Frequency Converter for Hindustan Aeronautics Ltd.

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Abstract - In this world of development today, there are various tools that the electronics or power electronics engineer can use to get his desired output. The reason being that there has been such a lot of improvement in the field of technology that just about everything is feasible these days. Probably the most key components that an engineer has up his sleeve are termed the static frequency converter that is simply the core of the contemporary equipment. Static frequency converters were initially called on when engineers needed to run equipment on differing alternative current frequencies.

I. INTRODUCTION

A frequency converter is an electronic equipment that converts alternating current (AC) of one frequency to alternating current of another frequency. The Frequency Converter is designed to supply 115V, 400Hz AC supply from 220V or 115V, 50Hz AC source supply by static conversion method. This equipment shall provide 115V, 400Hz, 2.2A and 250VA stable supply. The equipment design employs a PWM half bridge inverter circuit, with MOSFETs as the switching device. The PWM technique has very high efficiency and a fast response. The input AC supply is converted to DC voltage via a SMPS. This DC voltage is converted to AC supply of desired frequency via the half bridge inverter into small AC voltage i.e. 12.5VAC, then it step up by transformer up to 117VAC. After that this voltage has been filtered by LC filter and give to the output connectors.
This frequency converter is designed for defense application not for commercial purpose. The some features are provided as below;

- Good output voltage regulation.
- Fast dynamic response.
- Higher system efficiency over total output power range.
- Higher reliability.
- Reduced system size and weight.

II. SYSTEM ARCHITECTURE

Brief description of the Equipment and Sub-Assembly:

Input Supply:

Frequency converter can work with two Input AC supplies.

- Voltage: 220VAC (+/-10%) Current : 1.5A
- Voltage: 115VAC (+/-10%) Current : 3A

Input Switchgear:

Input Switchgear section comprises of Input controlling fuses and switches used to turn ON input supply to the Frequency Converter which is then provided to input transformer of the Inverter.

EMI/EMC Filter:

The Output from the Transformer is provided to an EMI/EMC Filter which is used to reduce or eliminate any unwanted Electromagnetic interferences present in Input Supply.

Switching Mode Power Supply:

SMPS used in Frequency Converter Works in the range of 100VAC to 250VAC and provides constant Voltage of 24VDC. The SMPS used provides Supply Voltages to all the cards which are used in frequency converter. It also provides 24VDC to MOSFETs at Collector- Emitter which are populated on Inverter card and the same is then switched to get 400Hz AC.

PWMSM Section:

Pulse Width Modulation and System Monitoring Section is the main Section of Frequency Converter, It comprises of Following Sections;
Power Supply Section: The Power Supply Section Provides Required Power to Every Circuit present in Frequency Converter. It provides +24VDC, ±15VDC & +5VDC supply.

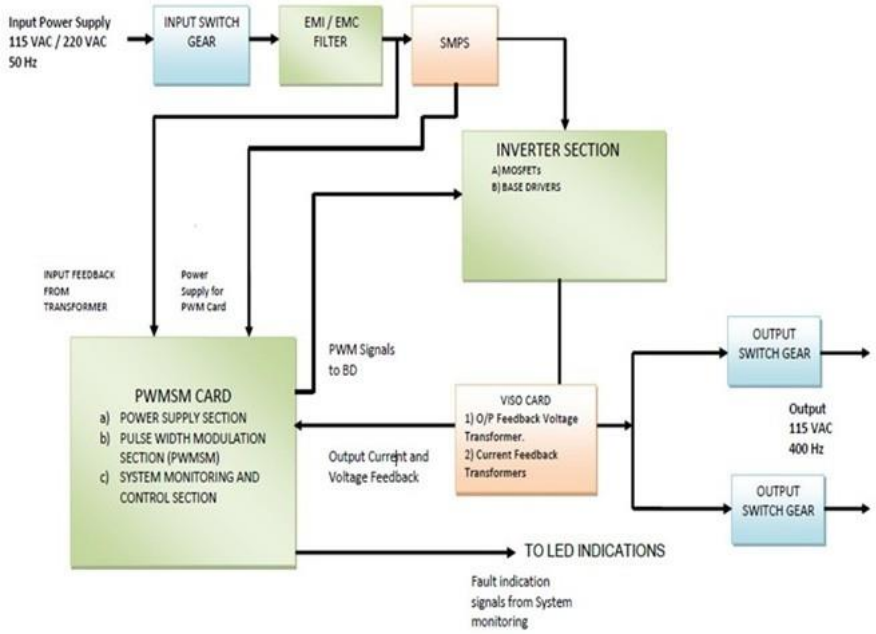

Fig.1 Block Diagram of System Architecture

Pulse Width Modulation Section: The Pulse Width Modulation Section Comprises of a Microcontroller circuit. It generates the sine weighted Pulse Width Modulated signal which controls the Gate-Emitter Pulses Reaching MOSFETs for Switching Operation. In that 89V51RD2 microcontroller is used. With the help of that controller we have generated 400Hz digital signal which is given to DAC08 IC. By using DAC08 IC we convert it into 400Hz sine wave which is called as Modulating signal. Also, we have generated 4 MHz signal from this controller. Firstly the square wave of 4 MHz is generated by 89S52 microcontroller at ALE pin. This square wave is applied to the input decade counter and at the output of decade counter we get square wave of 400 KHz. But we required 20 KHz square wave, so this 400 KHz square wave is again reduced by using two decade counters.
Now, we have square wave of 20 KHz but we required triangular wave of 20 KHz. Thus to achieve it we use integrator circuit. Because integration of square wave is triangular wave, by applying square wave at the input of integrator, we get triangular wave at the output of integrator which is called as carrier signal. After that both modulating & carrier signal are fed to comparator IC LF367 and we got sine weighted PWM signals which are fed in between gate & source of MOSFETs to Inverter Card.

System Monitoring Section:

In system monitoring section, the PIC18F2321 microcontroller is used for Sensing Input & Output feedbacks and its indications. By using this PIC18F2321, we continuously Monitors the Feedback of Voltage and Current from Output and protects the panel by tripping it during abnormal Operation of the Frequency Converter.

Inverter Section:

The Inverter Section is the main section of Frequency Converter it consists of the following Components:
MOSFETs: MOSFETs are used in Frequency Converter as a Switching Device. By Controlling the Gate emitter Pulses of MOSFETs with the help of PWM Signal coming from PWMSM Section the Frequency Conversion is carried out.
Base Driver Section: A Base Driver is specially designed to drive MOSFETs for their Switching Operation. The base Driver Forwards the PWM pulses arriving from PWMSM section to MOSFETs, It also protects MOSFETs from Short-Circuit and Overload by Blocking the Pulses reaching MOSFETs during abnormal Conditions.
Output Transformer: The output Transformer is of High Frequency Step-up type with primary voltage 0-12.5V, 400Hz and secondary voltage 0-117V/3A, 400Hz.

Filter Circuit:

Filter Circuit Comprises of Capacitors and a Choke to Form a LC filter Circuit to eliminate ripples.

VISO Card:

VISO Card provides Output Voltage & Current Feedbacks to PWMSM card. It comprises of Following;
Voltage Feedback Transformer: The Voltage Feedback Transformer provides output voltage feedback to PWMSM section. PWMSM card Monitors the output Voltage and protects the frequency converter in case of High Output Voltage.
Current Feedback Transformer: A current Feedback Transformer is used to provide output Current Feedback to PWMSM section which by monitoring the Output Current Protects the Frequency Converter in Case of Short-Circuit or Overload.

Output Switchgear:

Output Switchgear section comprises of Output controlling fuses and switches used to turn ON output supply.

Key features of SFC:

- The input and output are isolated via isolation transformer.
- The output voltage regulation can be stable up to 0.2%.
- The output frequency can be very stable up to 0.01 Hz.
- Suitable for indoor application with air conditioned ambience
- Small in size which save space for installation & commissioning.

III. TECHNICAL SPECIFICATIONS:

The frequency converter has provided following technical specifications.

- Electrical Power Supply : 220/115V AC (+/- 10%)
- Insulation : Class "H" as per IS-1271
- Temperature : +55°C(Operating)/ +70oC (Storage)
- Enclosure Protection : IP-23 (As per IS 12063).
- Mounting : Deck mounting on shock mounts (04 Nos.
- Weight : ≤ 30Kg. (Max.)
- Dimension : 320 (L) * 450 (B) * 200 (H) mm
- Duty : Continuous

Protections for Frequency Converter:

- Input Over-Voltage Protection
- Input Under-Voltage Protection
- Overload Protection
- Short circuit Protection
- Output Over-Voltage Protection

Software Required:

- OrCad Tool for PCB Designing
  - Capture CIS for Schematic
  - Layout Plus for Layout
- Flash Magic for programming of 89V51RD2 controller
- MPLAB IPE V6 for programming of PIC18F2321

IV. RESULT AND EXPERIMENT

The equipment design employs a PWM full bridge inverter circuit, with MOSFETs as the switching device. The PWM technique has very high efficiency and a fast response. The observations of frequency converter is provided as per below;

Sr. No.	I/P Voltage of FC	ON Condition O/P Voltage	O/P Frequency of FC in ON Condition	OFF Condition O/P Voltage	O/P Frequency of FC in OFF Condition
1	Vin = 103.2 V	Vout = 115.5 V	400.2 Hz	0.7 V	0 Hz
2	Vin = 120 V	Vout = 115.5 V	400.2 Hz	0.5 V	0 Hz
3	Vin = 151.2 V	Vout = 115.5 V	400.2 Hz	0.7 V	0 Hz
4	Vin = 180.1 V	Vout = 115.5 V	400.2 Hz	0.6 V	0 Hz
5	Vin = 220 V	Vout = 115.4 V	400.2 Hz	0.6 V	0 Hz
6	Vin = 245 V	Vout = 115.5 V	400.2 Hz	0.7 V	0 Hz

V. QUALIFICATION TESTS FOR FREQUENCY CONVERTER

The frequency converter has been qualified or tested as per below standard;

- Environmental Test as per Joint Service Specifications (JSS) 55555:2012.
- EMI/EMC Test as per MIL STD 461E.
- ESS Test for PCBs

VI. CONCLUSION

Implementation of this system or the frequency (400 Hz) power systems supply energy to the critical system and loads in aerospace, airplane, vessel and power supply for communication device in ships, where space and weight are at a premium or minimum. The converters are demanded to obtain 400 Hz power from fundamental frequency 50/60 Hz power systems. There is a rotary frequency converter (RFC). Now, we are using MOSFET based Frequency Converter and the result of this system shows that the system has fast dynamic response and Stable Output.

VII. APPLICATION

The Frequency Converter is used as power supply for communication device purpose in Indian navy ships and air force application.

VIII. REFERENCES

[1] Precision Power Products (I) Pvt. Ltd. Aurangabad.
[2] Second Edition, Power Electronics Circuit, Devices And Applications, Muhammad H. Rashid, Chapter No. 10, PWM Inverters, Page No. 10-12.
[3] Third Edition, Khanna Publication, Power Electronics, Dr. P.S. Bimbhra, Chapter No.8, Inverters, Page No. 1-10.
[4] Back, J.A.; Tedesco, L.P.; Molz, R.F.; Nara, E.O.B. An embedded system approach for rectifier
[5] Soe Winn | Hla Yin Htwe | Hla Hla Naing "Design and Performance Analysis of 400Hz Static Frequency Converter" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.2120-2122.