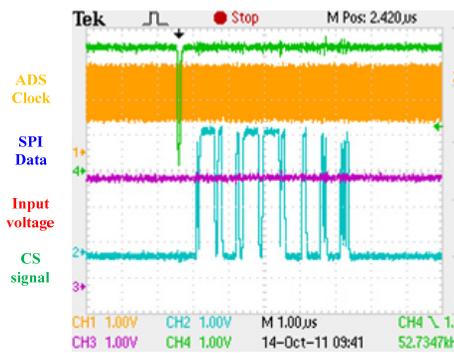


Figure 4: Timing of ADS1278 data converter.

DIGITAL CONTROL INTERFACE CARD DESIGN

The digital control interface card is embedded with a digital signal processor, the multi-channel analog-to-digital converter, multi-channel digital to analog converter and voltage signal transfer converter. The program code of DSP includes the McBSP interruptive events, A/D timing, RS-232 / Ethernet protocol to communicate with the virtual instrument control program. The ADS1278EVM card is adopted as the multi-channel analog to digital converter and the current feedback signal monitored from the shunt of Bira's MCOR30A is transferred into digital values. The digital current commands set by the virtual control program were transferred by the multi-channels digital-to-analogy

converter that drive the input references of MCOR30As. The picture of digital control interface card is shown in figure 5 [1~2].

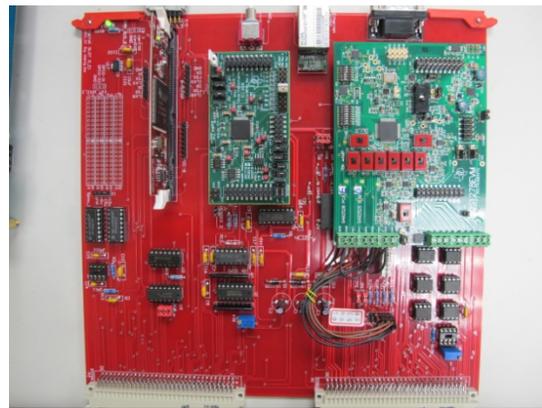


Figure 5: The picture of digital control interface card.

THE VIRTUAL CONTROL PROGRAM

The virtual control program for the digital control card was developed in NI LabVIEW. With this program, output current setting, real-time output current and fault state messages monitoring and reset of MCOR30As are well operated. Figure 6 is the virtual control program for digital control card [3].

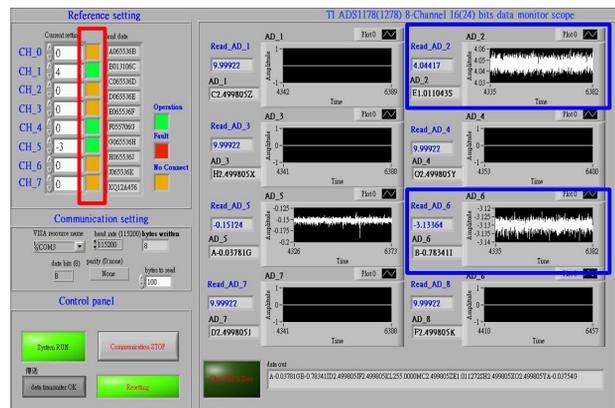


Figure 6: The virtual control interface.

EXPERIMENTAL RESULT

The performance of the digital control interface card and the virtual instrument program was well tested, the linearity of output current, the spectrum analysis of output current and long-term stability are measured in this experiment. The linearity error of output current feedback signal acquired by the analog to digital converter ADS1278EVM is shown in the figure 7(a). The output current command was adjusted from -9.5 to 9.5 volts with a step of 2 volts to fit an error equation that is used to correct the linearity error of output current and output current with correction is shown at figure 7(b). The spectrum of reference signal of the DAC8718 EVM converter for MCOR30 modules is shown in figure 8.

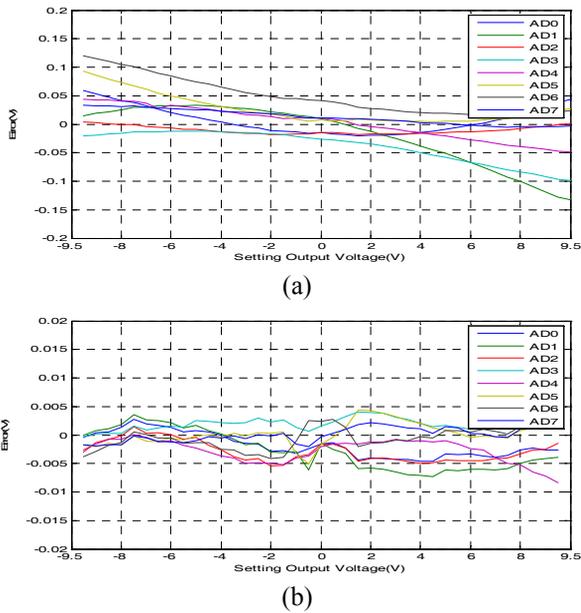


Figure 7: The capture current signal of ADS1278EVM converter (a) the linearity error without correction (b) the linearity error with correction.

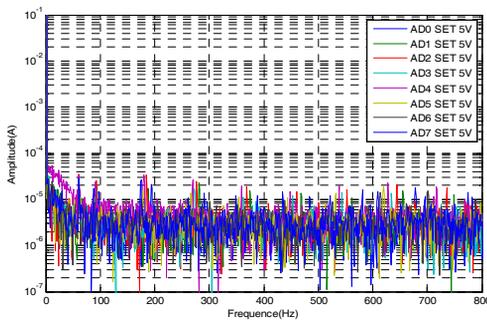


Figure 8: The spectrum of signal of DAC8718 converter.

The power converter was set to output 5 amperes, spectrum and long-time drift of output current were measured. Figure 9 shows the output current spectrum of corrector magnet power converter. The output current drift of the corrector magnet power converter within 8 hours is shown at figure 10, and the stability is within $\pm 10\text{ppm}$.

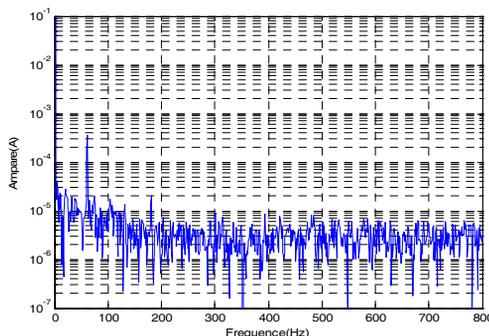


Figure 9: the output current spectrum of MCOR30A.

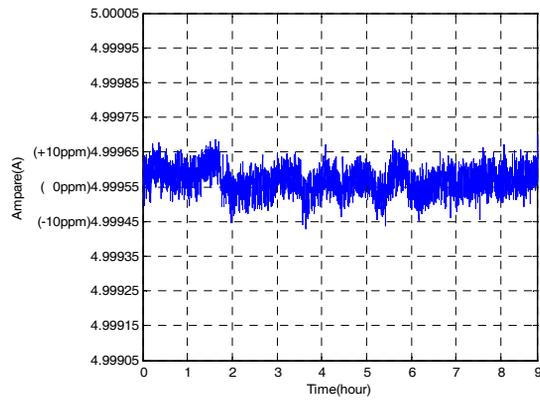


Figure 10: Stability of output current of the corrector magnet power converter within 8 hours

CONCLUSION

Bira's MCOR 12/30A single ended interface card of the TLS's corrector magnet power supply is upgraded by replacing a digital control interface card controlled by the virtual instrument program is fulfilled. There are some advantages with using the digital control interface card, such as low cost, improvement on the linearity of output current at zero current crossing and convenience to connect with PC by the program. With the digital control interface card is adopted, the output current ripple of the Bira MCOR30 modules is within $\pm 100\mu\text{A}$, and long-term stability is within $\pm 10\text{ppm}$. This digitally controlled interface card is designed by the power supply group and there are some functions would be added. In the future, temperature compensation, improvement on the signal/noise ratio, and the protection circuit will be integrated into the digital control interface card to increase system reliability and friendly controllability.

REFERENCES

- [1] MCOR crate operations manual model 2513; http://www.bira.com/manuals/mcor_crate.pdf
- [2] MS320F283xDSP Technical Reference; <http://www.ti.com>.
- [3] www.ni.com