

# 48V DC Grid-IT Station

# Introduction

- **48V DC grid Schemes to minimize use of Diesel and improve efficiency**
- **Power sources feeding the grid and their Characteristics and operation**
- **Interfaces between 48V bus and power sources.**
- **State Space Vector Controller as applied to power conversion**

# Objectives

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- **Continuity of power**
- **Reliable operation**
- **Low Maintenance**
- **Low cost and lower cost of operation.**

# **48V DC Grid for IT Station**

## **Objectives**

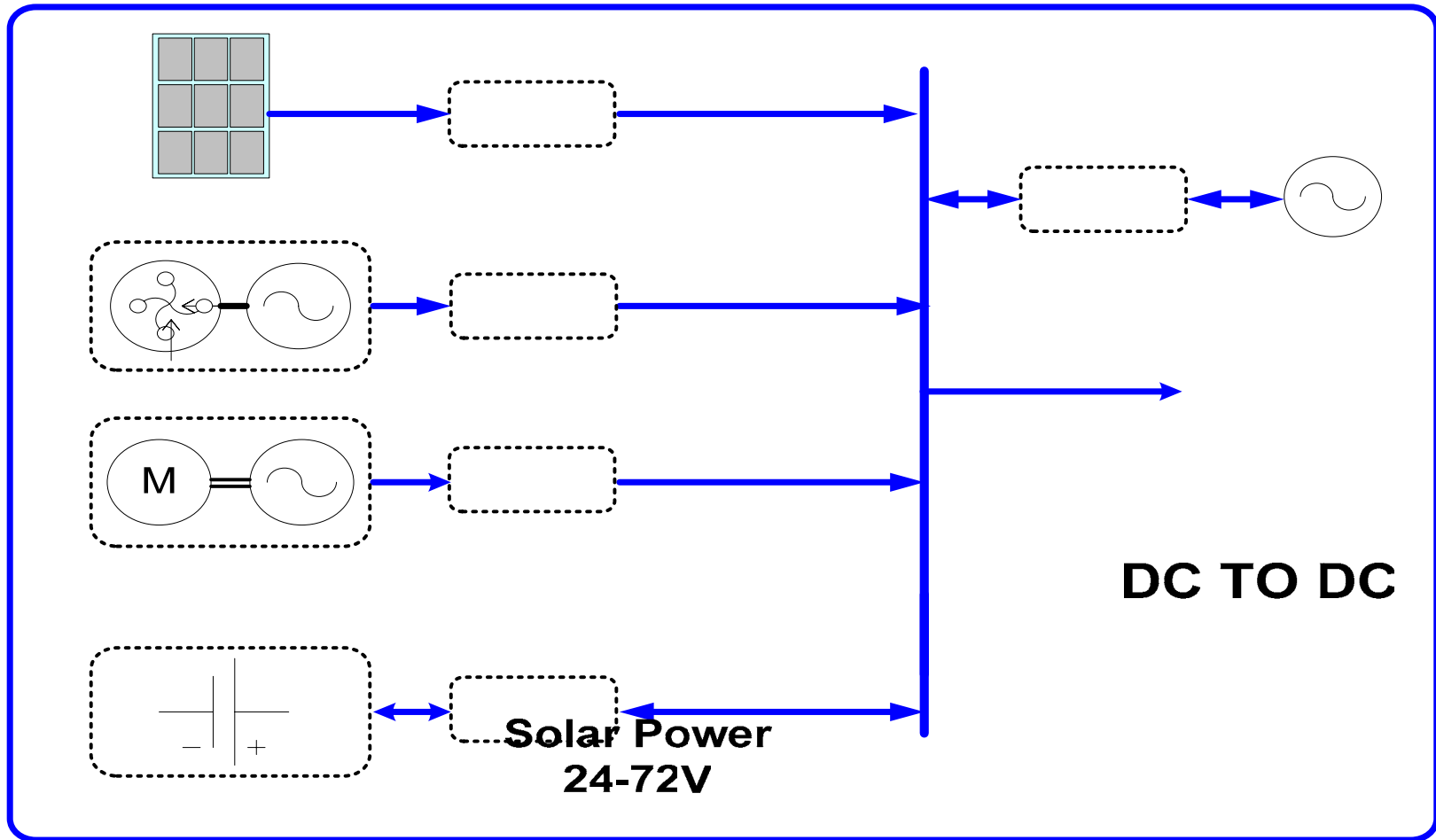
- **Continuity of power**
- **Reliable operation**
- **Low Maintenance**
- **Low cost and lower cost of operation.**

# Grid Sources and Interface

Fig 1 illustrates the single line diagram of 48V DC Smart Grid for IT station connected to AC and DC sources from:.

- Solar cells -connected with DC to DC converter Interface
- Batteries - connected with DC to DC converter Interface
- Wind power - connected with AC to DC converter Interface
- Diesel Gen Set- connected with AC to DC converter Interface
- Utility - connected with DC to AC converter Interface

# Fig1 48V Grid



**DC TO DC**

**Active  
Rectifier**

Wind Turbine

PM Gen

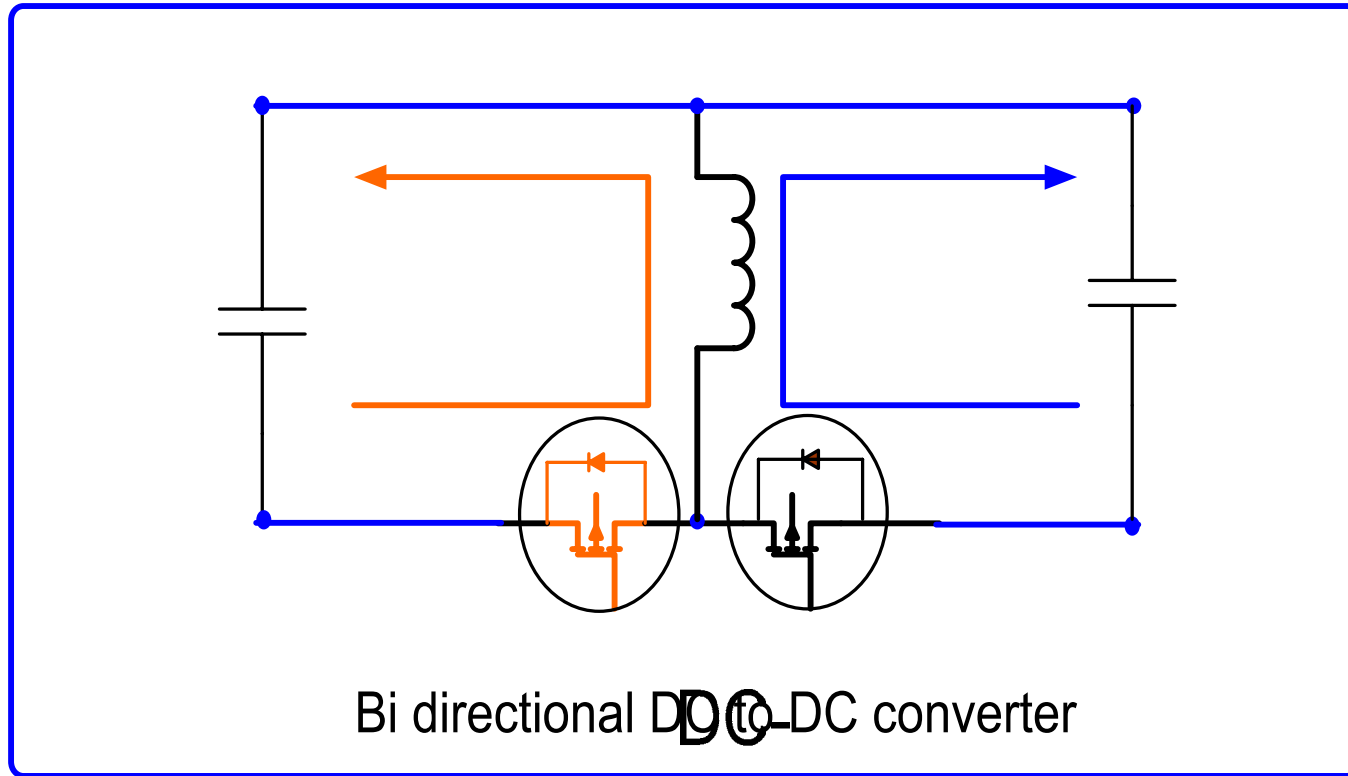
# Interfaces

- Solar Interface
- **Battery Interface**
- **Wind Generator Interface**
- **Diesel Generator Interface**
- **Utility Interface**

# Solar interface-DC to DC converter

- Fig 2 illustrates the single line diagram of bi directional buck/boost converter where consisting of two switching devices Q1, Q2 and inductor L1.
- Switches Q1 and Q2 are operated by complimentary PWM. At 50% duty cycle DC bus voltage is equal to Solar cell voltage. If pwm of Q1 is higher than Q2 than DC bus voltage is higher than the Solar cell voltage and vice a versa.
- 48V bus is fed as a current source using BUCK/BOOST converter till DC bus is charged to the desired voltage.
- When both the switches are OFF than there is no current flow through the switches as both the switches are reverse biased.
- PWM determines the boost or buck operation of the converter.
- 96% Conversion Efficiency is achievable with this configuration.

Fig 2 -DC to DC converter



**6Phase 1.5KW Bi directional DC to DC converter  
11.5" L X 5"D X 1.75"H**



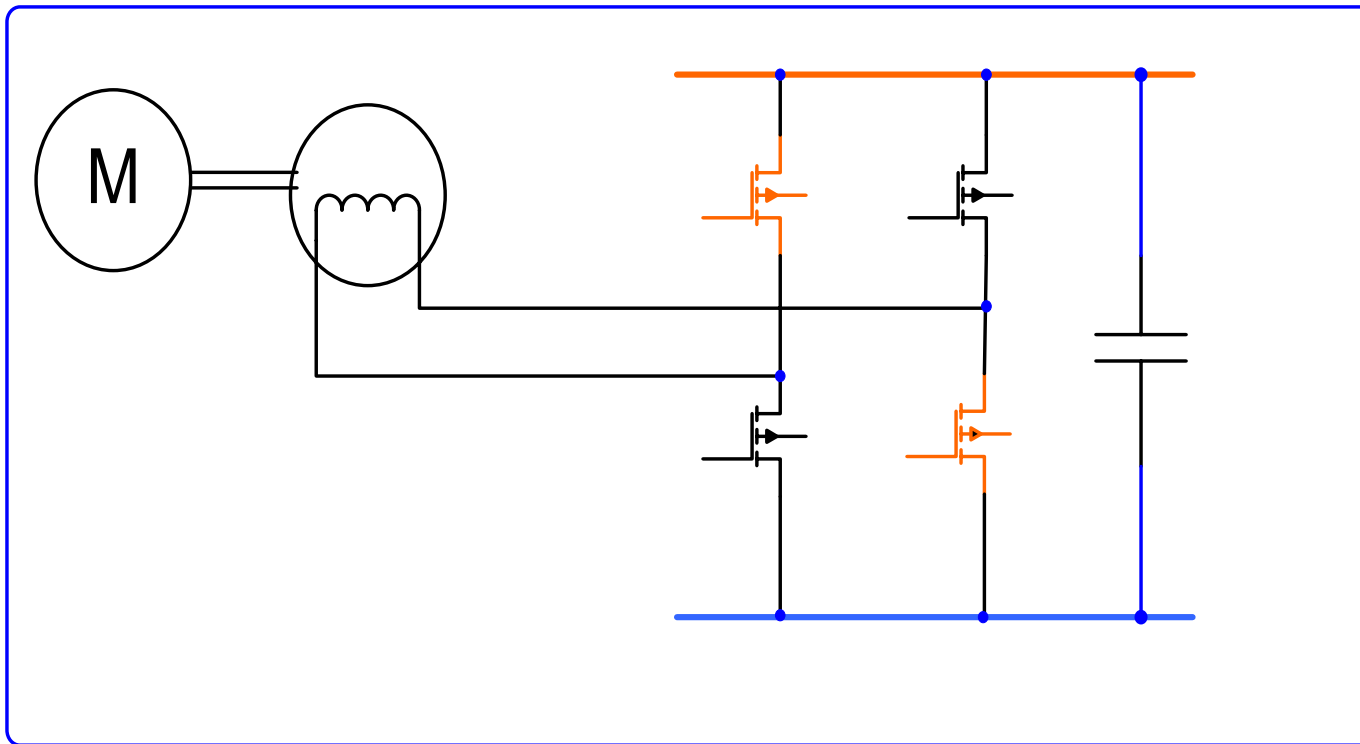
# Battery Interface

- Battery generates wide range of DC voltage. For 48V cells can produce voltage as high as 72V and as low as 30V depending on type of batteries (Lead acid, Li-ion and Liquid).
- Therefore interface should be able to operate in buck as well as boost modes.
- The interface required is same as solar Cell interface. In solar interface there is no reversal of power while in battery interface power has to reverse to recharge the batteries..

# Wind Generator Interface

- Wind generator also generates wide range of AC voltage. Most of the wind generators are designed using permanent magnet generator.
- Regenerative Active Rectifiers (RAR) is used to rectify AC from wind Generator
- RAR can boost AC Voltage to 48V DC or more as desired. wind interface also feeds the controlled current to 48V DC bus, till DC bus is approaches the desired voltage (54V)

# Fig 3 Regenerative Active Rectifier



Diesel genset

## 50 KVA Regenerative Active Rectifier 20"L X 11"D X 9"H



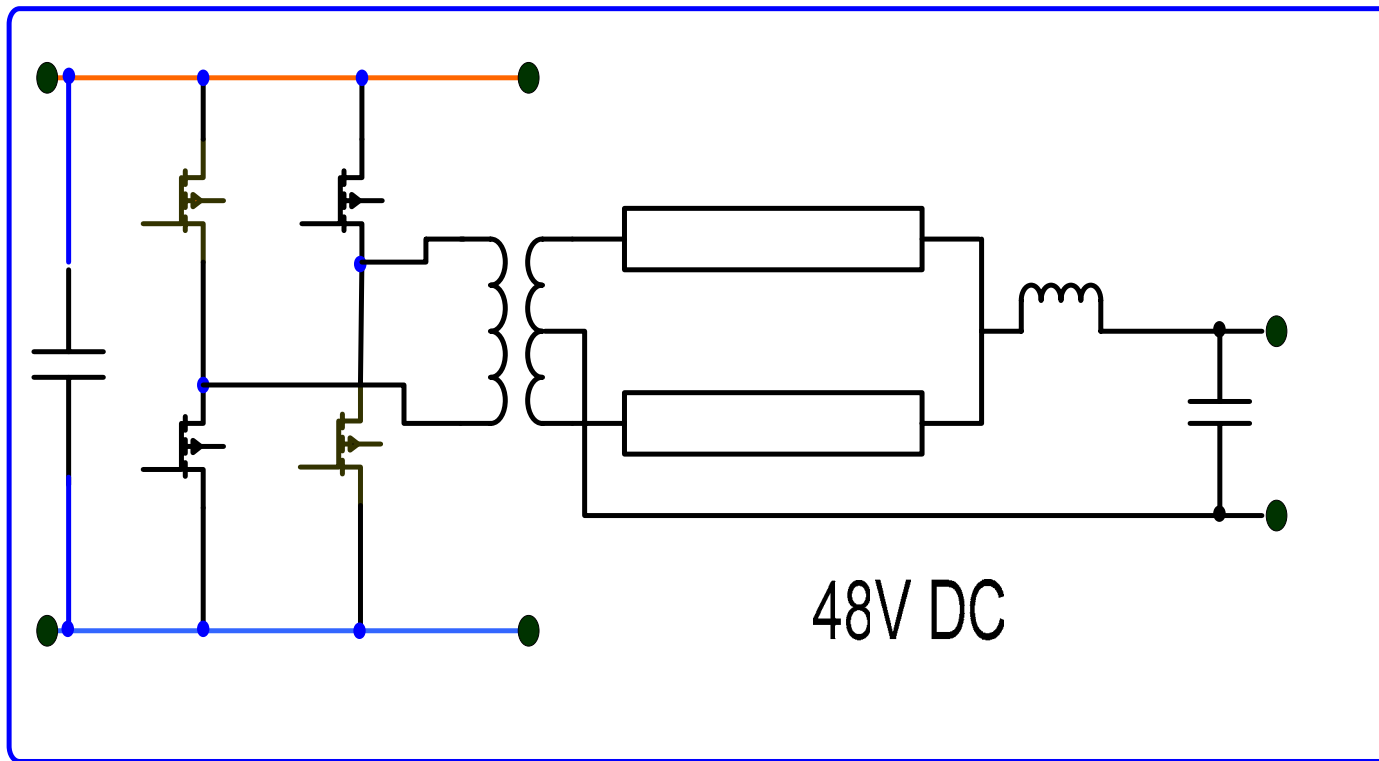
# Diesel Generator Interface

- Diesel generator also generates wide range of AC voltage as it is operated at variable speed with load to reduce the diesel consumption.
- Generator is permanent magnet generator to reduce the cost. Most of the diesel generators are half loaded when batteries are charged.
- At full load diesel is operated at full speed that could be as high as possible and half load it is operated half the speed.
- It is required to generate 36Volts to be converted to 48V DC or more using Regenerative Active Rectifiers (RAR) similar to wind generator. Diesel generator interface is exactly same as wind generator interface. .
- 98% Conversion Efficiency is achievable with this configuration also.

# Utility Interface

- Utility interface consists of bi-directional Cyclo converter. Which rectifies the utility voltage and supplies the current to the DC bus, control the PF and harmonics of line current as well.
- Cyclo converter is High frequency link using HF transformer for isolation and is operated by a single phase bridge inverter. The output of the transformer is synchronously rectified to produce 50HZ, 240V to match the utility voltage and works as line interactive inverter so long utility is available.
- It works as simple inverter as soon as utility fails and deliver AC output to operate AC loads.

# Fig 4 Cyclo converter



Q1

Q3

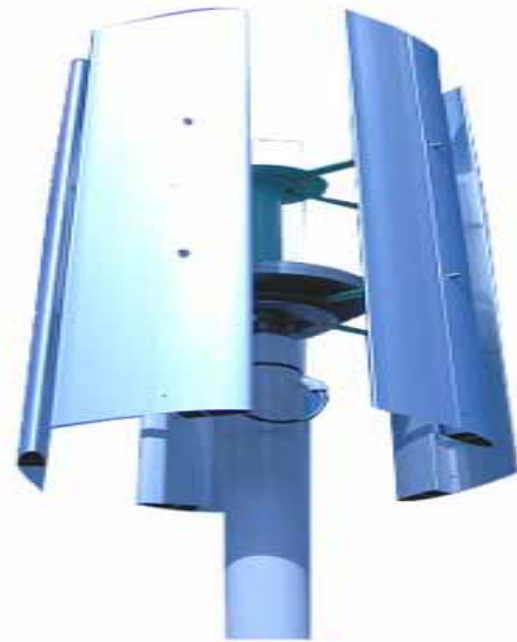
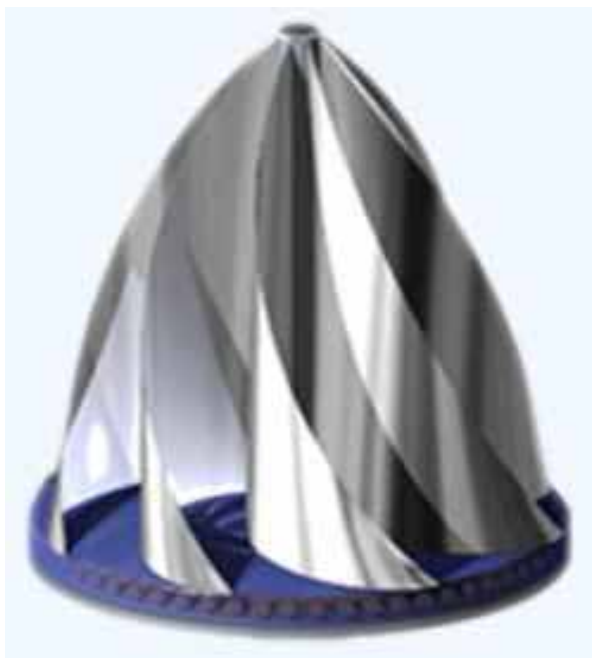
DC+

Syn

**3kw Cyclo converter - Line Interactive  
11"L X 5"D X 3.75"H**



# Vertical Wind generator

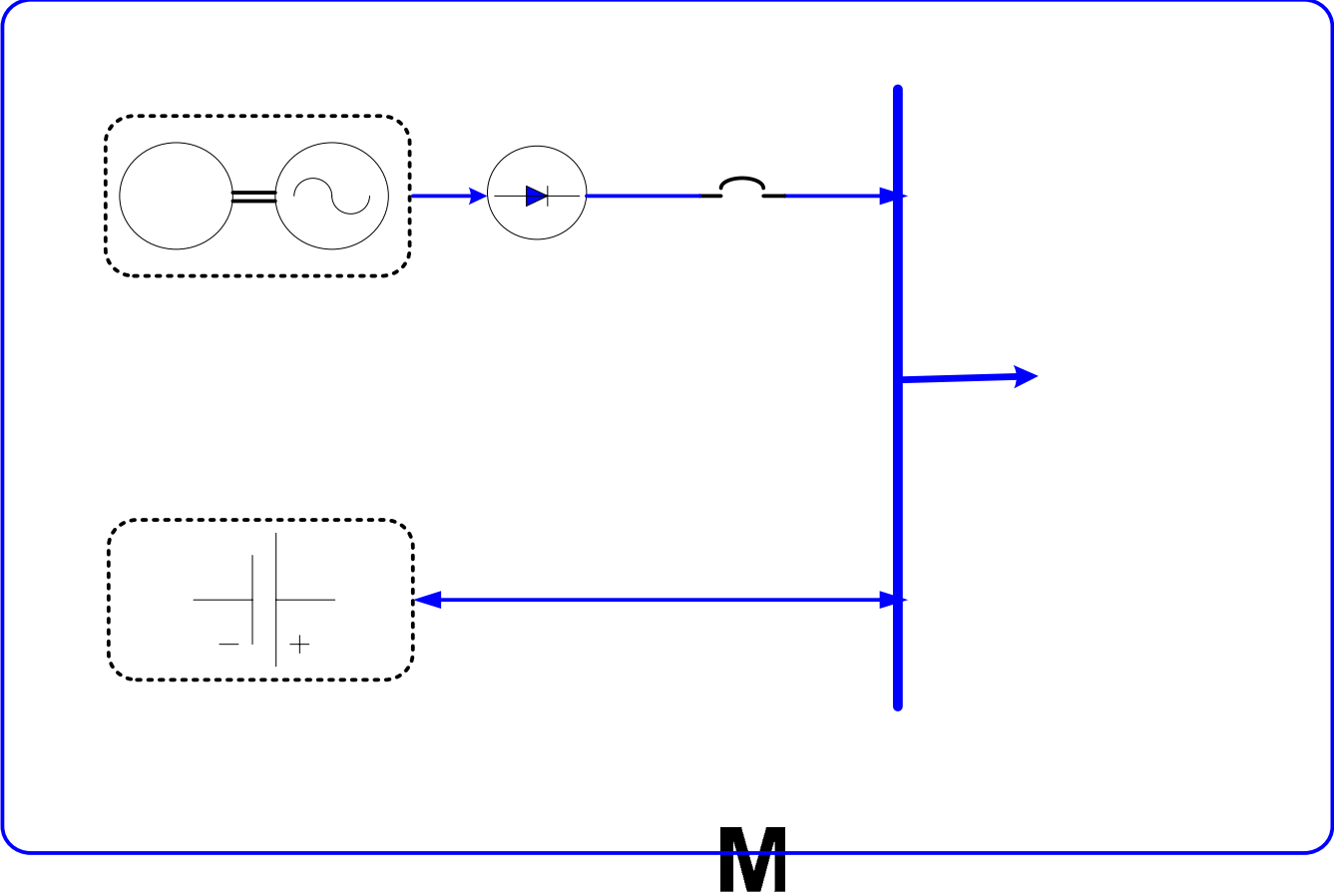


# Vertical Wind Generators

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# Stand Alone Diesel power System



Diesel

Diesel Power

Rectifier Charge

# Recent Solar cell Development

- Columbia's Engineering School has one solution for making buildings greener—hybrid solar cells that produce heat and electricity simultaneously.
- Dow Chemical unveiled its line of DOW POWERHOUSE™ Solar Shingle, revolutionary photovoltaic solar panels in the form of solar shingles that can be integrated into rooftops with standard asphalt shingle materials.
- Sun Power Corporation has produced a world-record, full-sized solar panel with a 20.4 percent total area efficiency. The prototype was successfully developed using funds provided by the U.S. Department of Energy (DOE) under its Solar America Initiative (SAI), which was awarded to Sun Power Inc, Portland, OR

# State Space Vector Controller

## United States Patent [19]

Levrn et al.

[11] Patent Number: 5,047,910

[45] Date of Patent: Sep. 10, 1991

- [54] IDEAL SINUSOIDAL VOLTAGE WAVEFORM SYNTHESIS CONTROL SYSTEM
- [75] Inventors: Alexander Levrn, Los Angeles; Anurag Chandra, Los Alamitos, both of Calif.
- [73] Assignee: Teledyne Inet, Torrance, Calif.
- [21] Appl. No.: 550,189
- [22] Filed: Jul. 9, 1990
- [51] Int. Cl.<sup>3</sup> ..... H02M 7/48
- [52] U.S. Cl. .... 363/41; 363/80; 363/98
- [58] Field of Search ..... 363/95, 97, 98, 71, 363/72, 41, 43, 80; 364/492

- [56] References Cited
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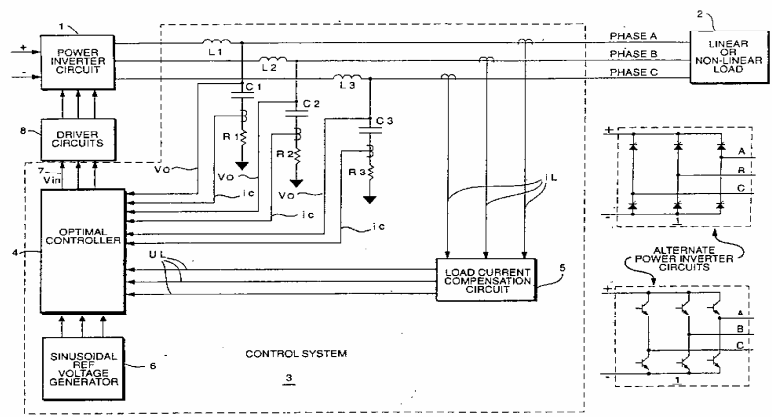
4,937,720 6/1990 Kirchberg ..... 363/41

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Assistant Examiner—Bruce Dunn  
Attorney, Agent, or Firm—Monty Koslover Assoc.

[57] ABSTRACT

A control system for poly-phase power inverters that uses feedback sensed voltages and currents to control the switching of solid state power switches in the inverter bridges, producing a nearly ideal sinewave voltage output regardless of load induced or switching harmonic voltages. The system operates in combination with the inverter power switches and switch drivers, particularly incorporating a digital programmed optimal controller with virtually no delay in implementing the feedback control, and automatically correcting for any sensed line voltage distortions. The system inherently provides a high recovery speed for voltage transients.

5 Claims, 5 Drawing Sheets

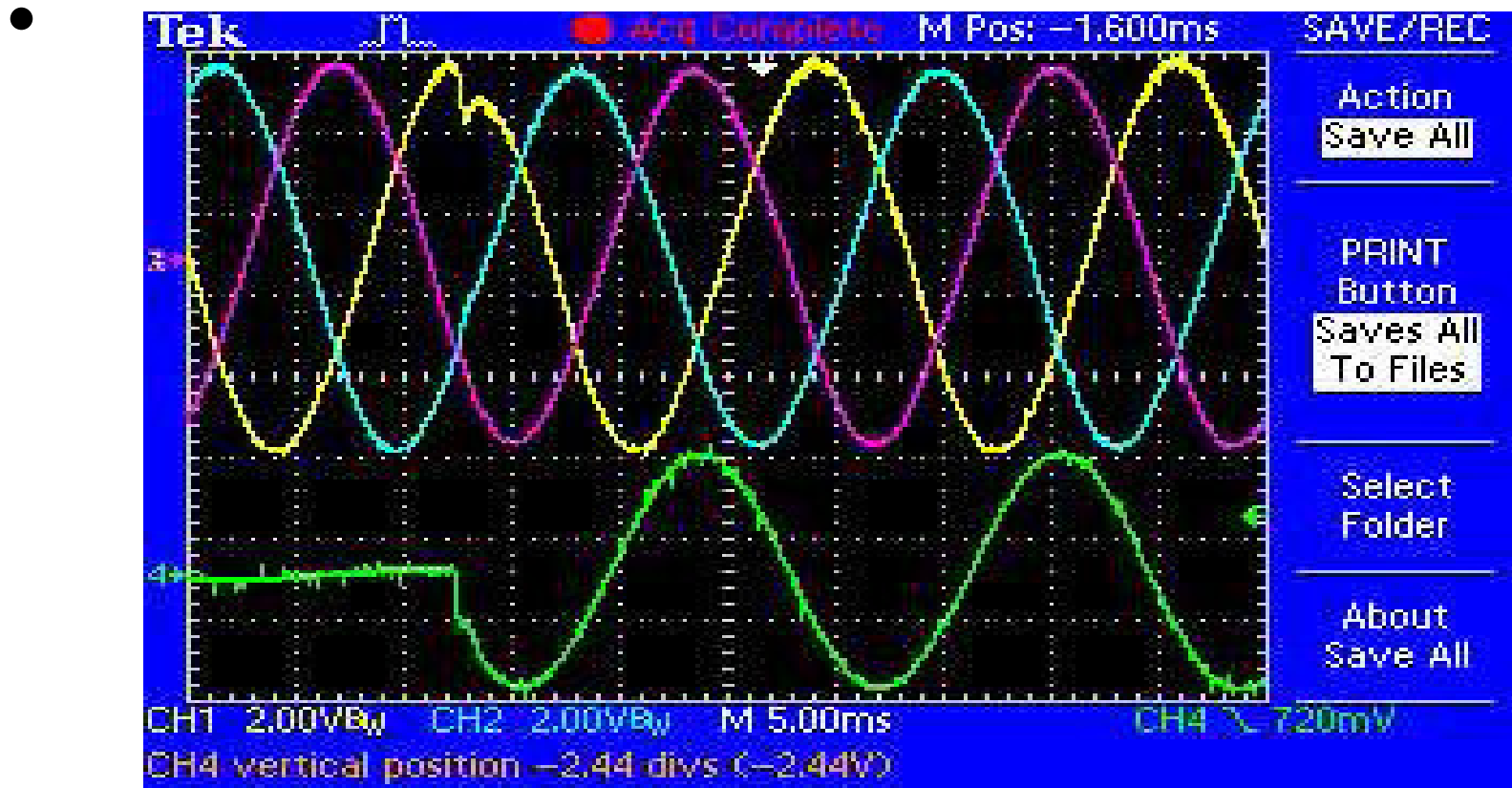


# Advantages Of SSVC

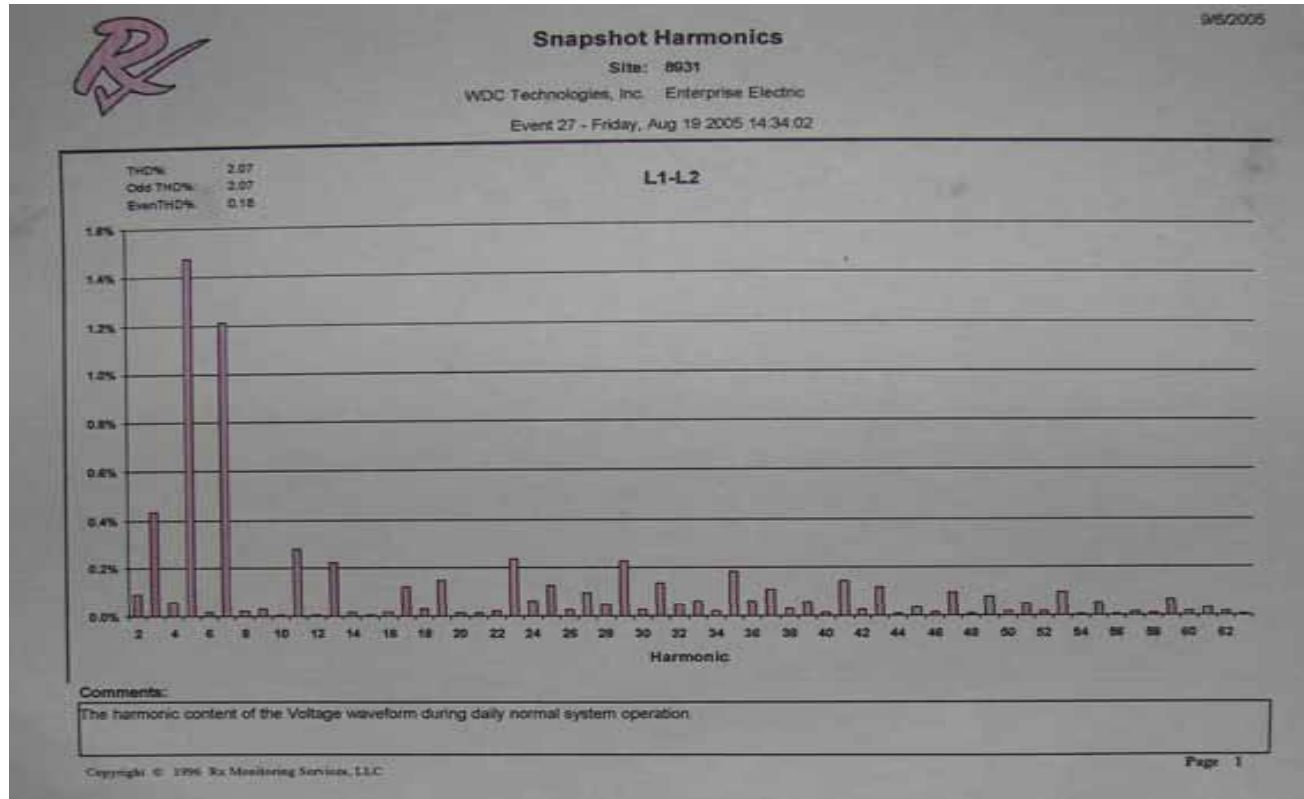
1. Transient response is super fast with switching frequency 6-7KHZ 1ms or less. Fig 6
2. THD performance is better with low PWM frequency see fig 5 and 6 2%or less. Fig 7
3. Controls are simple to implements.
4. Efficiency is higher as the switching frequencies are 96-98%
5. Performance of the controller does not degrade due to component degradation like output capacitor and DC bus capacitor.
6. Output filter are not critical and does not require any tuning.

- 7 No of DC caps required for DC bus are determined by the energy storage, not by the ripples.
8. DC bus ripples do not degrade the performance of the controller. So the product is less expensive due to smaller no of caps required for DC bus and AC output.
9. The output vector always remains constant in phase and amplitude unlike convention converters. So unbalance load does not cause unbalance voltage. This characteristic very useful when motor is driving synchronized mechanical loads. This is very unique characteristic only available in SSVC.
10. Applicable to mechanical systems such as operating diesel or steam turbine governors

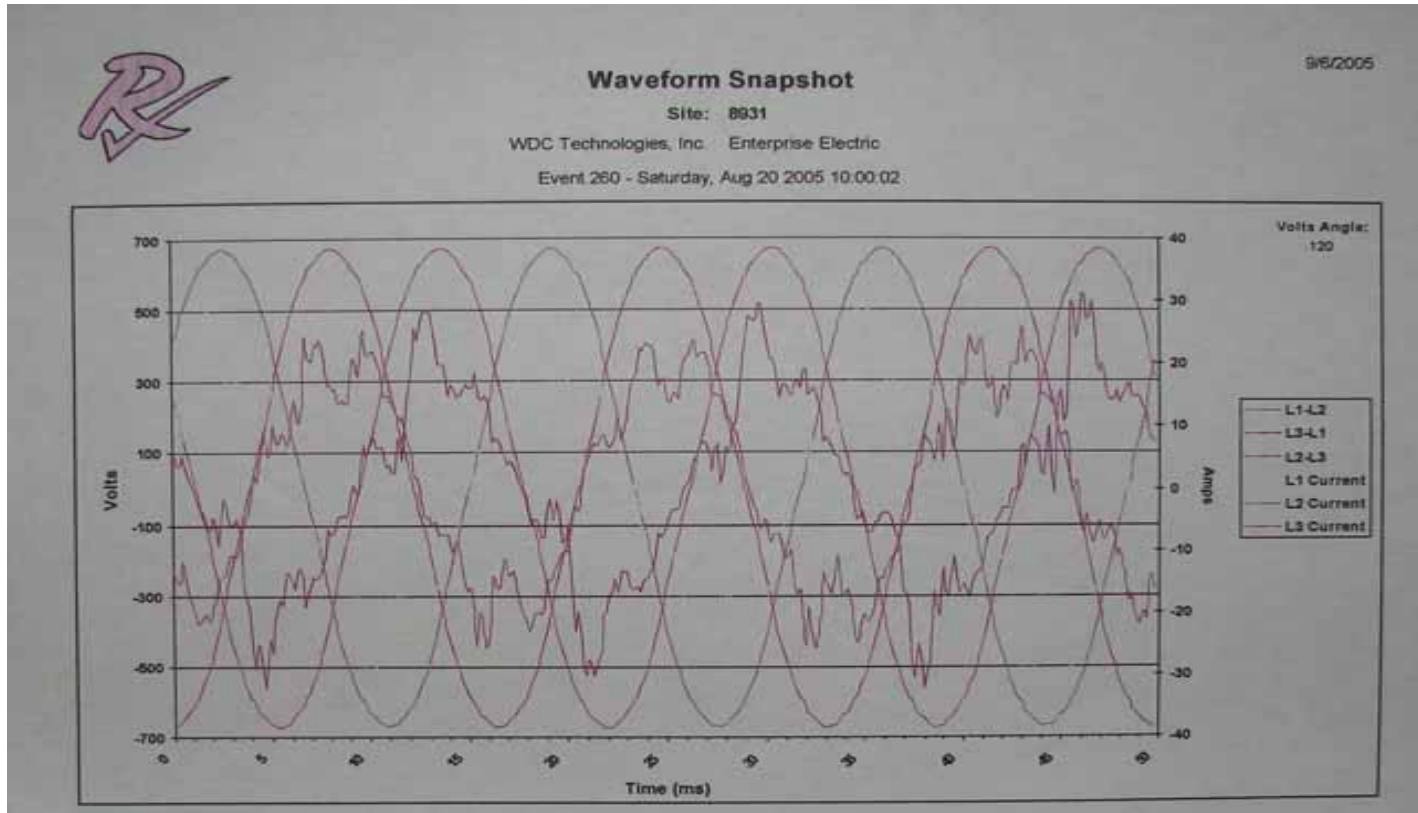
# Fig 6 Step response-100% load



# THD performance



# THD Performance



**output voltage waveform for non linear load from 100kva medical UPS-  
Field data**