6TH POCPA Workshop 2018

Improvement for a Fast Corrector Power Supply in TPS

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1.Introduction About the NSRRC

Formosa

by

Portuguese

NSRRC：National Synchrotron Radiation Research Center

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Taiwan Light Source

Taiwan Photon Source

TLS：Taiwan Light Source

TPS：Taiwan Photon Source

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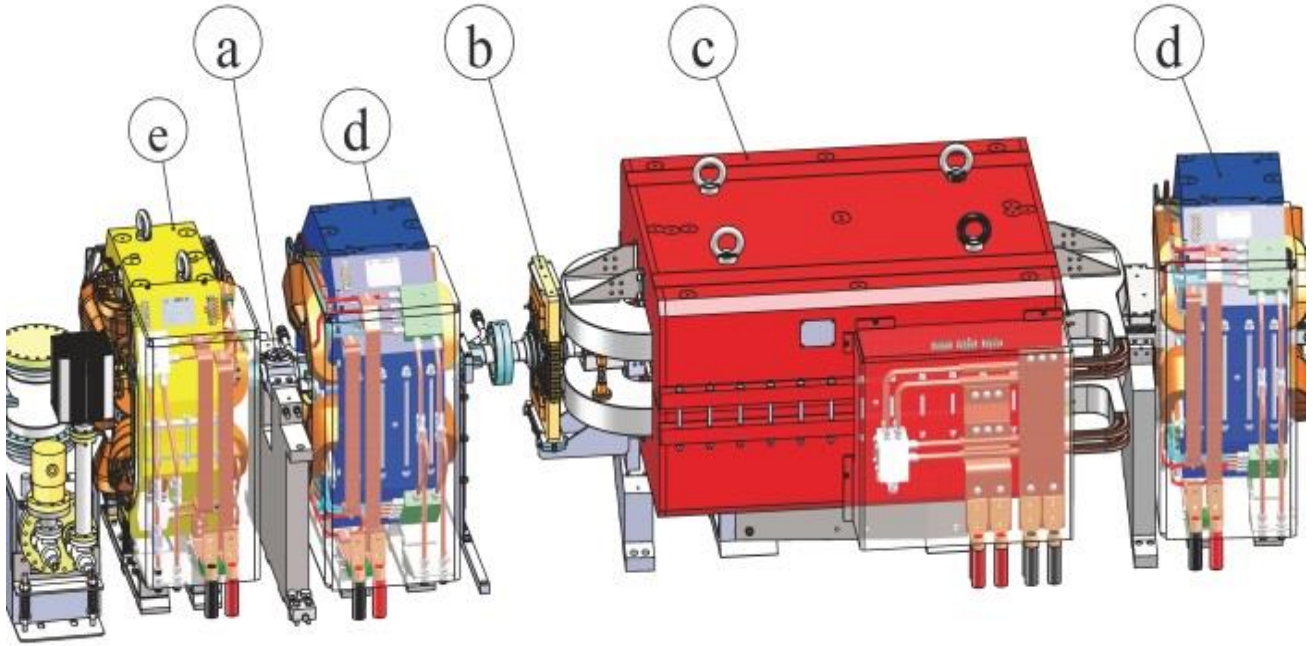
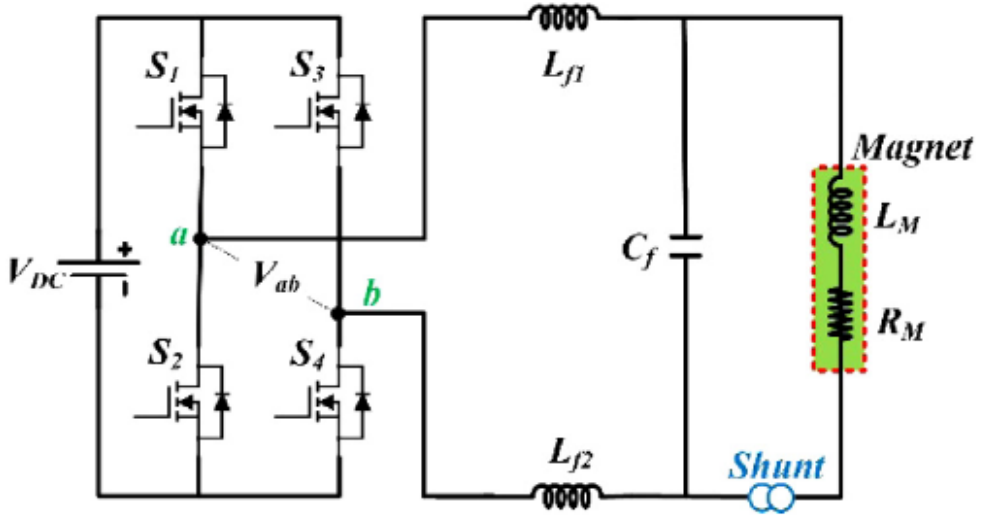
The Structure of Storage Ring Beam Position Monitor (BPM), and Corrector Magnet in FOFB



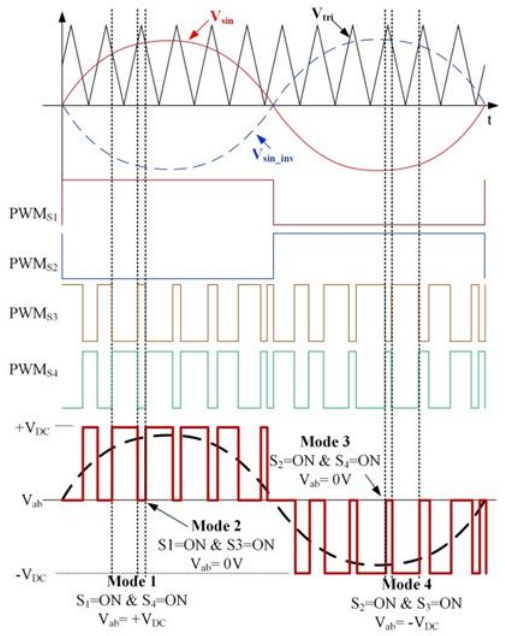
(a)BPM, (b) fast corrector magnet, (c)dipole magnet, (d)quadrupole magnet, (e)sextupole magnet

The FCPS employs the full-bridge topology with the rated current/voltage of ±10A/ ±50V

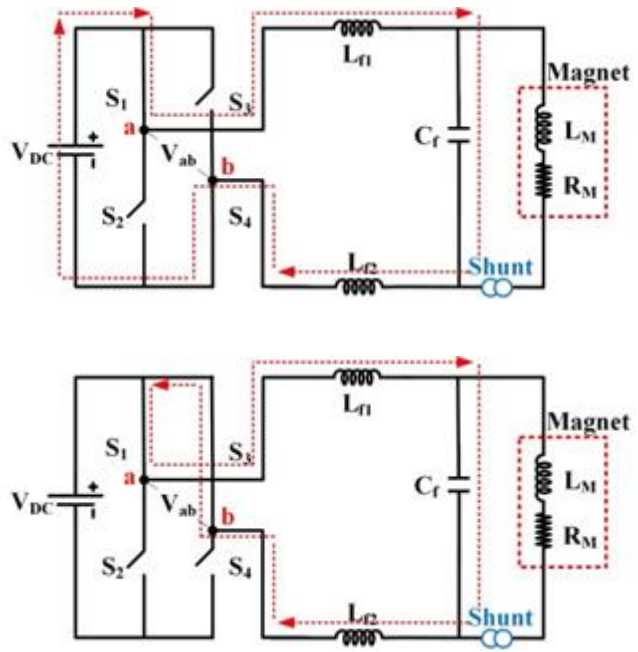


Basic Circuit Configuration of a Full-Bridge FCPS

The Triangular Carrier Signal; V_{SIN} and V_{SIN_INV} are the Sinusoidal Reference Signals for the positive and Negative Bridge Output Voltages

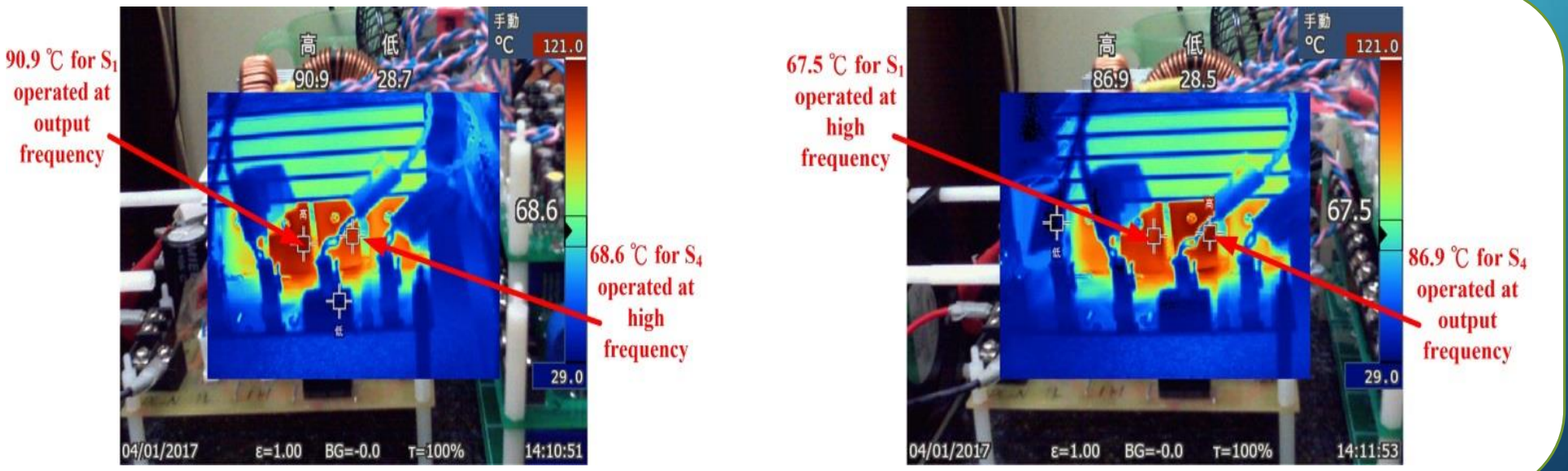


Key Waveforms of the Full-Bridge FCPS



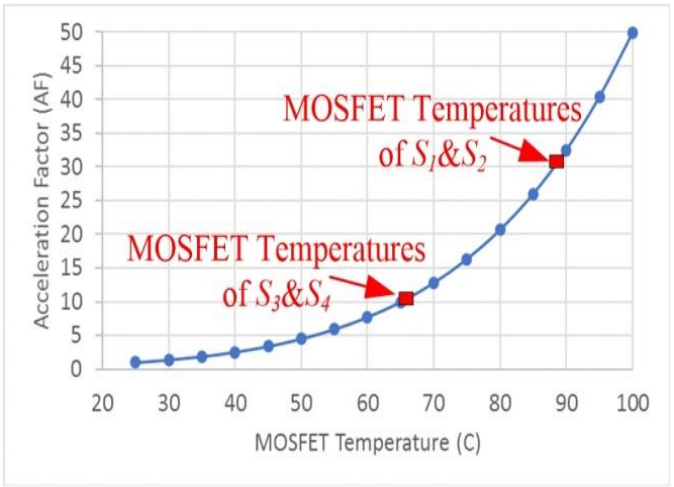
Operational Modes of the Proposed FCPS

MOSFETs' Temperatures Measured by an Infrared Thermography



Measured Temperatures of MOSFETs S_1 and S_4 while MOSFETs S_1 and S_2 and MOSFETs S_3 and S_4 operated at output frequency and high frequency, respectively.

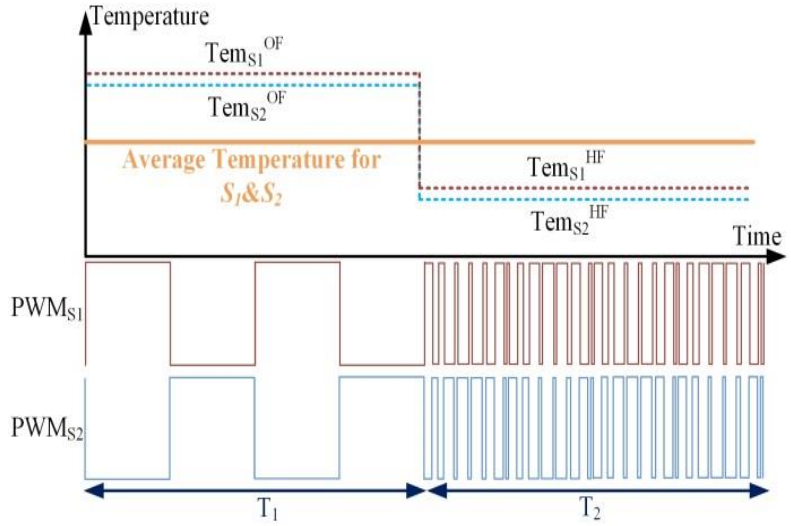
# Indicates the Acceleration Factors of MOSFETS S_1 and S_2 Are Greatly High Than the Factors of MOSFETS S_3 and S_4 Due to the Exponential Acceleration Factor Function



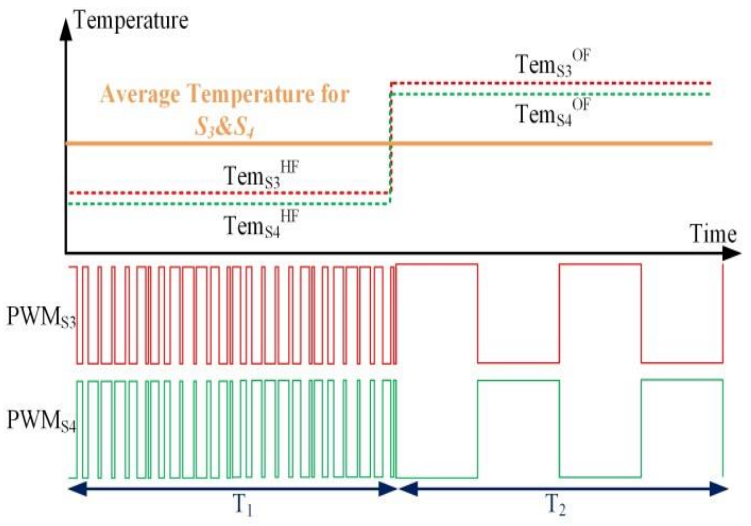
Acceleration Factors w.r.t. Actual Use Temperatures for HPWM

2. Upgrade the Fast Corrector Power Supply Project

The MPWMS and MOSFETS' Temperatures for the Proposed Average-Temperature Control

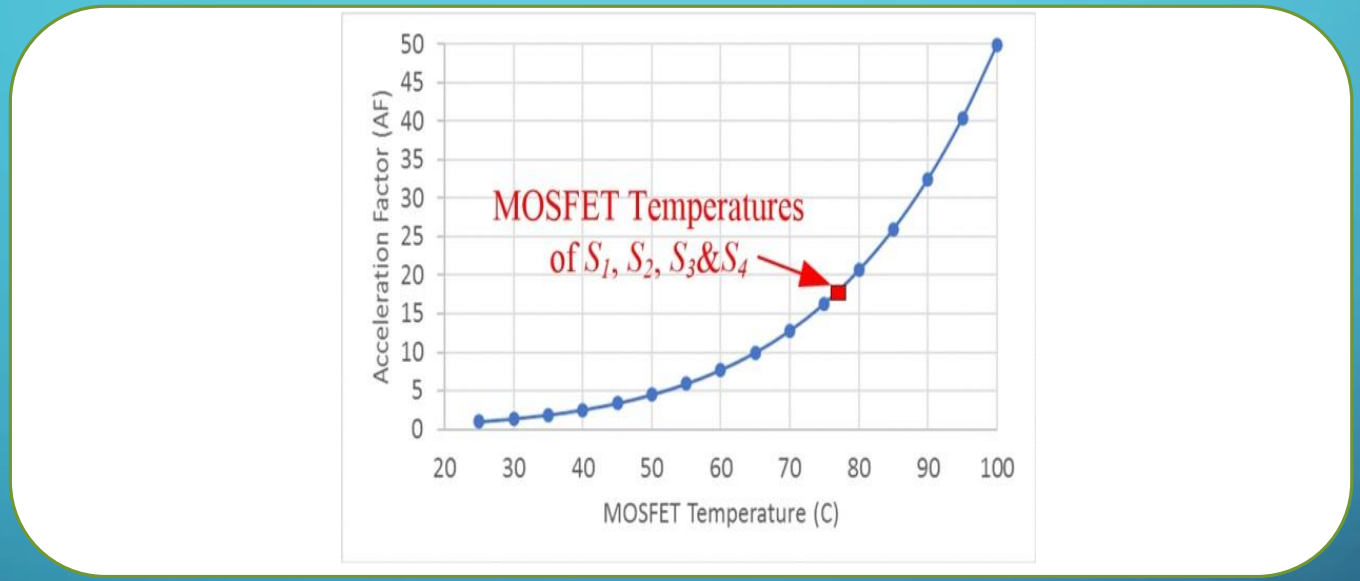


MPWMS and Temperatures for MOSFETs S_1 and S_2



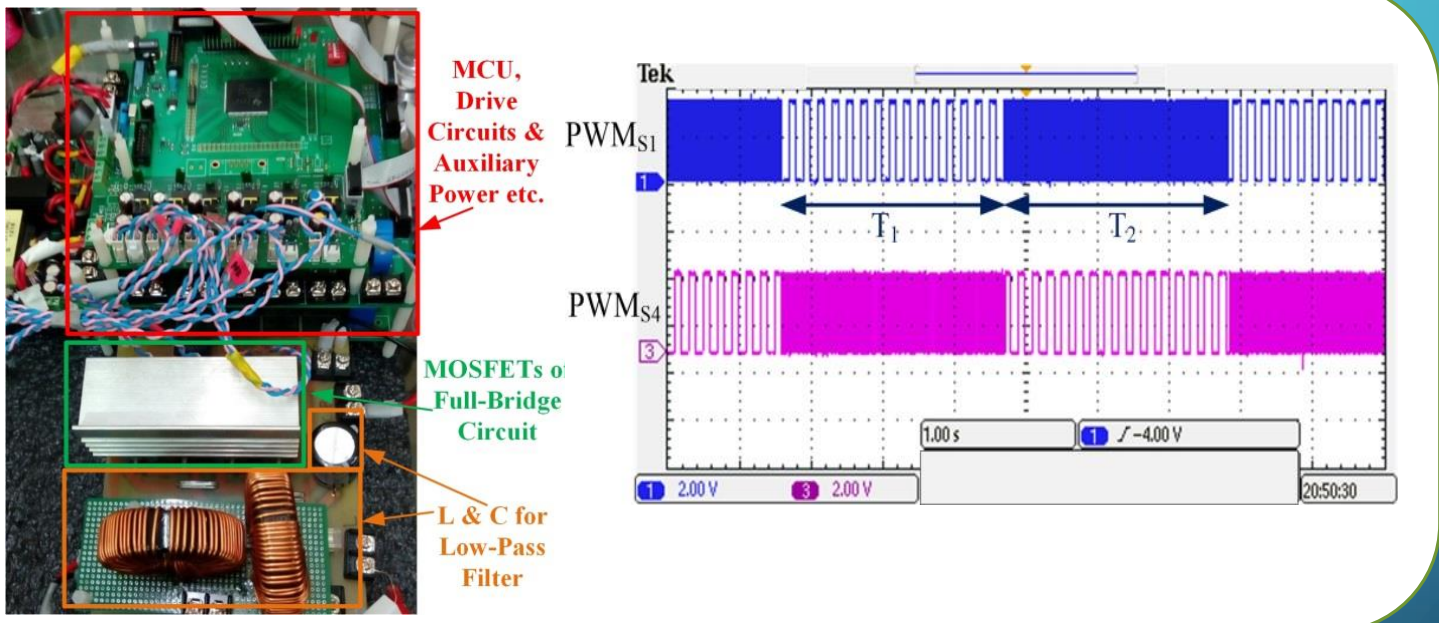
MPWMS and Temperatures for MOSFETs S_3 and S_4

The Acceleration Factors w.r.t. Actual Use Temperatures of MOSFETS for MPWMS



Acceleration Factors w.r.t. Actual Use Temperatures for MPWMS

Implemented FCPS prototype and example of the PWM signals of the Proposed MPWMS for the MOSFETS S_1 and S_4



The time intervals T_1 and T_2 can be adjusted according to the actual requirements and are set as 125 s in the following experiments

Lists the MOSFETs' Temperatures for the Different Operational Conditions and the Estimated Failure Rates for the Components Used in the Implemented FCPS Prototype

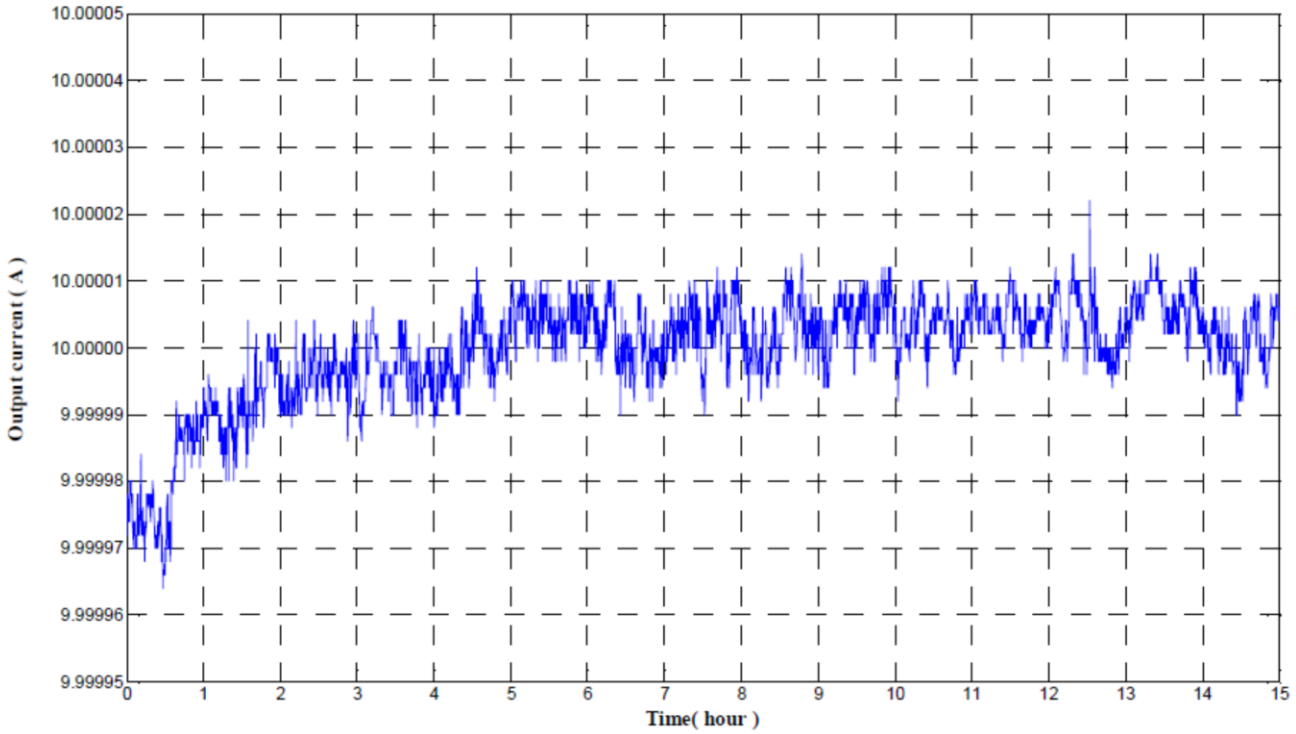
Temperatures while MOSFETs S_1 and S_2 and MOSFETs S_3 and S_4 operated at output frequency and high frequency, respectively.			
S_1	S_2	S_3	S_4
90.9 C	87.2 C	67.9 C	68.6 C
Temperatures while MOSFETs S_1 and S_2 and MOSFETs S_3 and S_4 operated at high frequency and output frequency, respectively.			
S_1	S_2	S_3	S_4
67.5 C	69.3 C	89.3 C	86.9 C

MOSFETs' Temperatures under Different Operational Modes

Component	Failure Rate (per million hours)
MOSFETs $S_1 - S_4$(78.6 C)	1.701
Low-pass Filter Inductance L_{f1}, L_{f2}	0.038
Low-pass Filter Capacitance C_f	0.87
Voltage Sensor	0.56
Current Sensor	0.5
Gate Drive	1.0

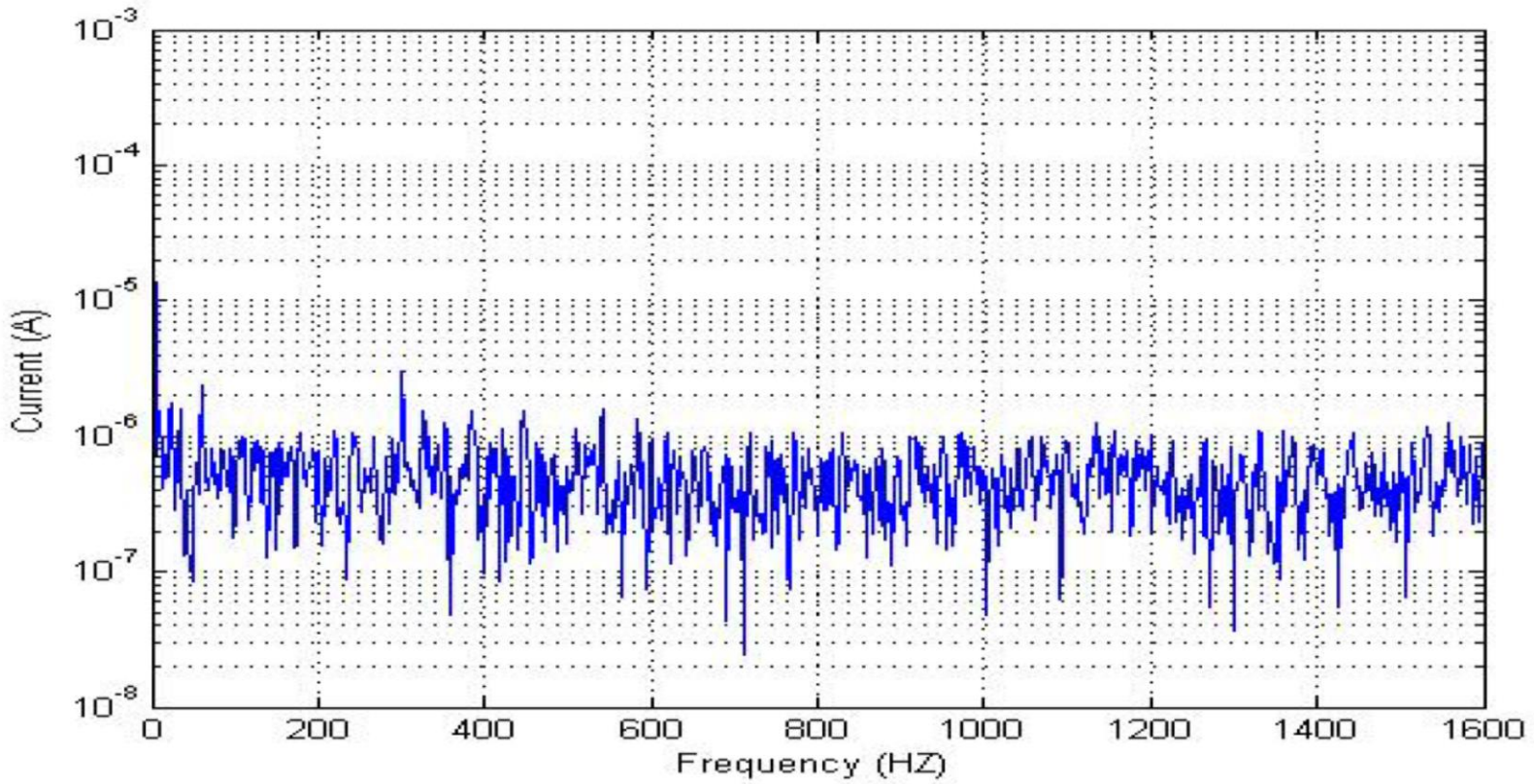
Estimated Failure Rates for Components Used in the Implemented FCPS

3. Test Result：**Long Term Stability Test for FCPS**



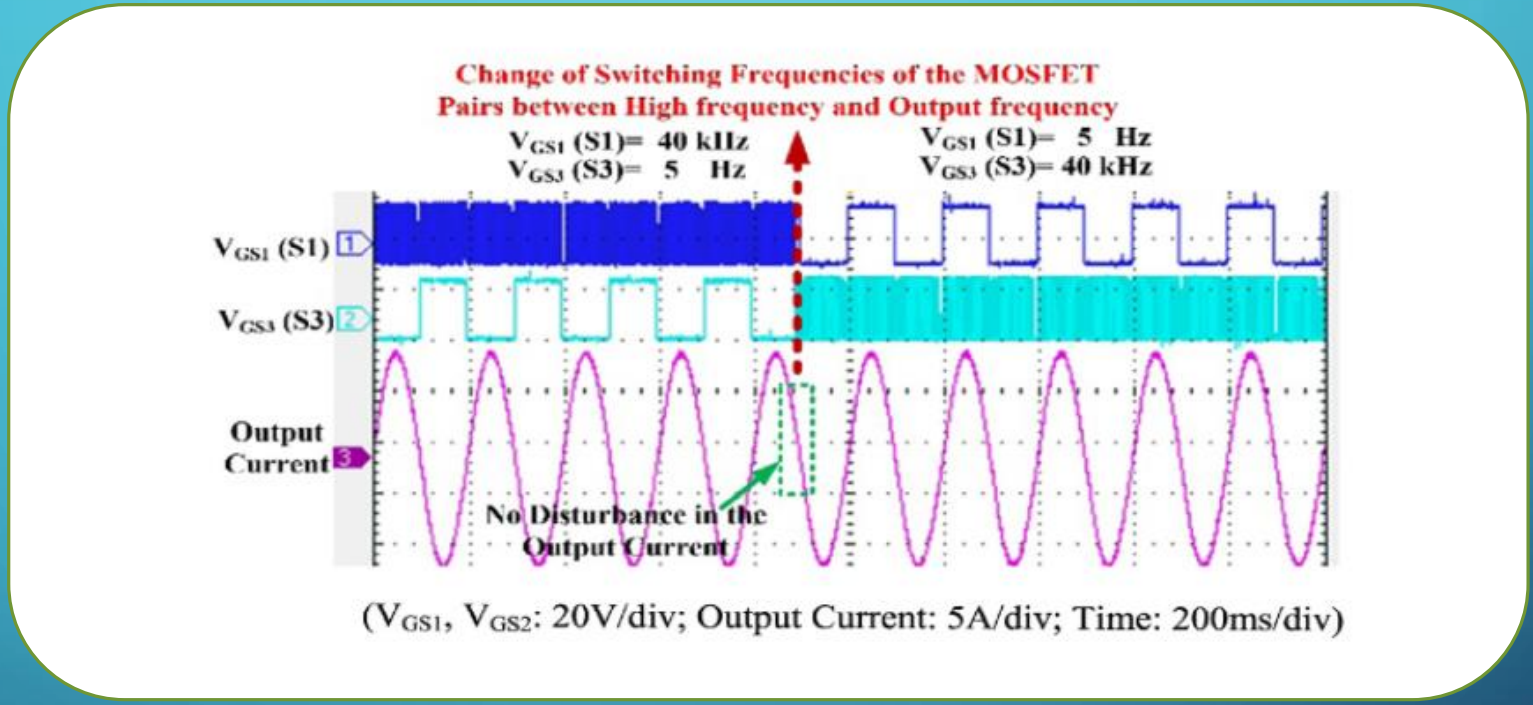
Measurement 15 hours: 5 ppm drift

Output Current Ripple for FCPS



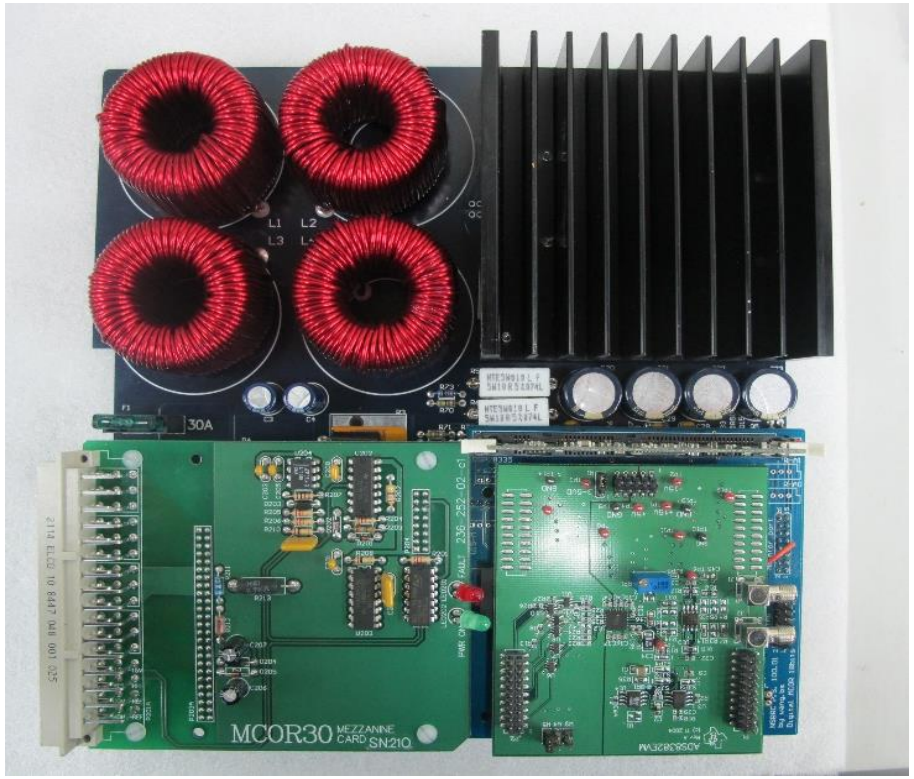
Frequency: from 0 Hz to 1.6k Hz

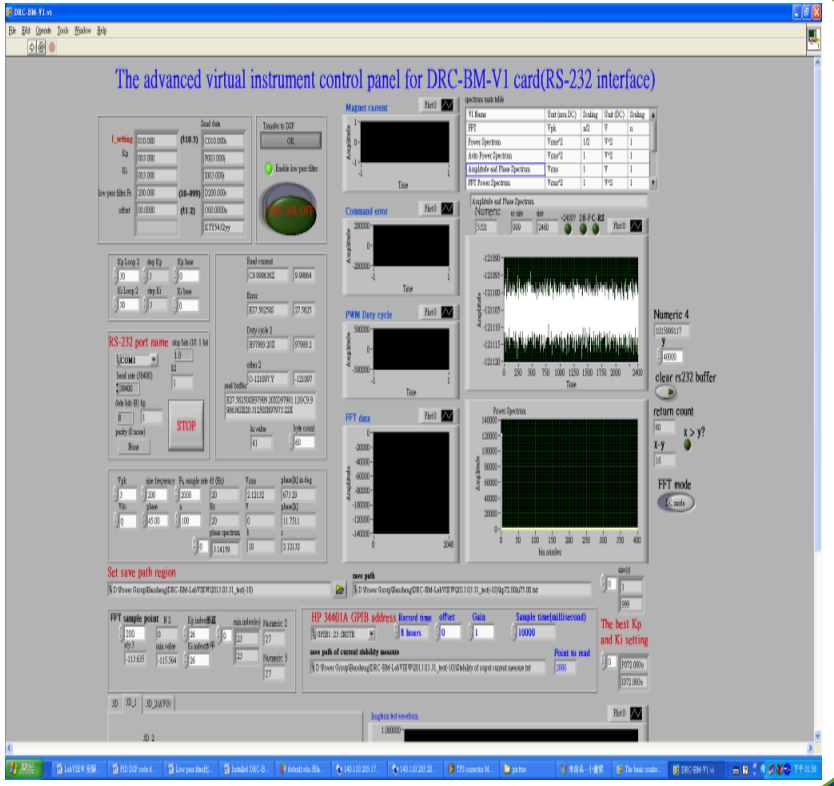
Output Sine Wave Current



The output current has no current distortion due to positive and negative conversion

4. Future Work





Full Digital Control by DSP TMS32028335 Add New MPWM Software Program in Real time System

Selected New Power MOSFETs

IXYS IXFK180N15P
Vdss：150V
Current：180A
rds(on)：11mΩ

IXYS IXFK250N10P
Vdss：100V
Current：250A
rds(on)：6.5mΩ

Change all Power MOSFETs：Conduction Loss reduce 0.45w
(Output Currnt：10A)

5. Conclusions

1. A FCPS prototype rated as ±10A/±50 V controlled by HPWM and MPWMS was implemented.
2. The MOSFETs' temperatures of the FCPS controlled by the HPWM and the proposed MPWMS.
3. The reliability indices under different PWM controls can then be assessed.
4. We can be observed that the reliability of FCPS using the proposed MPWMS can be effectively improved.

For More Formulas and Details Calculations Please Reference to the Journal be Published by NIMA

Nuclear Inst. and Methods in Physics Research, A 896 (2018) 53–59

https://doi.org/10.1016/j.nima.2018.04.015

Reliability Assessment and Improvement for a Fast Corrector Power Supply in TPS

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Thanks Your Attention!

Chen-Yao Liu Power Supply Group NSRRC POCPA 2018