Development of Small-scaled Converter for ITER Power Supply

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1. Introduction

In this paper, the small-scaled converter of High current magnetic power supply is designed for superconductor coil of Tokamak with controller with DSP-based controller. The small-scaled converter is composed of parallel and series structure with 4 quadrant converter. In order to verify AC-DC convertor's characteristic, resistor load test has been done and prove stability of a power stack and controller. Exchange a resistor load to reactor load to test current control characteristic. And than adjust PI gain of controller repeatedly to follow reference current (10~30[A]), set up the optimum gain value[1]. When the sign of current reference changes from positive to negative or vice versa, thyristor firing must be delayed until feedback current is zero. So zero-crossing has dead-time, it was confirmed through experiment. The bypass is to provide the protection of converter and magnet, in fault condition that come from converters or magnets. In case of fault, the converter bypass shall be first activated to avoid DC short. Among converter bypass, external bypass switch test that is divided into two: One is bridge terminal bypass method and the other is converter terminal bypass method have been conducted to verify the performance. All above-mentioned experiment get accomplished by both parallel and series structure.

2. Test Results

The small-scaled converter has been tested on converter's basic characteristic is designed as parallel and series types with DSP-based controller respectively. Parallel converter topology is shown in Fig.1 and Fig.2 shows the implemented system with the parallel and series converters topology.

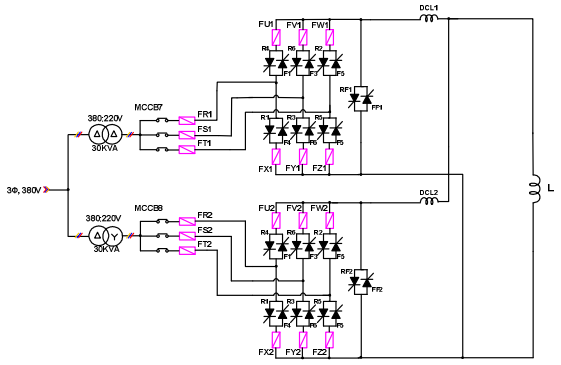

Fig. 1 Simplified schematics of a parallel converter

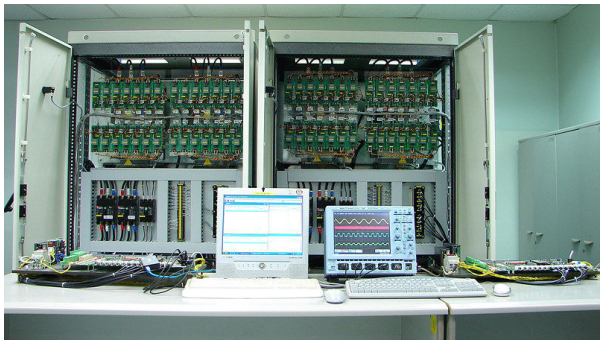

Fig. 2 Implemented system for AC-DC converter

2.1 Characteristics of Current Control

The current control is implemented as shown in Fig. 3. (a) is reference current, (b) actual current, (c)firing angle, (d) DC voltage. Adjust PI parameters of controller repeatedly to follow reference current (10~30[A]), set up the optimum gain values as follows

Initial value of Integral gain : 0.25
Proportional gain : 0.012
Integral gain : 0.18

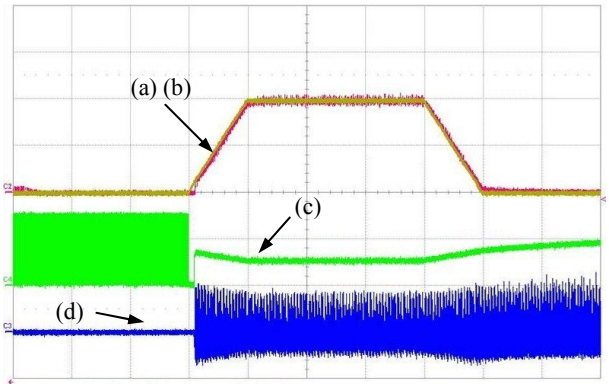

Fig. 3 Waveform of current control

When the absolute value of current is below10~15% of the maximum current, the polarity changes from positive to negative or vice versa is occurred[2]. To avoid the danger of current extinction at zero crossing during the polarity change, dead-time must exist. Considering the small-scaled converter's rating, polarity change procedure is happened when the absolute value of current is below 5[A]. If exist current extinction at zero crossing, maximum firing angle(150°) is triggered for 20msec and than it will have dead-time for 20msec to guarantee safety. The experimental results of the

changes from positive to negative are given Fig. 4. (a) is Reference current, (b) Actual Current, (c) Firing angle, (d) DC voltage.

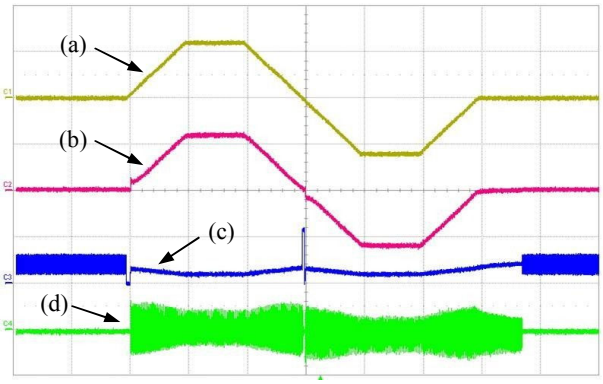

Fig. 4 Waveform of current polarity change

2.2 External Bypass Switch Test

The purpose of the experiment is to verify whether bypass switch operate or not in fault condition. If the current path could flow DC current continuously be made by bypass switch action, the short circuit can prevent through delay of converter's off-time. To artificially occur fault condition during a steady state, lower the over current standard below measured current. External bypass switch test is divided into two. The bridge terminal bypass method is place the bypass switch between the thyristor bridge and the DCL. And the converter terminal bypass method is place the bypass switch between the load reactor and the DCL. The DC current waveform through the method of bridge terminal bypass switch is given Fig.5 and Fig.6 shows the enlarged waveform of the Fig.5. The DC current waveform of converter terminal bypass is similar to Fig.5 and 6. But the difference between two methods is converter terminal bypass is influenced by DCL when the current flow changes to bypass switch. So, commutating time is longer than compare to Fig.5 and 6.

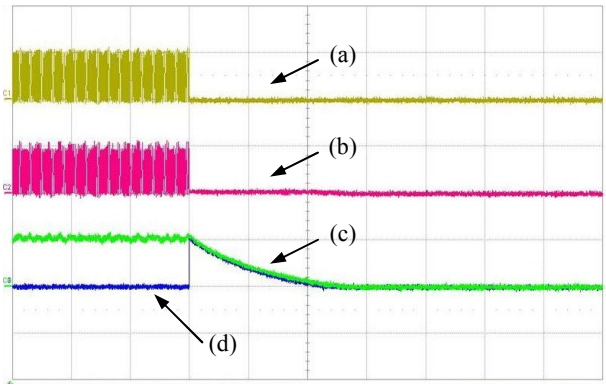

Fig. 5 DC current waveform of external bypass test

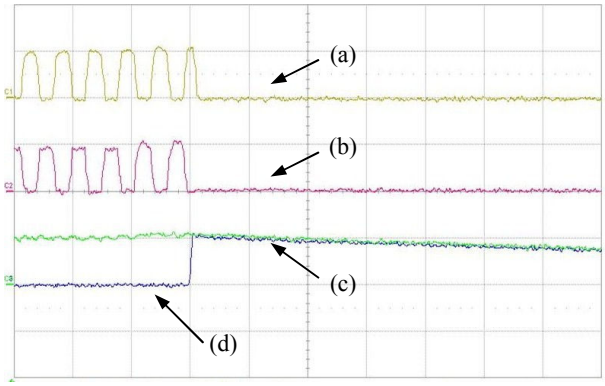

Fig. 6 Zoom in Fig. 5

In above Fig. 5 and 6, (a) is Y-converter current, (b) Δ -converter Current, (c) DC current (d) Bypass current.

3. Conclusions

VS(Vertical Stabilizations) convertor consists of four 6-pulse back-to-back thyristor bridges combined in two 12-pulse groups, with two groups of series-connected bridges in parallel through a DC reactor. Before carrying out VS convertor test, basic experiment for AC-DC thyristor converters of parallel and serial structure had been done. Using parallel convertor, circulation current test which ought to apply to ITER power supplies will be carried out. Sequential control could improve the power factor and reduce the reactive power to complete systems will be accomplished by using series convertor. Those experiments are expected to apply to the structural design for power supplies of ITER.

REFERENCES

[1] SEUNG-HO SONG, Current Control of 12-Pulse Regenerative Converter for High Currnt Magnetic Power Supply, Electric Power Components and Systems, pp.917-926, 2006.
[2] ITER Design Description Document - N 41 DDD 16 01-07-06 R 0.3, 2001