

Fédération Internationale pour la Sécurité des Usagers de l'Electricité International Federation for the Safety of Electricity Users Federacion Internacional para la Seguridad de los Usuarios de la Electricidad





Evolvement of Electrical Safety

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Symposium Fisuel – Liban – 30 Avril & 2 MAI 2019

fisuel Impact of Technology Progress on Safety



Shed Lights on the evolvement of : safety , earthing system , protection design in four domains :

- Communication
- ➢ Industrial
- ➢ Health Care Unit
- ≻ Renewable energy



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High Speed Transmission Data

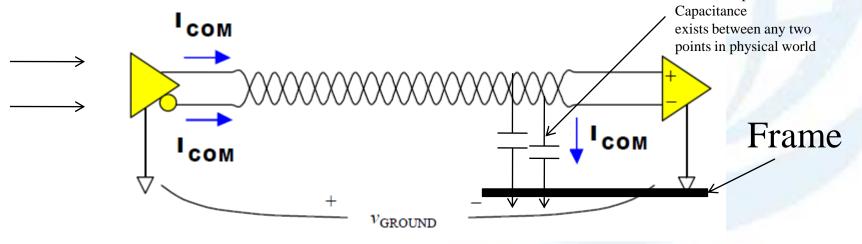
-As the transmission frequency increases and approaches several GHZ the common mode current cannot be negligible .

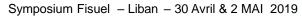
-If VGROUND Large, Vc at the receiving device will be high, malfunctioning of the electronic device.

-TT earthing system is not recommended anymore fore communication system.

-TNS is more robust.

-For very high speed meshing is required.





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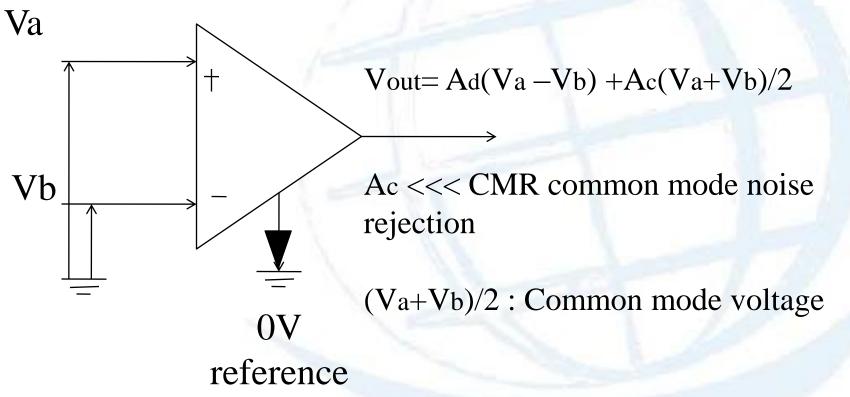
Parasitic capacitance,



Common Mode Voltage







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Signal Reference Grid Meshing

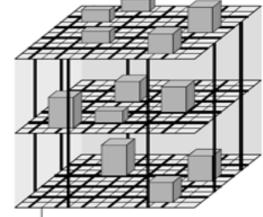




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To Minimize voltage differences between interconnected equipment by providing a low impedance equipotential ground plane for high frequency, low voltage noise.





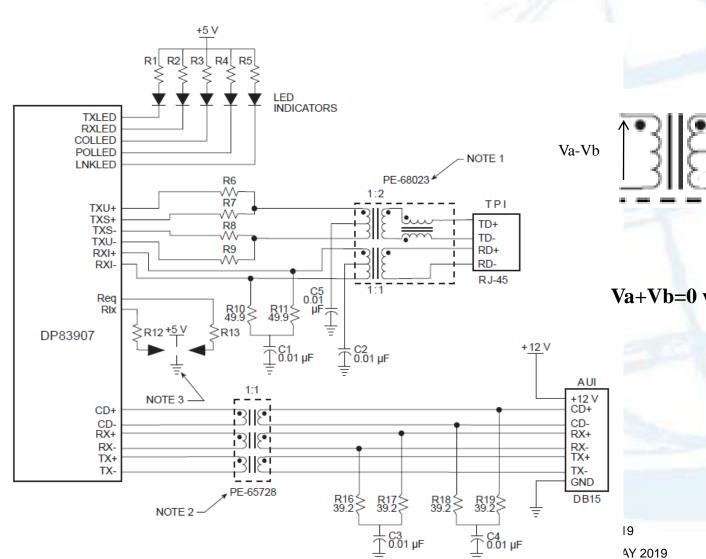
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Ethernet

Isolating Transformer or Photovoltaic isolator





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Va+Vb=0 with respect to the local earth

Va-Vb



Modern Data Center





TotalimmunityHigh immunityPartialimmunityLow immunity•Fiber-optic
•Wireless•Ethernet•Modbus
•RS-485
•SCSI•Parallel ports
•RS-232 ports
•Proprietary backplane
•Video cables



Industrial Sector

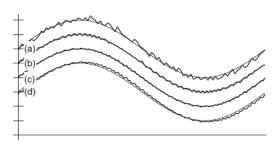




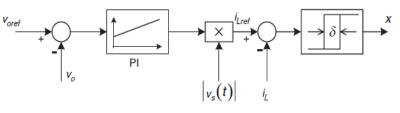
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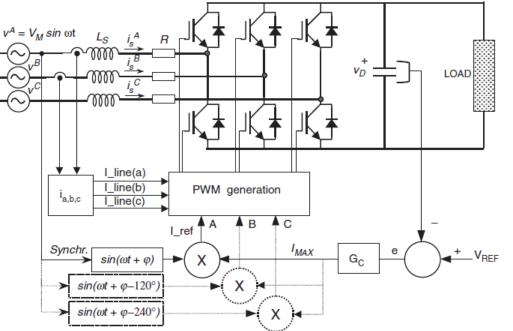
No More Harmonics !!!



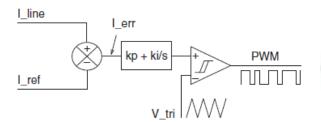
Waveforms obtained using 1.5 kHz switching frequency and $L_S = 13$ mH: (a) PS method; (b) HB method; (c) TC method ($K_P + K_I$); and (d) TC method (K_P only).



Control system of the boost rectifier.



Voltage-source current-controlled PWM rectifier.



Switching frequency 10KHZ to 100KHZ

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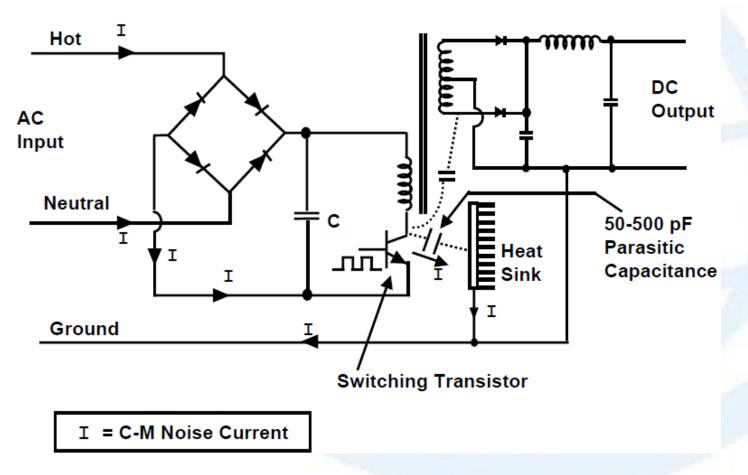




Switching power supply





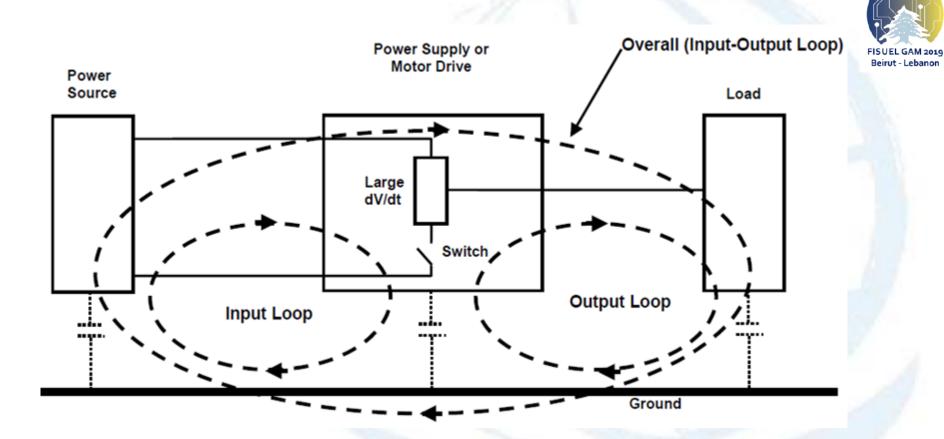


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<u>C-M Current Loops</u>



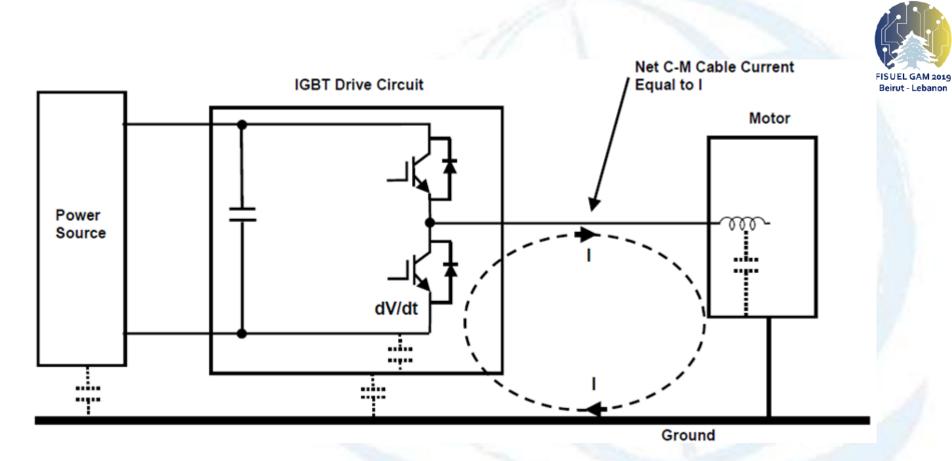


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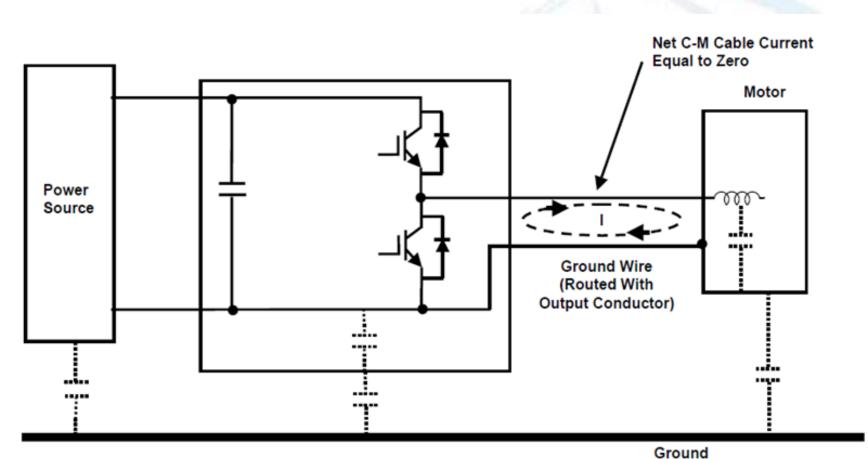
Basic IGBT Motor Drive





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Ground Wire From Motor Housing to VFD



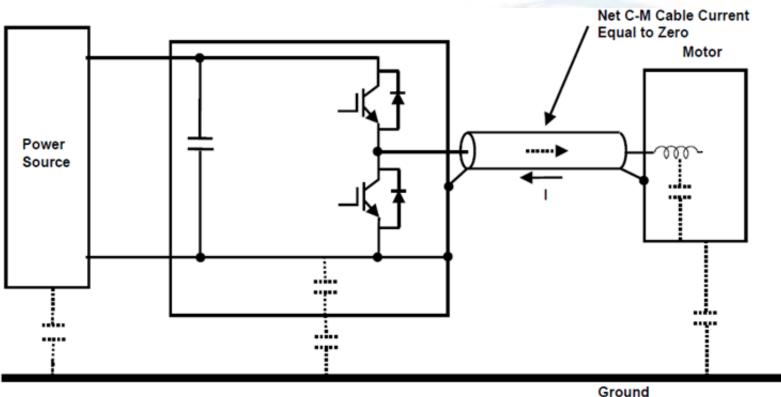
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This is the <u>Ideal Solution</u> But May Be Difficult to Implement Either the Motor Housing Must be Floating (as shown), or the Switch Common Must be Connected to Ground

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Shielded Cable Solution



Similar to the Ground Wire Described Previously, But More Effective For Radiated Emission Shield Must Be Connected to Motor Housing on One End and to the Switch Common on the Other End Shield May Be Terminated With a Capacitor on One End as a Compromise

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PWM type power cable is intended to minimize the common mode voltage by providing a better high frequency return path to the VFD power source.

VFD Cables





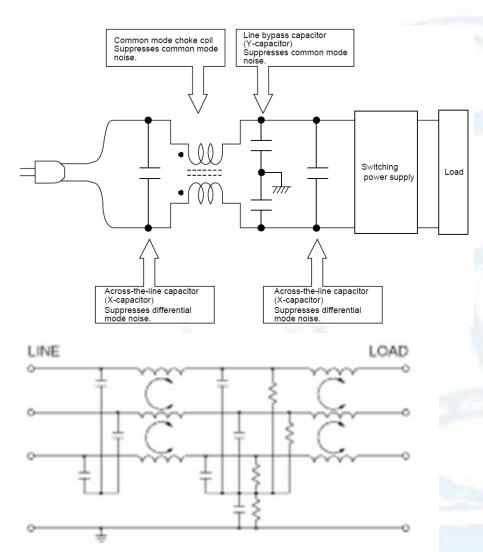
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Original Design Original Symmetrical Design Original Design with Signal Pair Three Stranded One Full-sized Insulated **Three Symmetrical One 16 AWG Shielded Signal** Ground (same AWG as **TC Circuit Conductors** BC Grounds (full size) Pair for Brake with Drain Wire **Circuit Conductors**) with XLPE Insulation **One Full-sized Insulated Ground** (same AWG as Circuit Conductors) Three Stranded TC **Circuit Conductors** with XLPE Insulation Three Stranded **TC Circuit Conductors** with XLPE Insulation **Overall Duofoil** Shield + 85% **Two Spiral Copper** TC Braid plus full Tape Shields size TC Drain Wire **Overall Duofoile** (100% Coverage) Shield + 85% TC Braid plus full size TC Drain Wire



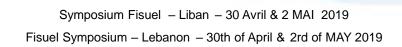
Power Conditioner







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Common Mode Choke







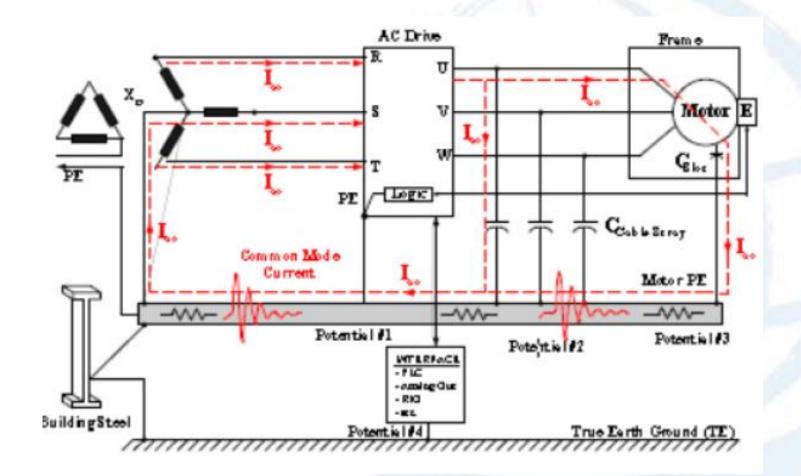
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Bearing Damage







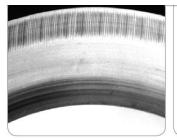
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Insulated Bearing









Fluting on the outer ring raceway of a bearing

Fluting on the inner ring raceway of a bearing

-Insulated bearings (ceramics)





Blackened grease



Healthcare Unit





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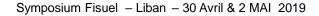


General Operating Room





SEMI-RESTRICTED CORRIDOR RECESSED FILM ILLUMINATORS OR FLAT PANEL MONITORS (AR) P519 PROVIDE POWER & DATA MEDICAL GAS ZONE VALVE BOX SS SHELF CONNECTIONFOR FLAT PANEL (VACUUM, MEDICAL AIR, MONITORS ' NITROGEN, NITROUS OXIDE, OXYGEN), SEE NOTE 9, GP4-1d THERMOSTAT (The second seco OPTIONAL RECORDER ę SEE NOTE 4. OPERATING ISOLATED POWER GP4-1d TABLE UNIT. SEE NOTE 6, GP SEE NOTE 7, 4-1d (TYP) GP4-1d-HUMIDISTAT PROVIDE POWER AND JUNCTION BOX FOR ELAPSED TIME CLOCK sw[c ç PROVIDE POWER AND JUNCTION OPERATING BOX FOR ELECTRIC CLOCK WITH TABLE SWEEP SECOND HAND swc ELECTRICAL POWER MODULE. LASER UTILITY PANEL SEE NOTE 2, GP4-1d (TYP) WITH WATER SERVICE FOR LASER. SEE NOTE 8. GP4-1d ----LASER UTILITY PANEL-AIR COOLED. SEE NOTE 8, GP4-1d SURGICAL LIGHT AND NITROGEN CONTROL OPTIONAL FLAT SREEN PANEL. SEE NOTE 10. **DDD** MONITOR GP4-1d CABINETS -CASE CART ARTICULATING UTILITY EXHAUST AIR GRILLES LOW ON WALL COLUMN. SEE NOTE 3, SEE NOTE 1, GP 4-1d - (TYP) GP4-1d (TYP OF 4)



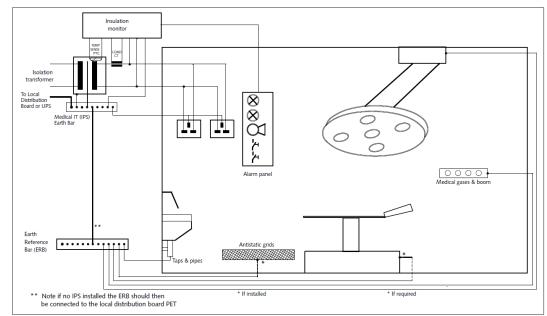


IT earthing -IMD





2 Figure 38 IPS theatre earthing arrangement



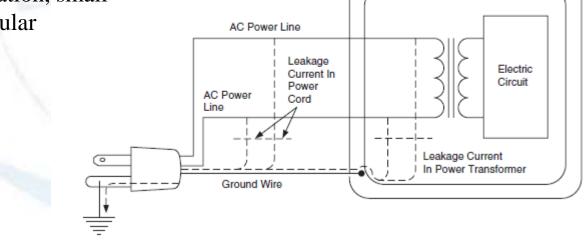


Ground Wire Sizing

The grounding conductor provides a path for leakage current which could be conducted to an electrical appliance case. The magnitude of this leakage current depends on the characteristics of the appliance and its insulation.

The leakage current could result in potential differences between pieces of equipment and could flow through vital organs of the patient, if a patient current path is established.

For example, during cardiac catheterization, small amounts, of current could cause ventricular fibrillation.



Path of Leakage Current



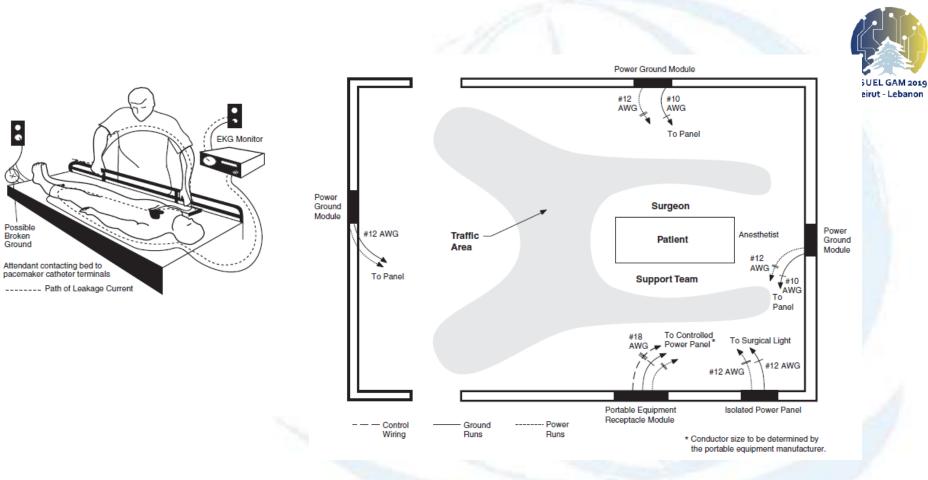


Instrument Cases



Ground Wire Sizing





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Current codes and standards for new construction of critical care areas require that no more than 40 mV exist between the reference point and exposed conductor surfaces in the patient's vicinity.

Using the isolated system, an initial line to ground fault can be kept as low as 5 mA, if the system is operating in the "safe" condition. The power cord ground wire could easily accommodate a 5 mA fault and stay well within the requirements of NFPA No. 99 and the NEC



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Best Photovoltaic Inverters





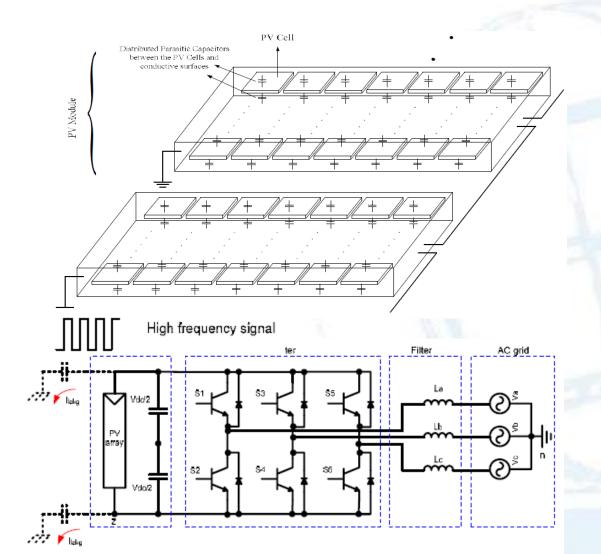
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Stray Capacitance







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Leakage Current





Stray capacitance, between earth and metallic frame, can reach $1\mu F$ for 1 kW of installed peak power $(1\mu F/kWp)$.

The PV modules become vulnerable to leakage currents especially for the case of Transformer less Inverter due to the lack of galvanic isolation.

This ground leakage current will :

- Lead to safety issues,
- Degrade the efficiency of thin-film modules,
- Create EMI problems,
- Disrupt protection coordination and introduce extra losses, and line current distortion.

Conditions	Capacitance
Glass-faced panels	50 - 150 nF/kW _{peak}
Thin-film panels	$Up \ to \ 1 \ \mu F/kW_{peak}$ (damp environments or rainy days)

EARTH CAPACITANCE OF PV UNGROUNDED SYSTEMS

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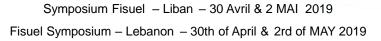
DIN-VDE 0126-1-1 standard



Some standards have been established in Germany by DIN (Deutsches Institut für Normung e. V.).



The DIN-VDE 0126-1-1 standard limits the rms value of leakage current in PV systems to 300 mA.



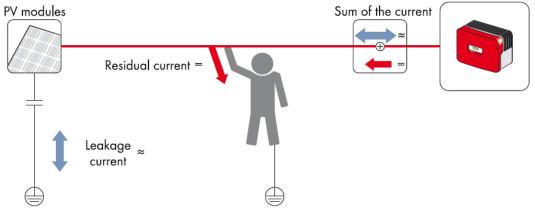


DIN-VDE 0126-1-1 Standard



Moreover, according to this standard, even a jump in the leakage current requires disconnection of the inverter.

Sudden surges of residual current of over 30 mA, the inverter disconnects automatically from the utility grid as a preventative measure .



Leakage current rise disconnection times specified in VDE 0126-1-1.

Leakage Current Increase (mA)	Disconnection Time (sec.)
30	0.30
60	0.15
100	0.04

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Injected DC Current



These inverters may inject DC currents to the utility grid.

-Decreases the power rating of the distribution transformer and decreases the systemet - Lebanon energy efficiency by causing additional losses both in the grid side and in the inverter side.

-Saturate the distribution transformer.

To avoid these drawbacks, the DC current injection is limited in several standards.

DC current injection limits specified in IEEE 1547, IEC 61727, VDE 0126-1-1, and

	IEEE 1547	IEC 61727	VDE 0126-1-1	EN 61000-3-2
DC Current Injection	< 0.5% of rated output current	< 1% of rated output current	< 1 A	< 0.22 A

EN 61000-3-2.

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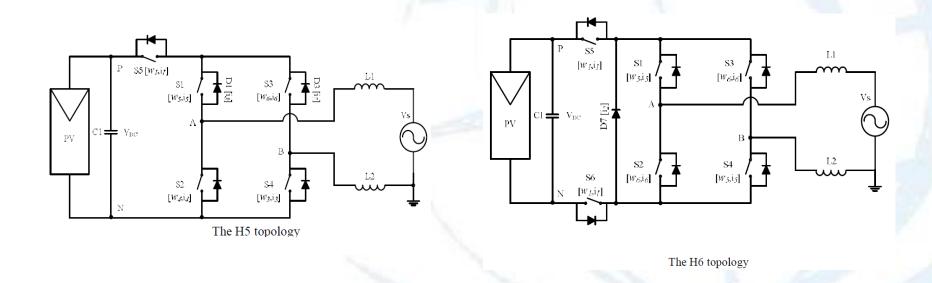


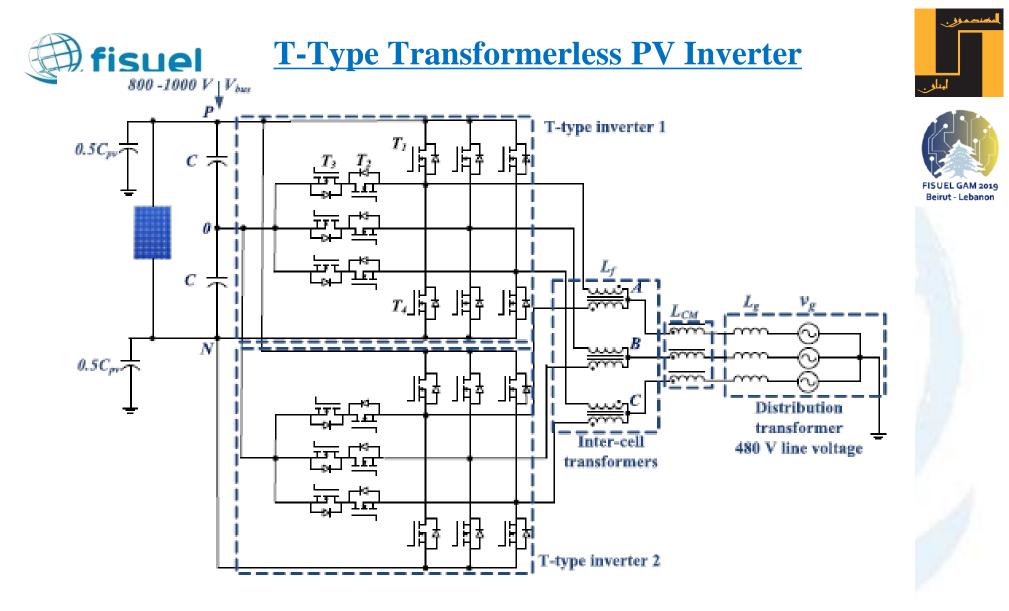






F Due to these restrictions on leakage current and due to the aforementioned drawbacks of Beirut - Lebanon leakage current, several GCTSIs are invented with low leakage current characteristic





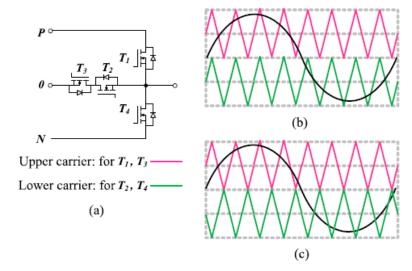
5-level T-type transformerless PV inverter.

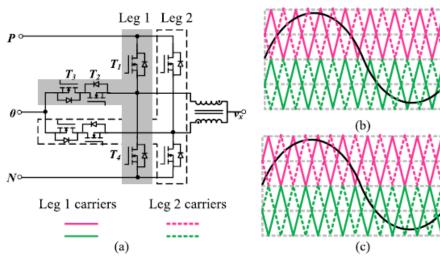
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fisuel Modulation method for 3 and 5 T Level Inverters









Modulation methods for 3LT² inverters: (a) One T-type phase leg; (b) PD modulation; and (c) POD modulation.

Modulation methods for the 5LT² inverter: (a) Two T-type phase legs; (b) interleaved modulation based on PD; and (c) interleaved modulation based on POD.

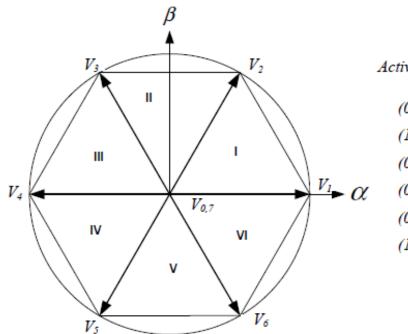
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Active Vectors

 $(0,0,0)V_1$ $(1,1,0)V_2$ $(0,1,0)V_3$ $(0,1,1)V_4$ $(0,0,1)V_5$ $(1,0,1)V_6$ Null Vectors

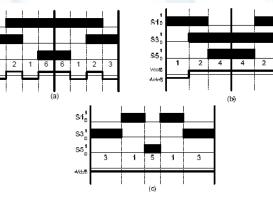
 $(0,0,0)V_0$

 $(1,1,1)V_7$



S3

S5



Reduced Common Mode Voltage Space Vector Modulations, (a) AZSPWM1, (b) AZSPWM2, (c) RSPWM3

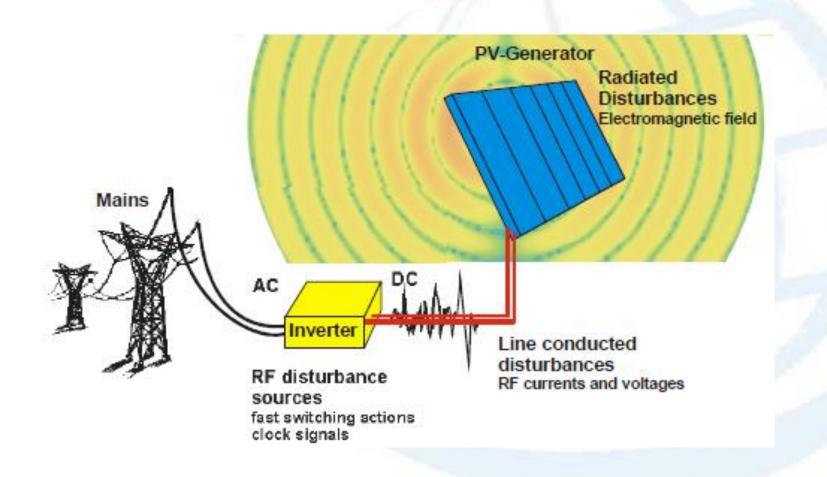
.General Space Vector Modulation for three-phase inverters.



EMI Electromagnetic Interference







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Frequency Range





Cables connecting PV panel with inverter are hundreds of meters, This current-carrying conductor can work as active unintended antennas in the radio frequency range. therefore, the most significant interference may be at the frequency range 30-300kHz – 300-3000MHz.

WAVELENGTH IN DIFFERENT FREQUENCY RANGE

Frequency	Wavelength [meters]	Antenna length [meters]	
3-30 Hz	$10^{8} - 10^{7}$	$10^{8} - 10^{7}$	
30-300 Hz	10^{7} - 10^{6}	10^{7} - 10^{6}	
300-3000 Hz	10 ⁶ -10 ⁵	10^{6} - 10^{5}	
3-30 kHz	10^{5} - 10^{4}	10^{5} - 10^{4}	
30-300 kHz	10 ⁴ -10 ³	10 ⁴ -10 ³	
300-3000 kHz	10 ³ -100	10 ³ -100	
3-30 MHz	100-10	100-10	
300-3000 MHz	10-1	10-1	
300-3000 MHz	1-0.1	1-0.1	
3-30 GHz	0.1-0.01	0.1-0.01	
30-300 GHz	0.01-0.001	0.01-0.001	

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Interferences influencing shortwave broadcast and beacons look particularly dangerous because they are used to communicate with merchant ships and aircraft.

if PV generation systems are close to airports or placed on the building roofs the noise can be dangerous.

Guidelines to minimize interference :

- Install the right EMC filters (reduce leakage current)

- Use twisted Shielded pairs, connected at both sides to ground, to connect the PV inverter to the PV panel.







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THANK YOU MERCI



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