THE COMPENSATOR DESIGN OF THE FULLY DIGITAL CONTROLLED CORRECTOR MAGNET POWER CONVERTER BY USING LABVIEW AS THE DEVELOPMENT TOOLS*

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Abstract

The auto-tuning of PI-compensator for the digital regulation controlled corrector magnet power converter is fulfilled by using the LabVIEW. The current error signals of the power converter with different PI compensating parameters are transferred by RS-232 or Ethernet communication interface from DSP card into LabVIEW and FFT analysis are calculated. The FFT analysis are stored in the batch file for further numerical analysis, the parameters with the best response will be recognized and set as the default PI parameters. In addition, the feasibility and validity of auto-tuning theorem was verified by measuring the long-term stability of output current, and during the long-term measuring period the stability and ripple current of the power converter are also observed.

In this paper, the fully digital regulation controlled corrector magnet power converter with a shunt as the current sensing component was used as the developing platform. The PI parameters auto-tuning method was realized and applied to the compensator of the power converter, and the best output current response of the power converter was fulfilled.

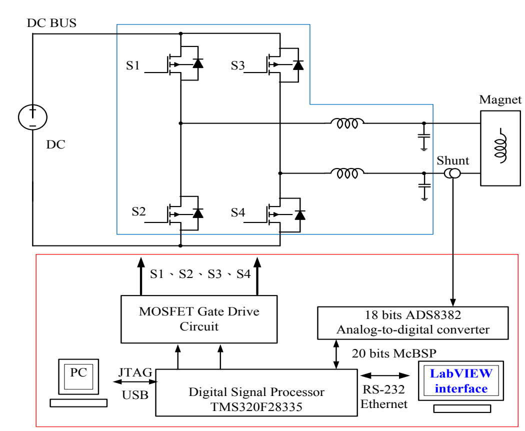
INTRODUCTION

The analogy compensator circuit of power converter consists of operation amplifiers, resistors and capacitors, which are inconvenient to be adjusted. It's much easier to tune the compensator of a fully digital regulation controlled power converter. The homemade fully digital regulation controlled corrector magnet power converter with a shunt as the current sensing component was used as the platform, the virtual instrument control interface and PI parameters auto-tuning of compensator are developed by the LabVIEW to recognize the best PI parameters of compensator. The function of the virtual instrument control interface includes the basic control of power converter, the monitor system information, auto-tuning of compensator, the FFT analysis of feedback output current, recognition of the best operation point, and long-term stability measuring program. With the virtual instrument control interface, the R&D design loading of compensator for full digital regulation control at the difference kind of magnet load was minimized.

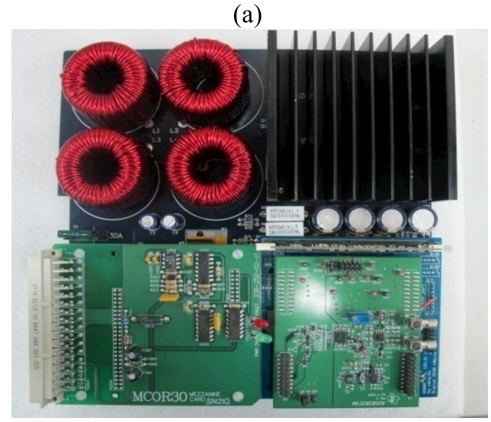
To confirm the accuracy of FFT analysis policy before implementation of the virtual instrument interface, this FFT analysis of the virtual instrument control interface was simulated with MATLAB Simulink [1-3].

THE STRUCTURE OF DIGITAL CONTROL POWER SUPPLY

The digital regulation controlled corrector magnet power converter could be roughly divided into five functional blocks: Bira's MCOR30A power module/the high resolution AD8382EVM 18-bits analog-to-digital converter/digital signal process TMS320F28335 controller/the virtual instrument control interface/and RS232/Ethernet communication interface. Fig. 1(a) is the structure of the digital regulation power supply, fig. 1(b) is the picture of Bira's MCOR30A module with the DSP control card was plugged.



(a)



(b)

Figure 1: The digital regulation power converter (a) the structure circuit (b) Bira's MCOR30A module with the DSP control card was plugged.

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THE VIRTUAL INSTRUMENT CONTROL INTERFACE OF POWER CONVERTER

The virtual instrument control interface of digital regulation power supply could be roughly divided into four functional blocks: basic control unit/communication console unit/numerical analysis unit and system measuring unit. Fig. 2 shows the virtual instrument control interface of digital regulation power supply. The basic control unit includes control of power converter and setting of compensator parameters. RS-232 console is the communication unit between the DSP control card of power converter and LabVIEW. There are two function of numerical analysis unit, the first one is the FFT analysis of output current error of power converter, and the second one is the analysis of the best operation point of compensator. After auto-tuning process, the system measuring unit will measure the long-term output current stability of power converter.

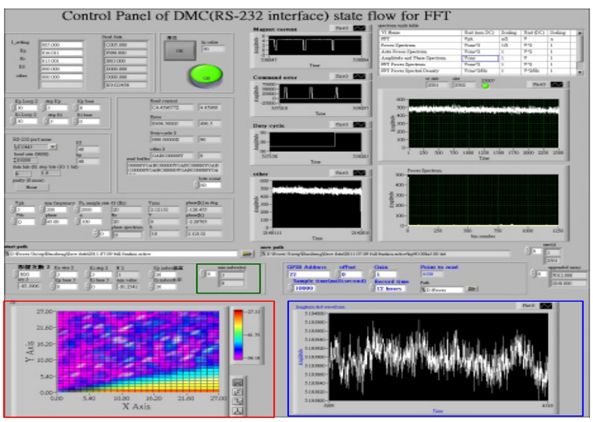


Figure 2: The virtual instrument control interface of digital regulation power supply.

THE AUTO-TUNING OF COMPENSATOR REGULATION ALGORITHM

The output current step response of power converter with different parameters of the compensator were measured and shown in Fig. 3. The output current error signals of the power converter are transferred by RS-232 communication console from DSP control card into LabVIEW and FFT analysis are calculated. The FFT analysis of output current data was stored in the batch file for further numerical analysis shown in Fig. 4.

The spectrum of output current error signals is calculated by Equ.1 to get the total harmonic distortion (THD) of output current error. The THD values of output current error signal are stored in the two dimension array file that would be read by the best operation point program to search for the best operation point. The THD value arrays of output current error signal are calculated by Equ.2 to get the $\mathbf{D}_{n\times m}$ matrix, that is square average of THD would be used to search the D_{min} index. The D_{min} value is the best response of power converter with lowest output current ripple in the $\mathbf{D}_{n\times m}$ matrix. The index of D_{min} is the best P-I compensator parameters of DSP controller.

$$I_S = \left({I_{S0}}^2 + \sum_{h=1}^{1250} \left(\frac{I_{Sh}}{h} \right)^2 \right)^{1/2} \tag{1}$$

$$D_{n\times m} = \frac{1}{9}\left[\sum_{a=n-1,n,n+1} \left(\sum_{b=m-1,m,m+1} I_{Sab} \right) \right] \tag{2}$$

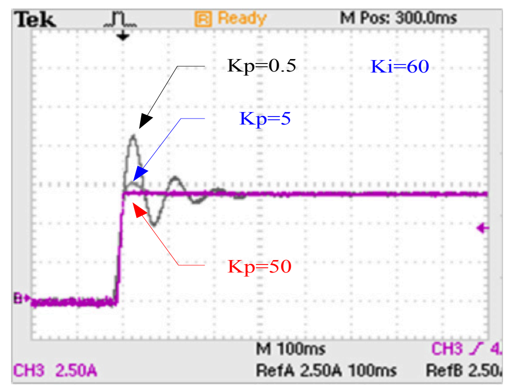


Figure 3: The step response of power converter.

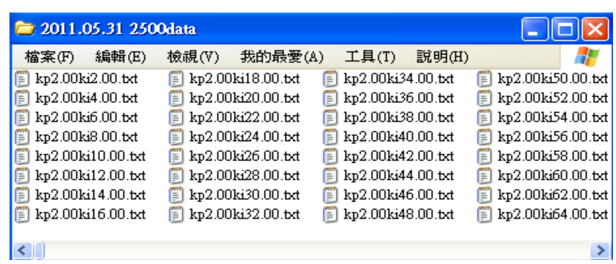


Figure 4: The batch file of output current FFT analysis.

MATLAB SIMULATON

The FFT analysis function of LabVIEW is confirmedly simulated by MATLAB Simulink. A harmonic sinusoidal signal waveform is generated by MATLAB Simulink program (Fig. 5) and import into the virtual instrument control interface.

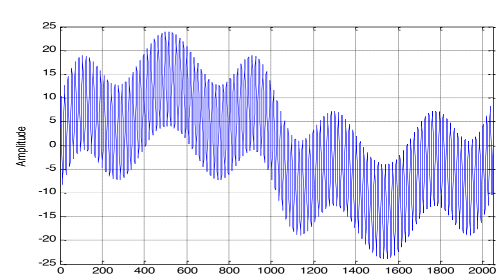
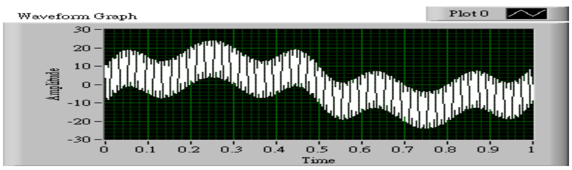
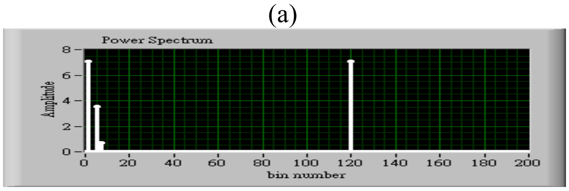


Figure 5: MATLAB program waveform.

Fig. 6(a) is the harmonic sinusoidal signal waveform measured by the virtual instrument control interface. Fig. 6(b) is the spectrum of the harmonic sinusoidal signal waveform after FFT analysis by the virtual instrument control interface, and the harmonic spread is well matched with the harmonic sinusoidal signal waveform generated by MATLAB Simulink.



(a)



(b)

Figure 6: The FFT analysis (a) Capture in the LabVIEW, (b) Spectrum of waveform.

EXPERIMENTAL RESULT

In order to find out what is the best operation condition, parameters Kp and Ki were set with different values and the correspondent THD amplitude of power converter output current ripple were measured and represented with the color bar in Fig. 7. With 5.193A output current of power converter, the best current response of power converter is -97.09dB THD amplitude, and under this operating condition Kp is 45, Ki is 30. The best response is recognized by the virtual instrument control interface and the auto-tuning of P-I compensator for virtual instrument control interface was implemented with correspondent parameters being set as the default P-I parameters.

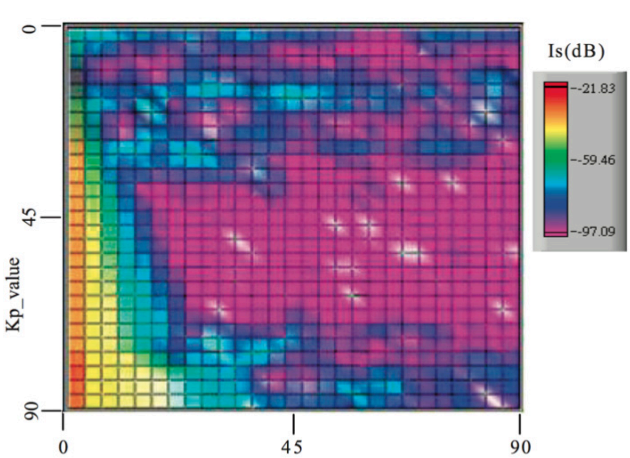


Figure 7: The output current spectrum with different P-I compensator

After Kp and Ki were set as default values of the compensator, the long-term output current stability of power converter was measured. Figure 8 shows the output current stability of fully digital controlled corrector magnet power converter with duration of 12 hours, and the stability was within ±10ppm.

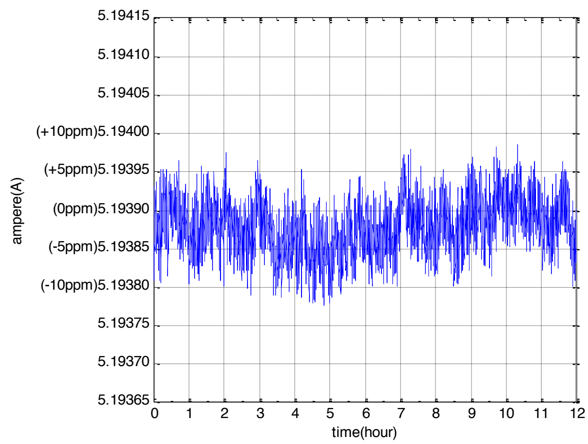


Figure 8: Stability of output current of power converter.

CONCLUSION

The best parameter values Kp and Ki of compensator of the fully digital controlled corrector magnet power converter is recognized by the virtual instrument control interface with adopting LabVIEW as the development tools. The output current stability of the fully digital control corrector magnet power supply system is about ±10ppm with duration of 12 hours, and the function of auto tuning of P-I compensator and the virtual instrument control interface is operated normally.

REFERENCES

[1] William J. Palm III, “MATLAB for Engineering Applications”, McGraw-Hill, Inc, 1999.
[2] TMS320F283xDSP Technical Reference.
[3] http://taiwan.ni.com/

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