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100 years
1903-2003

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Although due diligence and reasonable care has been taken to provide accurate and authoritative information about our products/services in this Training Manual as well as other documentation provided in connection with the subject training program, the user remains solely responsible for all consequences arising out of its use. This information is believed to be accurate and current as of the date of training; it is the user's responsibility to periodically check with Square D Co. headquarters (1415 S. Roselle Rd., Palatine, IL 60067) for any updates reflecting introductions, changes, or obsolescence of products and/or related functions. Competent professional advice or other expert assistance should always be obtained with respect to specific applications; it is the user's responsibility to ensure that the information in this documentation is appropriate for a particular application.

SQUARE D COMPANY
Schneider Electric

AC DRIVES AND SOFTSTARTS

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- Merlin Gerin
- Modicon
- Square D
- Telemecanique

Square D AC Drives Support

- www.squared.com - Technical manuals on-line
- 1-888-SQUARED - 888- 778-2733 -
  - **Factory Technical Phone Support in Raleigh, NC**
- Factory stock up to 500 HP.
- 24 Hour Field Service line -1-888-SQUARED
  - **1-888-778-2733**

Square D Presents AC Drives

- **What is an AC Drive?**
  - **–Drive and Motor Basics**
- **Why should we use them?**
  - **–Affinity Laws**
- **Applications**
- **Application Considerations**
- **AC Drive Troubleshooting Techniques**
- **Square D's line of AC Drives & the Embedded Web Server Demonstration**

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What is an AC Drive?

TERMINOLOGY

AFC

ASD

VFD

VSD

VSC

INVERTER

FREQUENCY CONTROLLER

AC DRIVE

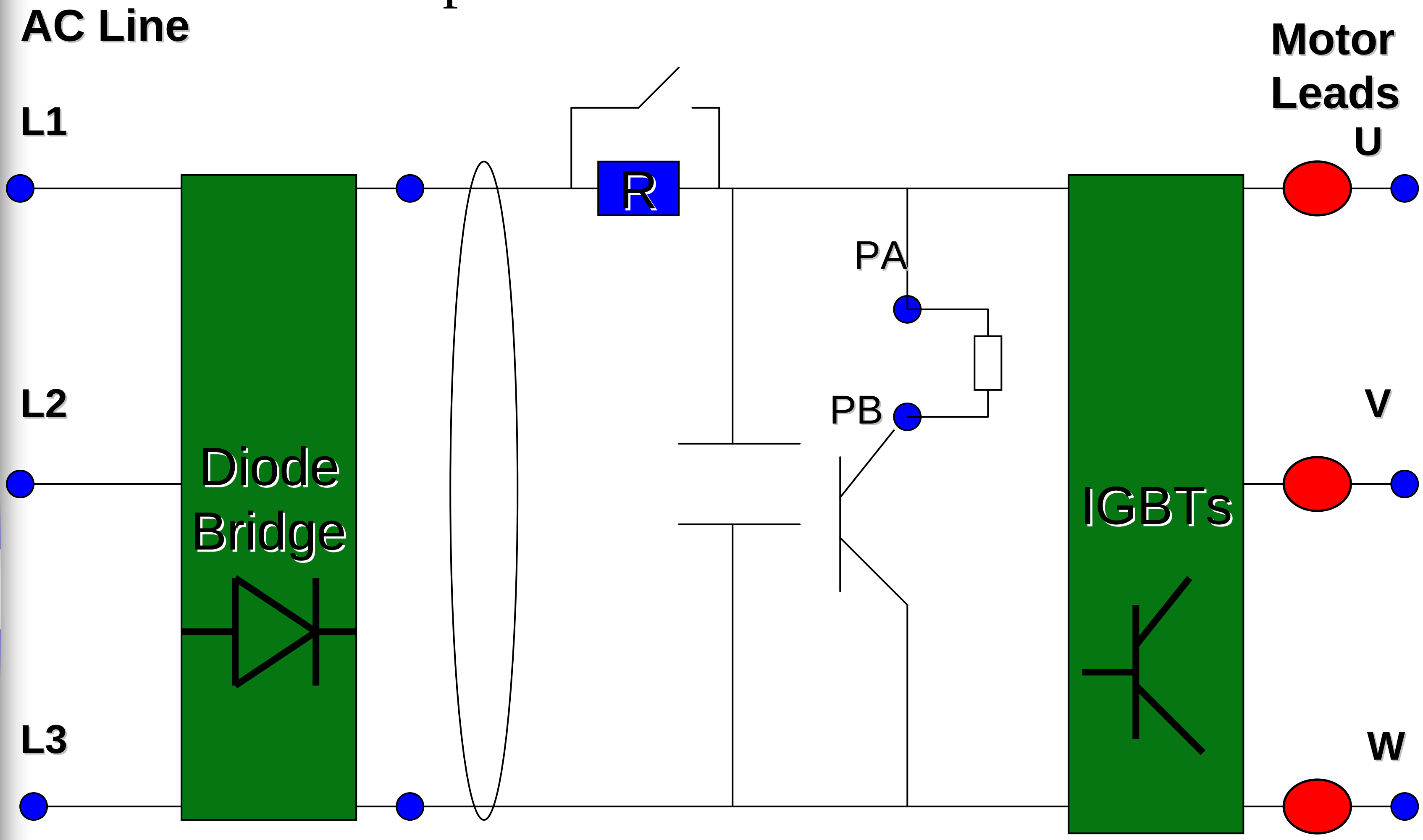
CONSTANT TORQUE

VARIABLE TORQUE

CONSTANT HORSEPOWER

Typical AC Drive Schematic

Three parts of an AC Drive

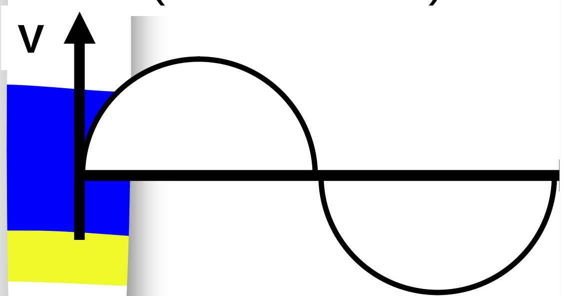


Diode Converter - Front-End of Drive – AC to DC

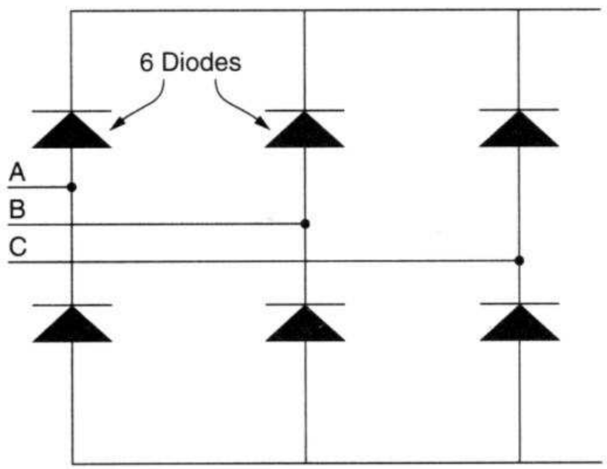
DIODE: A device that passes current in one direction, but blocks current in the reversed direction.

DIODE BRIDGE RECTIFIER: A diode bridge rectifier is a device composed of diodes which converts AC current or voltage into DC current or voltage.

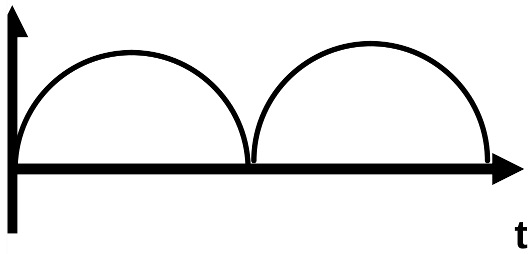
AC Line Voltage
(non-rectified)



(Single-phase shown)



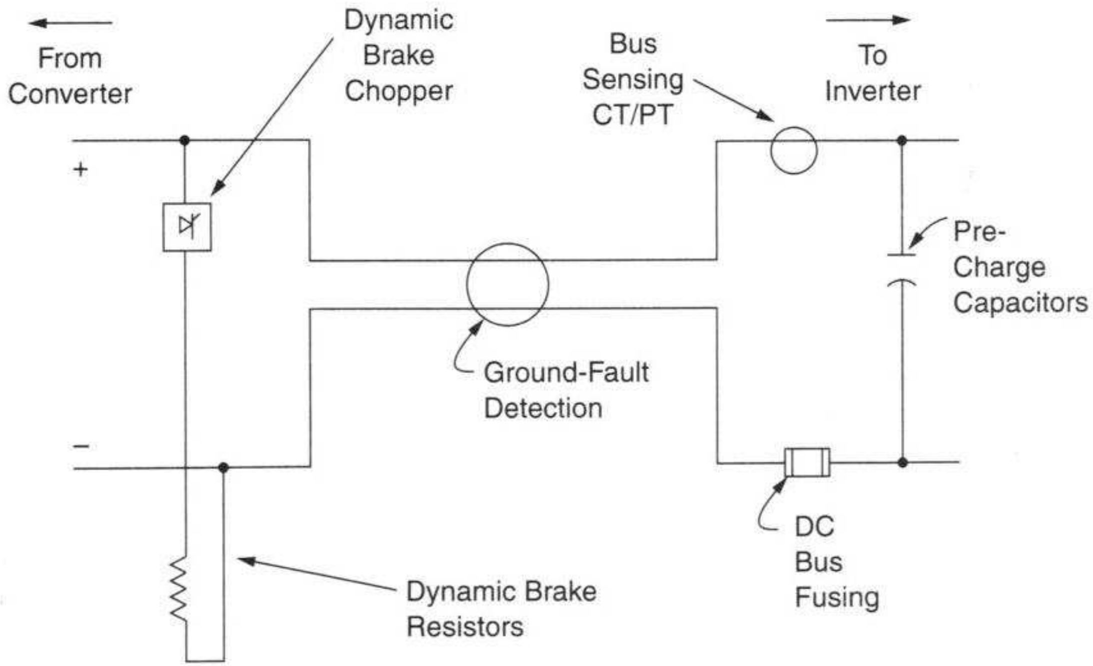
DC Voltage
(rectified)



(Single-phase shown)

DC Bus – DC Link or Filter Section

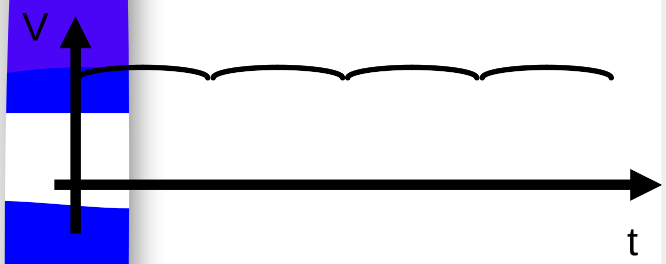
Provides much of the monitoring and protection for the drive and motor. Dynamic braking circuit allows bleeding of energy to resistors for overhauling loads.



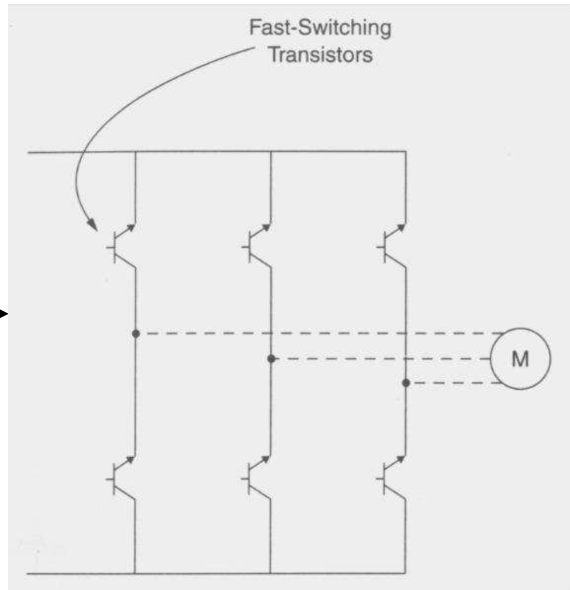
INVERTERS – Back-End of Drive – DC to AC

INVERTER: An inverter is a device which converts DC energy into three channels of AC energy that an induction motor can use.
Typically these are IGBT's.

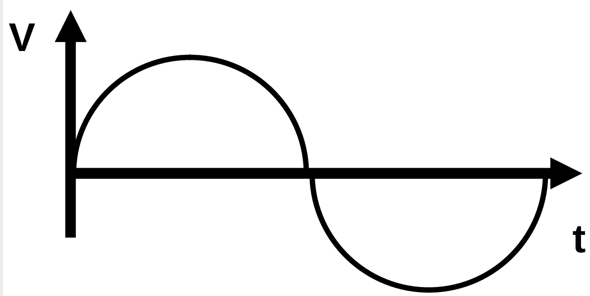
DC Voltage
(non-inverted)



(Three-phase average shown)



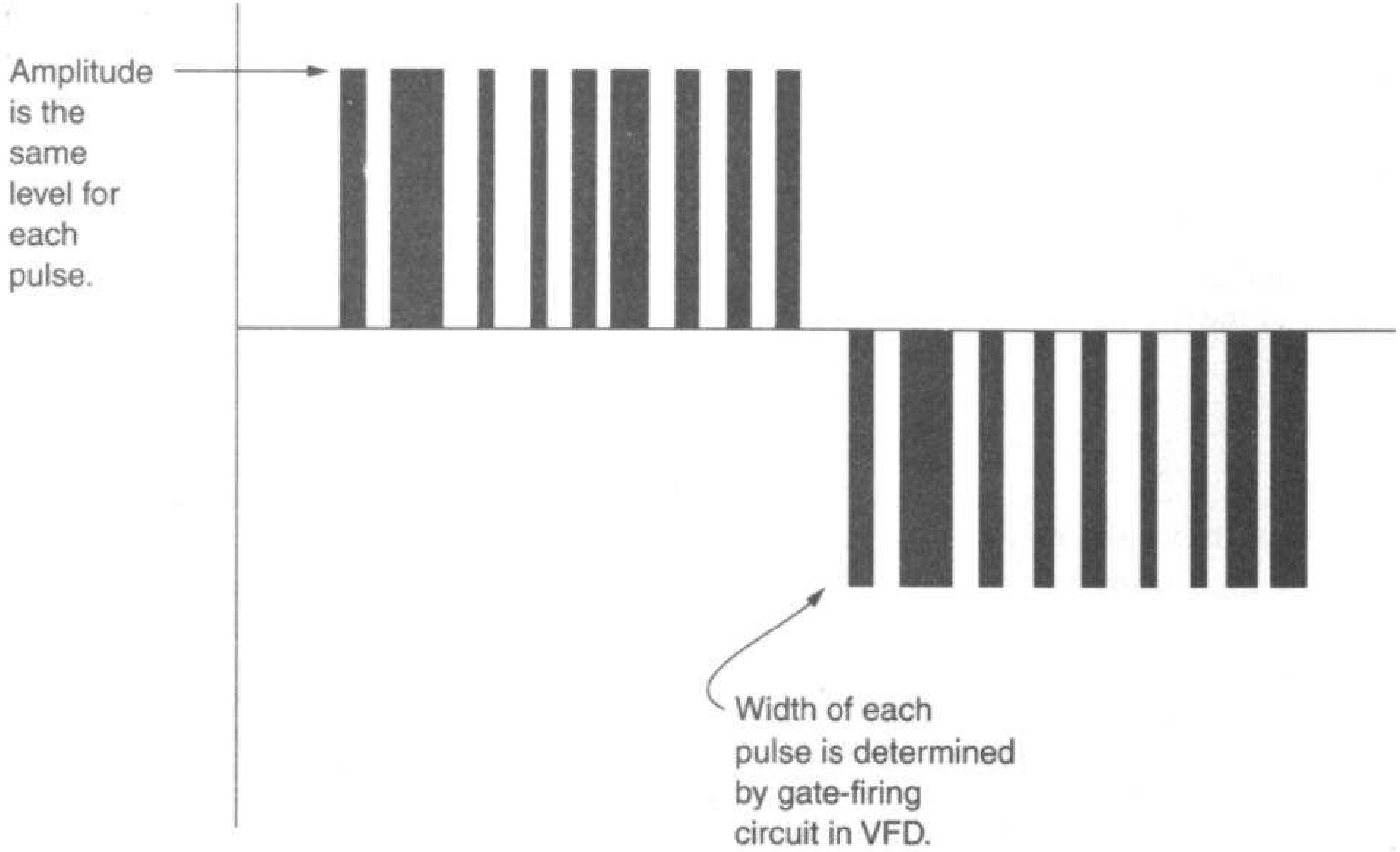
AC Voltage
(inverted)



(Single-phase shown)

Pulse Width Modulated Waveform

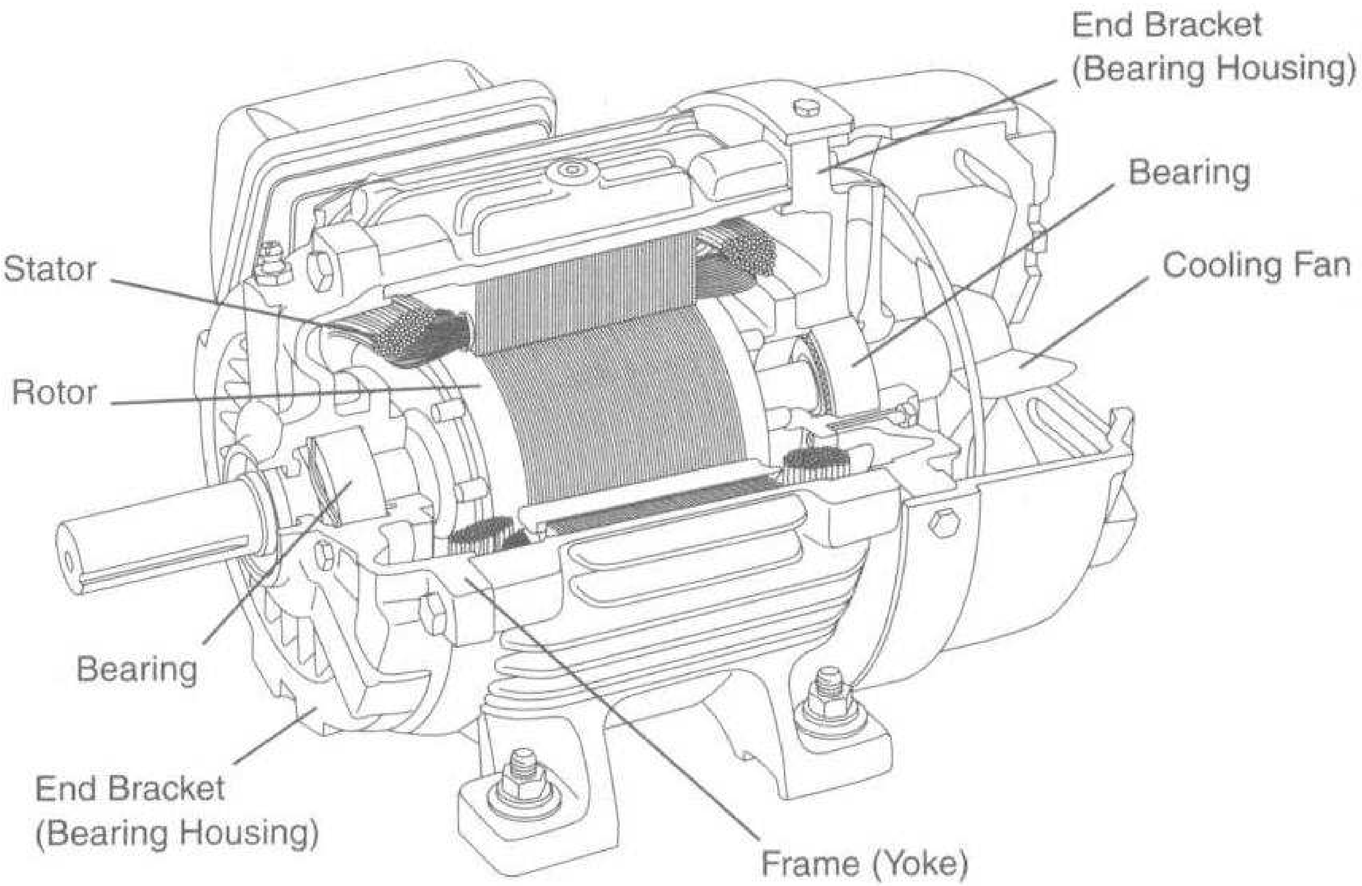
- Controls the width of the pulses, many times per half cycle to manufacture a sinusoidal output to the motor.
- Even though the RMS value of voltage is lower, the drive is still sending pulses of 650VDC power to the motor.



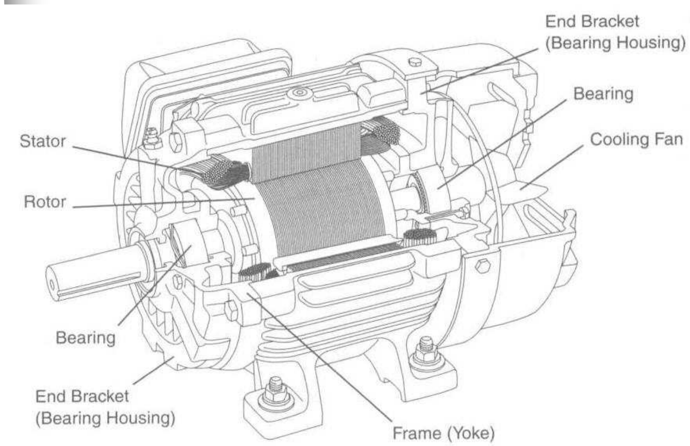
Motor Basics

Motor Basics

AC Induction Polyphase Motor: *Acts as a rotating transformer. Primary is motor windings (Stator), secondary is Rotor.*



Three ways to control motor speed



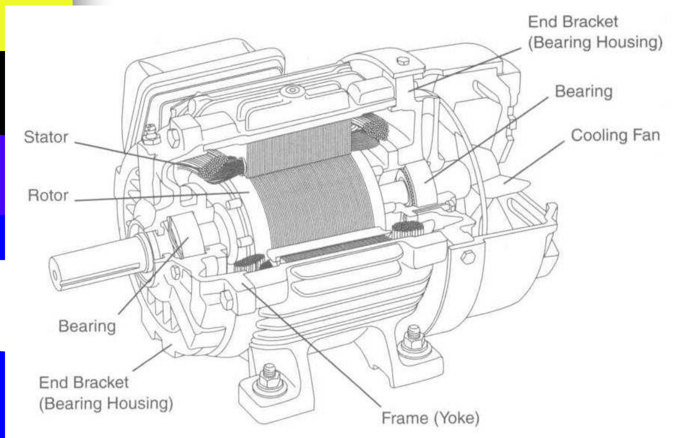
1) ***Change the number of poles in the motor, ie. separate windings.***

2) ***Change the slip characteristics of the motor, ie varying resistors as in a wound-rotor motor***

3) ***Change the frequency of the power supplied to the motor, ie <u>variable frequency drive</u>***

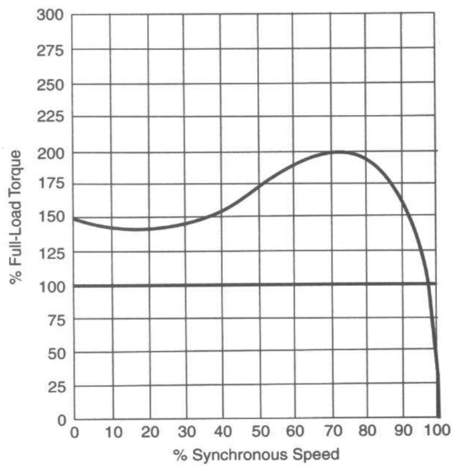
Synchronous Speed

Synchronous Speed = $\frac{120 * \textbf{frequency}}{\# \text{ poles}}$ = $\frac{120 * 60 \text{ Hz}}{4}$ = 1800 rpm



1) **Stator receives current from the drive which creates a rotating magnetic field.**
2) **This rotating field moves the rotor.**
3) **The frequency is how often the current flows through the stator.**
4) **Controlling the frequency to the stator controls the motor speed.**
5) **Controlling the voltage and frequency, controls the torque capability of the motor.**

Slip – Generating Torque



Typical speed versus torque curve for a NEMA design B motor

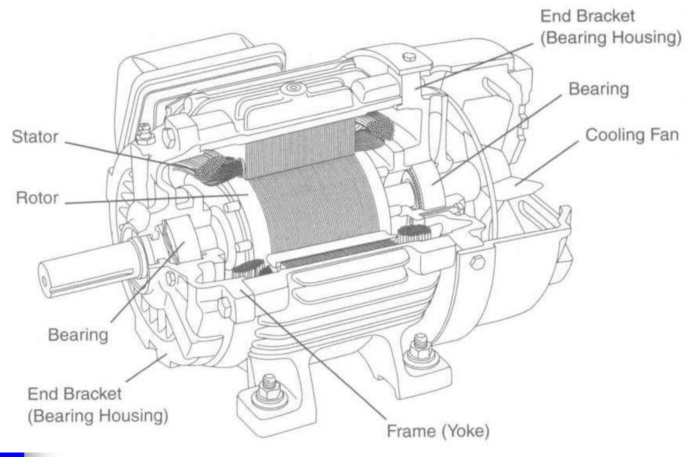
1) ***Once the motor is loaded it will not be able to reach synchronous speed.***

2) ***The difference between synchronous speed and full-load motor speed is Slip.***
3) ***(i.e. 1800 rpm synchronous speed, 1780 full load speed)***

4) ***Induction motors are classified by their slip characteristics as shown in speed vs torque curves. (Designs A, B, C or D).***

Volts / Hertz Control

460 Volts/60 Hz = 7.6 V/Hz ratio



- **Maintaining the V to Hz ratio over the operating range of the motor maintains a constant flux in the air gap of the motor.**
- **This allows full torque output of the motor down to very low speeds.**

Why do we use AC Drives?

WHY DO WE USE AC DRIVES?

- ENERGY SAVINGS *(PUMPS & FANS)*
  - *Affinity Laws*
- REDUCE MECHANICAL STRESS
  - *(Save wear and tear on belts, chains, gears)*
  - *Softstarting*
- ELIMINATE POWER SURGES
  - *Lowering inrush current*
- RETROFIT EXISTING INEFFICIENT SYSTEMS
  - Damper, inlet vane, valve systems, eddy current or any slip or mechanical variable speed systems.
- BETTER PROCESS CONTROL
- BETTER MOTOR PROTECTION OVER A MECHANICAL VARIABLE SPEED DRIVE

Affinity Laws & Energy Savings

Apply only to Variable Torque Loads

- Flow is directly proportional to Speed
- Pressure is proportional to the Square of Flow(Speed)
- Power is proportional to the Cube of Flow(Speed)
  - i.e. At 50% of full speed, the application will require12.5% of full power.

Energy Savings Analysis

Eddy Current Clutch versus AC drive - 50 HP

Energy Savings

AFD Vs. Eddy Current Clutch

% of Motor Max Speed	Annual Hours @ Speed		Shaft HP Per Unit @ Speed Cubed	KW Output Per Unit HP x .746 KW/HP	System Efficiency Motor and Control		KW Input Per Unit HP @ Speed		KW-HRS /Year	
	%	Hrs/Yr			AFD	Alt.	AFD	Alt.	AFD	Alt.
100.0	10	876	1.0	0.75	.873	.864	0.85	0.86	749	756
95.0	10	876	0.9	0.64	.855	.828	0.75	0.77	655	677
90.0	15	1314	0.7	0.54	.837	.774	0.65	0.70	854	923
85.0	15	1314	0.6	0.46	.828	.720	0.55	0.64	727	836
80.0	20	1752	0.5	0.38	.819	.666	0.47	0.57	817	1005
75.0	15	1314	0.4	0.31	.801	.612	0.39	0.51	516	676
70.0	10	876	0.3	0.26	.783	.558	0.33	0.46	286	402
65.0	5	438	0.3	0.20	.765	.513	0.27	0.40	117	175
	100	8760								

	AFD	Alt.
Total KW-Hrs/HP	4722	5450
Energy Cost Cents/KW-Hr	7.0	7.0
Motor Rated HP	50	50
Total KW-Hr/HP Cost	331	381
Total Annual KW-Hr Cost	16,526	19,073

Annual Energy Savings	$2,548
Cost of Drive	$5,000
Payback Period	1.96Yrs

Done

Energy Savings Analysis

Outlet Damper versus AC drive - 50 HP

AFD Vs. Outlet Damper

% of Motor Max Speed	Annual Hours @ Speed		Shaft HP Per Unit @ Speed Cubed	KW Output Per Unit HP x .746 KW/HP	System Efficiency Motor and Control		KW Input Per Unit HP @ Speed		KW-HRS /Year	
	%	Hrs/Yr			AFD	Alt.	AFD	Alt.	AFD	Alt.
100.0	10	876	1.0	0.75	.873	.891	0.85	0.84	749	733
95.0	10	876	0.9	0.64	.855	.729	0.75	0.88	655	769
90.0	15	1314	0.7	0.54	.837	.621	0.65	0.88	854	1151
85.0	15	1314	0.6	0.46	.828	.522	0.55	0.88	727	1153
80.0	20	1752	0.5	0.38	.819	.441	0.47	0.87	817	1517
75.0	15	1314	0.4	0.31	.801	.369	0.39	0.85	516	1121
70.0	10	876	0.3	0.26	.783	.315	0.33	0.81	286	712
65.0	5	438	0.3	0.20	.765	.261	0.27	0.78	117	344
	100	8760								

	AFD	Alt.
Total KW-Hrs/HP	4722	7499
Energy Cost Cents/KW-Hr	7.0	7.0
Motor Rated HP	50	50
Total KW-Hr/HP Cost	331	525
Total Annual KW-Hr Cost	16,526	26,248

Annual Energy Savings	$9,723
Cost of Drive	$5,000
Payback Period	0.51 Yrs

Done

Reducing Mechanical Stress with AC Drives

- Life of bearings are extended, since the motor is running at lower speeds
- Wear on impellers and blades are reduced due to lower back pressures.
- Audible noise of fans and pumps are reduced
- AC Drives offers a more precise way of controlling the system
- Life of V-Belts are extended due to a soft-start

BETTER MOTOR PROTECTION OVER A MECHANICAL VARIABLE SPEED DRIVE

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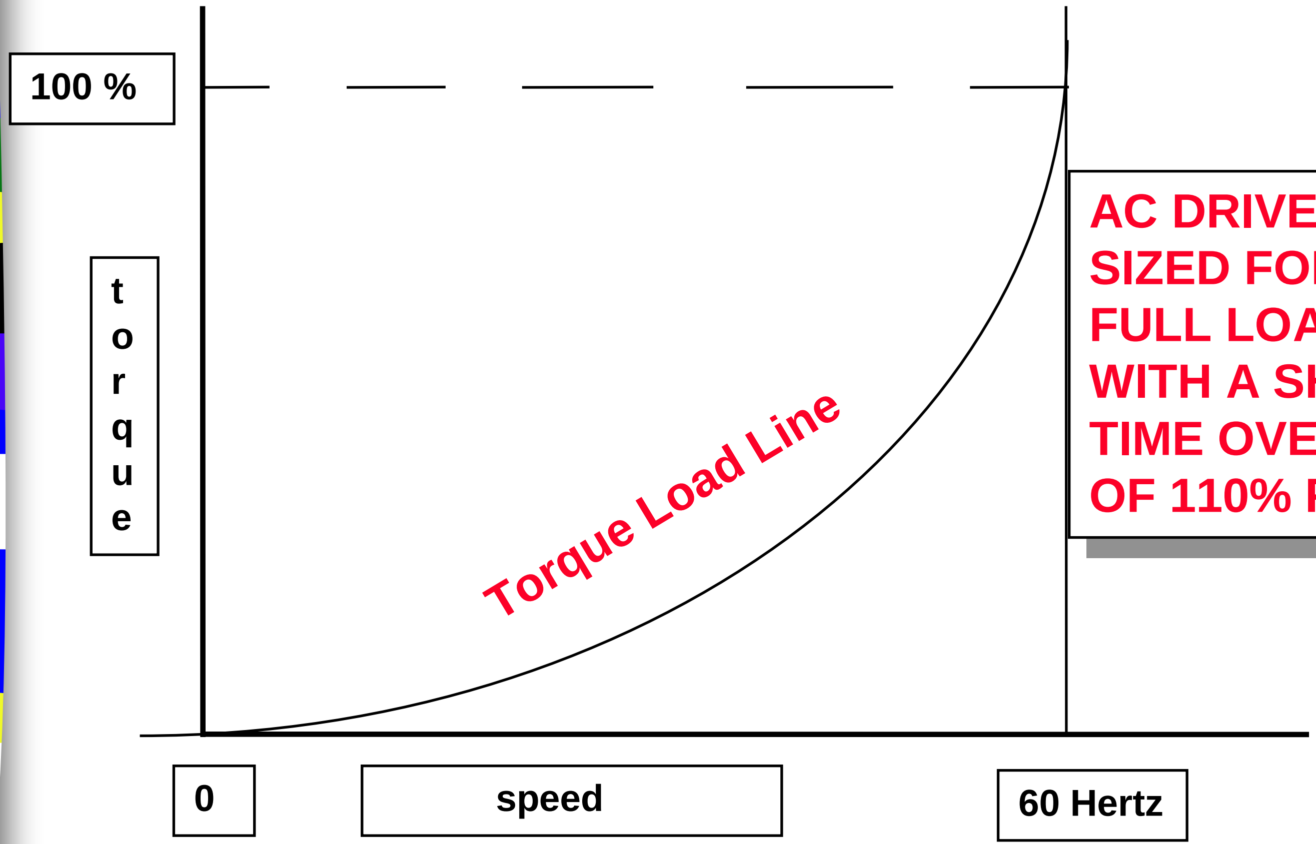
- **Input phase failure**
- **Phase rotation**
- **Brown out or under voltage protection. If you have a brown out the motor will burn up unless you have this built into somewhere else in the system.**
- **With a bypass, you have a back up. How do you bypass the mechanical speed drive? If it is down, you are Down!!**
- **Instantaneous over current protection.**
- **Over-voltage protection**
- **Power factor correction!! You are looking at .97 or better power factor. Standard motor is in the .85 area at full load.**
- **Output phase protection**
- **Short Circuit protection**
- **Ground Fault protection.**

APPLICATIONS

Load Characteristics

VARIABLE TORQUE LOAD

TORQUE VARIES AS THE SQUARE OF THE SPEED



AC DRIVE MUST BE SIZED FOR MOTOR FULL LOAD AMPERES WITH A SHORT TIME OVERLOAD RATING OF 110% FOR 1 MINUTE

Variable Torque Applications

- Centrifugal Fans
- Centrifugal Pumps
- Centrifugal Chillers

VT Loads are found where?

Office Buildings, Water Plants, Wastewater Plants:

Equipment:

Water Pumps

WasteWater Pumps

Cooling Towers

Chill Water Pumps

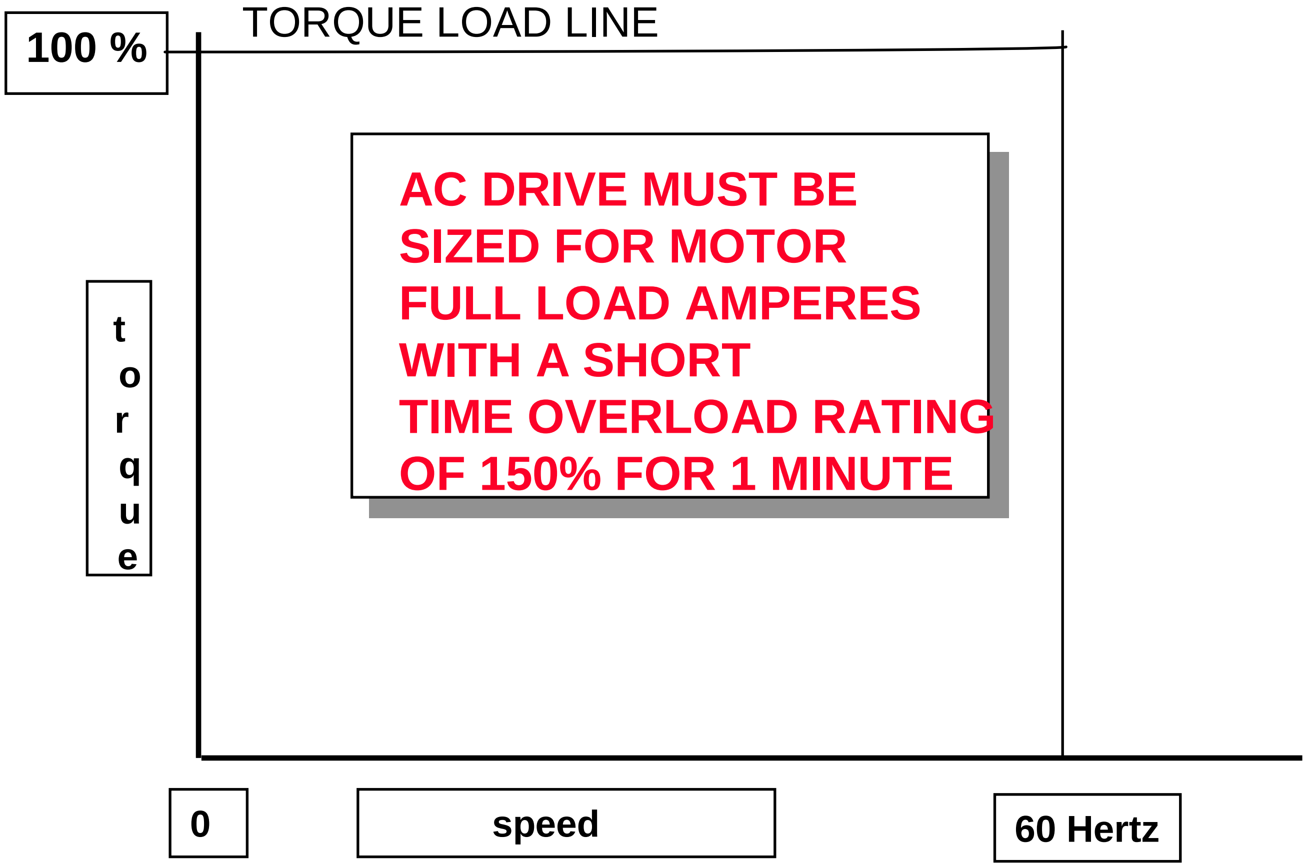
Condenser Water Pumps

Air Handlers

Load Characteristics

CONSTANT TORQUE LOAD

TORQUE IS CONSTANT AS SPEED CHANGES



AC DRIVE MUST BE SIZED FOR MOTOR FULL LOAD AMPERES WITH A SHORT TIME OVERLOAD RATING OF 150% FOR 1 MINUTE

Constant Torque Applications

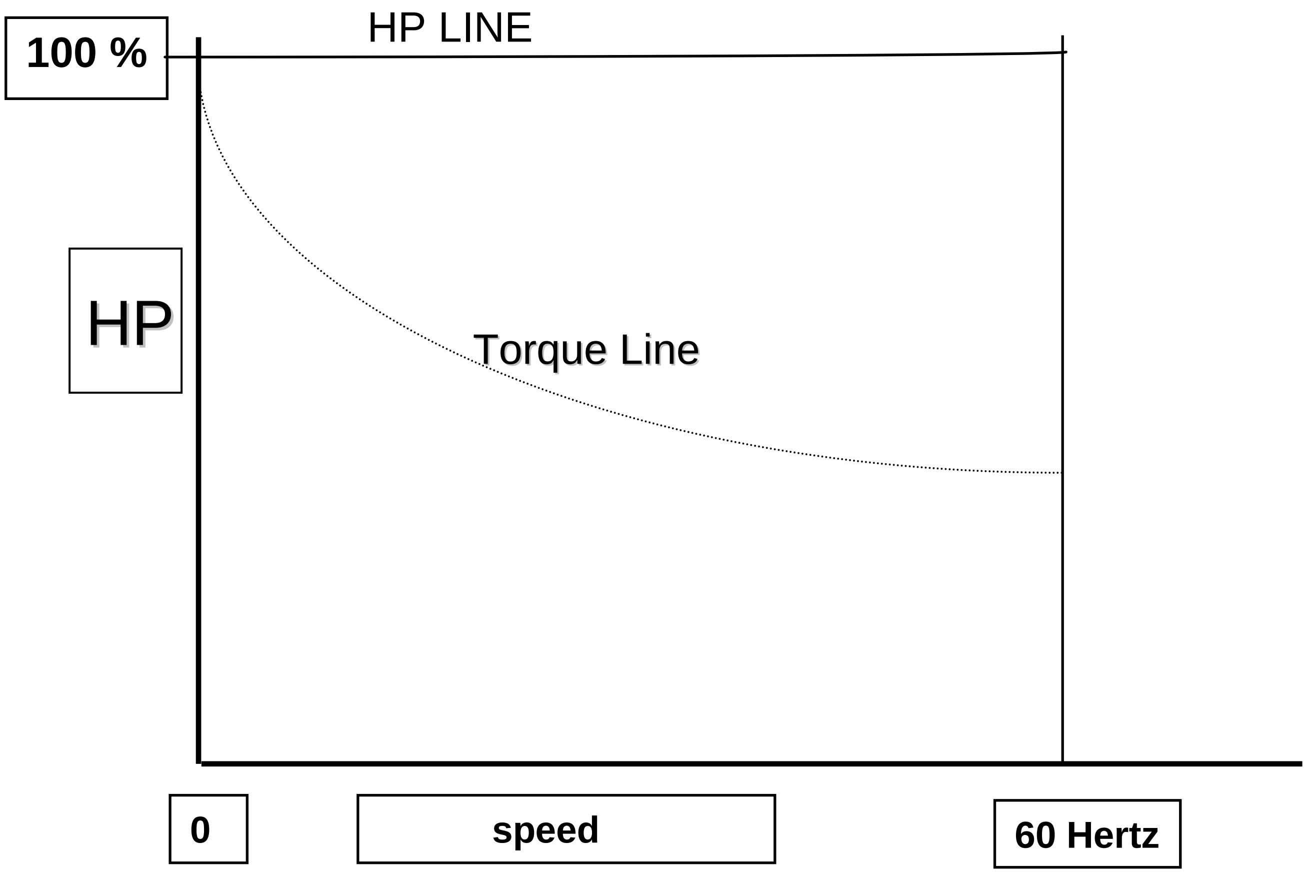
Is there any energy savings in Constant Torque Loads?

- Clarifiers - Water Plants
- Compressors - Buildings and WWTP/WTP plants
- Conveyors - Wastewater Plants, Phosphate Plants, Bottling Plants..
- Extruders - Plastic Bottling Manufacturers
- Hoists and Cranes - Ship Yards, Manufacturing Plants
- Positive displacement pumps and Progressive cavity pumps - Wastewater and Citrus Plants

Load Characteristics

CONSTANT HP LOAD

Horsepower IS CONSTANT AS SPEED CHANGES



Constant Horsepower Applications

- Drill Presses
- Grinders
- Lathes
- Milling Machines
- Tension Drives
- Tool Machines
- Winders

AC Drive
Application Considerations

Application Considerations

- **Sizing an AC drive -**
  - **HP vs. Amperage (& volts)**
    - **Watch out for Low RPM motors. (720/900/1200)**
    - **Low RPM motors have higher amps than 1800 rpm motors.**
    - **Motor Nameplate data vs. Actual Data, take measurements**

Motor Nameplate Data

Serial #	120356RC-69	**HP**	30	**Frame**	286T		
Phases	3	**Hz**	60	**Voltage**	460/230	**rpm**	1755
FLA	36.2/72.4	**SF**	1.15	**NEMA Design**	B	**Encl**	TEFC
Code	G	**Insulation**	Class H	**Ambient Temp**	40°C		
Duty	Inverter Duty—Suitable for 6:1 Turndown	**Misc**	C-Face				

What is important here ?

HP, Voltage, FLA, Design, Insulation Class, SF, Inverter Duty

Application Considerations Applying AC Motors To AC Drives

- **Motor Insulation and Construction**
  - **Inverter duty motors have a higher insulation rating. 1600 Volts vs. Standard motors, 1000 volts.**
  - **Inverter duty motors are sized per the application, Variable torque vs Constant torque.**

Motor Insulation Standard

NEMA MG-1 (Part 30)
1000V
2µs
500V/µs

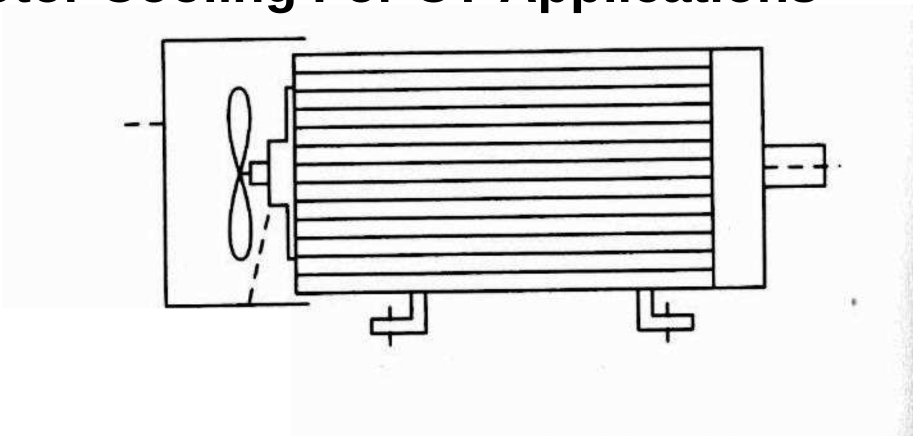
- **NEMA MG-1 Part 30**
- **Indicates winding insulation of motor can withstand 1000Volts peak at a minimum rise time of 2 µsec.**
- **To protect a motor, the dV/dt should limited to 500V/µsec.**

Motor Insulation Standard

NEMA MG-1 (Part 31)
1600 V
0.1 μs
16,000 V/μs

- **NEMA MG-1 Part 31**
- **Indicates winding insulation of motor can withstand 1600Volts peak at a minimum rise time of 0.1 μsec.**
- **Note: an inverter duty motor does not guarantee compliance with Nema MG-1 part 31. Consult manufacturer.**

Motor Cooling For CT Applications

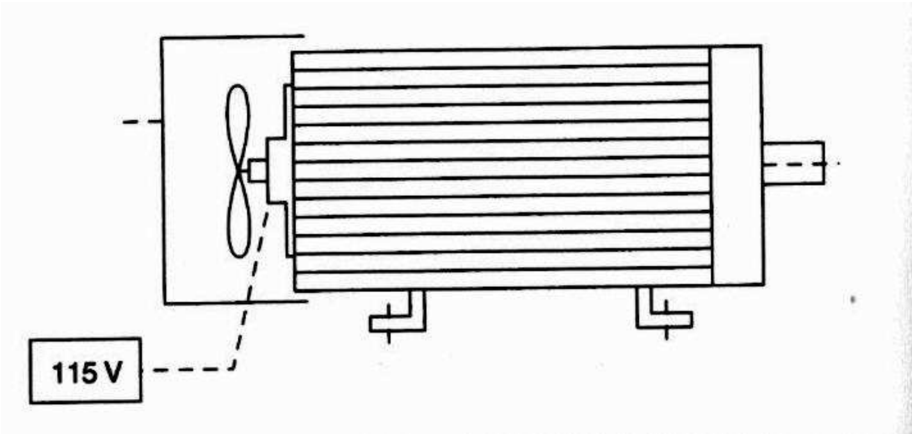


1) Running a motor lower than full speed with a drive means the fan attached to the motor shaft will turn slower, providing less cooling.

2) Motor heating is affected by: Speed Range & Loading (VT vs CT)

3) Service Factor is lost when running on inverter power.

Motor Cooling Solutions For CT Applications



1) Use a separately controlled cooling fan.

2) Set your minimum speed above zero

3) Duct cooled air to the motor.

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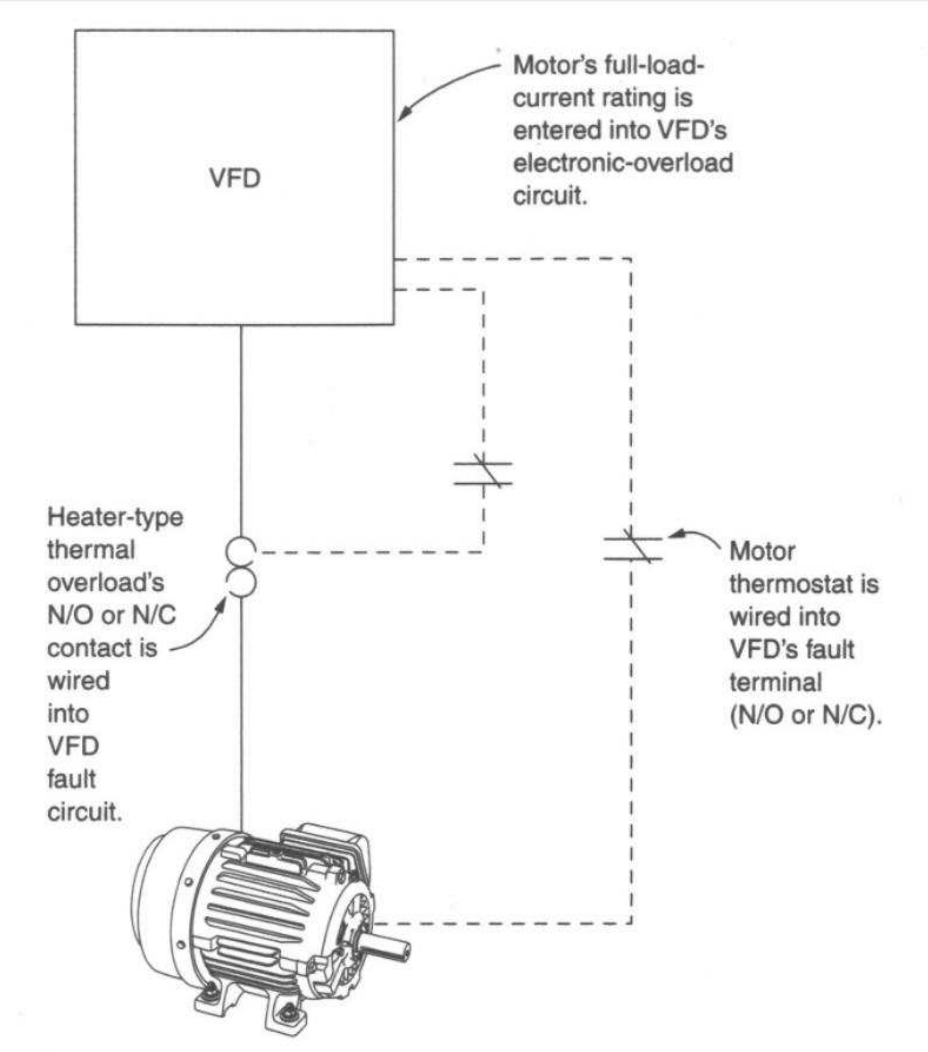
Protecting the Motor



1) ***The drive provides I^2Tprotection for the motor based on FLA setting.***

2) ***Output Overload also provides I^2T for motor when drive or bypass is used.***

3) ***Thermostat set into motor provides additional thermal protection***

Application Considerations
Applying AC Motors To AC Drives

Motor Lead Length from AC drive will determine the voltage level at the motor.

- **Special Considerations – Long Lead Lengths**
  - **Over 100' for up to 100 HP**
  - **Over 200' for 125HP and above**
  - **<u>Reflected Waveform can cause voltage doubling at the motor</u>**
  - **Solutions include:**
    - **Lowering the carrier frequency of the drive**
    - **Specify and purchase NEMA MG-1, Part 31 motors**
    - **Install output reactors (Also reduces ground fault) or output filters (Also used to protect older motors).**
    - **Utilize VFD rated cable, Belden, Shawflex, Olflex**

Reflected Wave Phenomenon

Z(cable) = Z(motor)

No Reflection

Z(cable) > Z(motor)

Current is reflected at the motor

Z(cable) < Z(motor) ***(Typical for AC Drive/Motor)***

Voltage is reflected at the motor

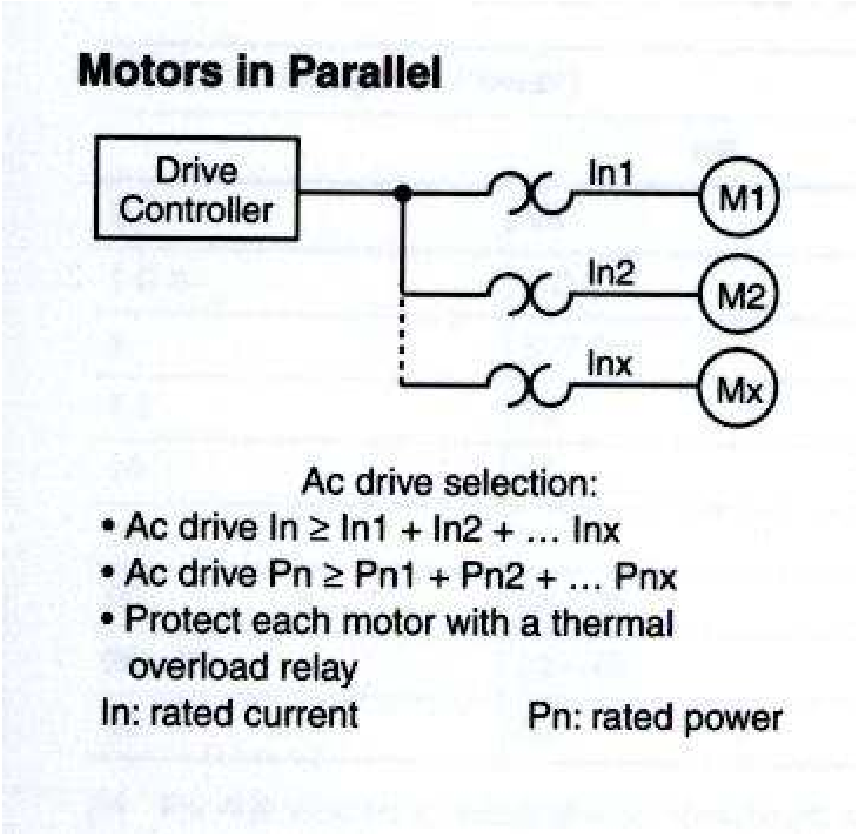
(What do electricians do for long motor lead runs?)

Application Considerations
Applying AC Motors To AC Drives

- **Carrier Frequency**
  - **Higher carrier frequency can cause audible motor noise**
    - **Increasing above 8 kHz makes it inaudible to humans**
  - **Higher carrier frequency stresses motor**
  - **Higher carrier frequency makes shaft voltage build-up more likely (Typically over 8 Khz)**
  - **Higher carrier frequency makes reflected waveform more likely**

Application Considerations
Applying AC Motors To AC Drives

- **Multiple Motors**
  - Size drive for full load amp rating of all motors combined.
  - Provide separate overload and GF protection for each motor.
  - Ramp up and down all motors at once
    - If "slamming" a motor into the circuit we need size the drive to provide the inrush requirements of the "slammed" motor.
  - Motor Lead Lengths added together.



Application Considerations
Applying AC Motors To AC Drives

- **Shaft Voltage Build-Up**
  - Voltage build-up of 5-30VDC on the shaft is possible with higher carriers (above 8 Khz).
  - This will either bleed away or flash to ground
  - Typical flash point is bearings
    - This will pit the bearing and the race
  - Common solutions include:
    - Decrease carrier frequency from drive
    - Ground shaft with a brush
    - Use conductive grease
    - Ceramic bearings

Application Considerations

- Power Circuits
  - Open Units - Non-Combo
  - Input Circuit Breakers - Combo
  - Bypasses -
    - **3 contactor**
    - **dual disconnects**
    - **Nema rated contactors (What is a Nema Rated Contactor?)**
    - **softstart bypass**.

Combo with Bypass

Application Considerations

Environmental Considerations

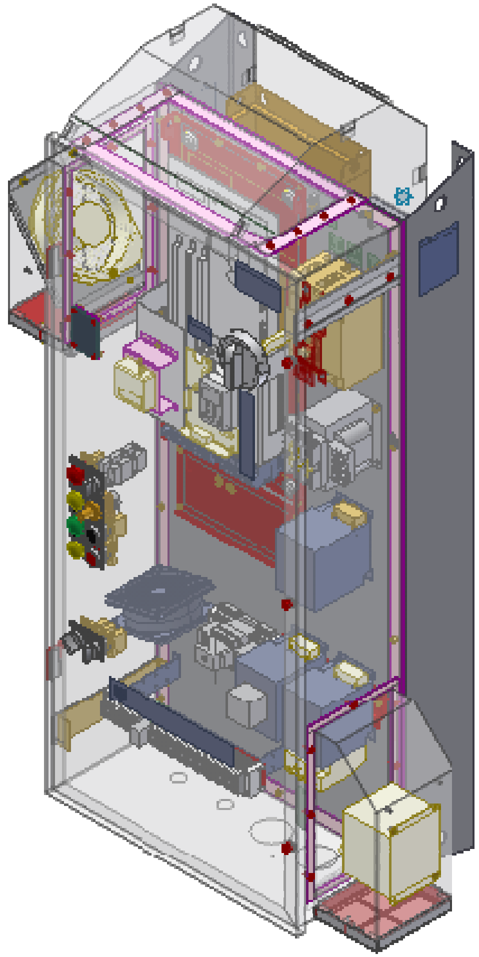
- Rating for the Enclosure
- Indoor, Nema 1, Nema 12
- Outdoor, Nema 3R, Nema 4, Nema 4x, Direct Sun?
- Ambient Temperature
  - Most drives are rated 0-40 degrees C Ambient
  - Derating is required above 40 degrees C.(50 C inside the Enclosure)
  - Heating is required below zero degrees C.

Application Considerations

Environmental Considerations

- Humidity
  - Most drives are rated for 95% humidity, non-condensing
  - Leaving the drive energized should provide enough heat to minimize condensation unless ambient drops below zero degrees C

Nema 3R Cabinet



Application Considerations

Environmental Considerations

- Altitude
  - – Most drives are rated up to 3300 feet above sea level
  - – Derating is required above 3300’ due to thinner air

Application Considerations
Installation and Wiring

- **Input Power wiring**
  - **Can be grouped with other 460/230 VAC equipment**

- **Output Motor Leads**
  - **Must be separated by space**
    - **(PVC conduit - 12” spacing) and shielding using rigid conduit or shielded wiring (3” spacing).**

Application Considerations Installation and Wiring

- **Control Interface - Analog vs. Digital**
  - **Relays and analog signals, Start, Stop, Speed reference, Fault feedback vs.**
  - **Serial communications - Modbus, Modbus plus, Modbus TCP/IP (Ethernet), etc..**

- **Signal Wiring -**
  - **Must be separated from power wiring or at right angles when crossing power wiring. Shielding is required for ma signals and serial communication. Ground shield at source.**

Application Considerations

- Special Considerations
  - Single-Phase in Three Phase Out
  - Smaller drives are rated for this already
  - For larger HP's
    - **De-rate the drive typically by one size**
      - **Check input diode bridge amp rating (1.732 x motor full load rating)**
    - **Add line reactors (For continuous duty, not necessary for intermittent duty)**
    - **Turn off input phase loss**

Application Considerations

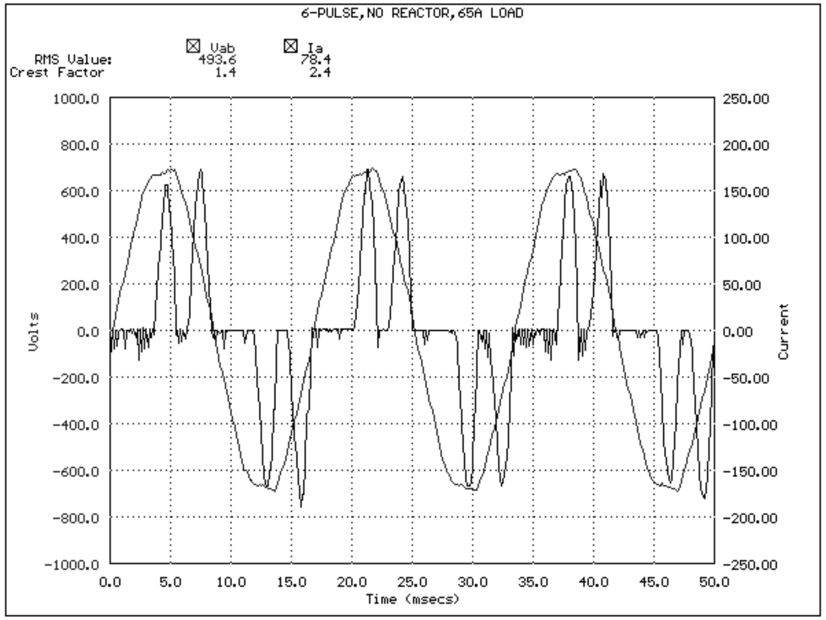
- Harmonics and Abatement Techniques
  - – IEEE Guidelines
    - 519-1981- Voltage Distortion
    - 519-1992- Current and Voltage Distortion
      - – **Defining PCC.**
      - – **Utility vs. Generator Supply.**
  - – Abatement - Cost vs Benefit.
    - Line Reactors
    - Passive Filters - Tuned, Broadband
    - Multi-pulse inputs, 12,18,24
    - Active Filters

Application Considerations

- Power Quality and Harmonic Requirements
  - Line Reactors
  - Multi-Pulse
  - Passive Filters
  - Active Harmonic Injection

"Stiff" Distribution feeder (High Fault Current)

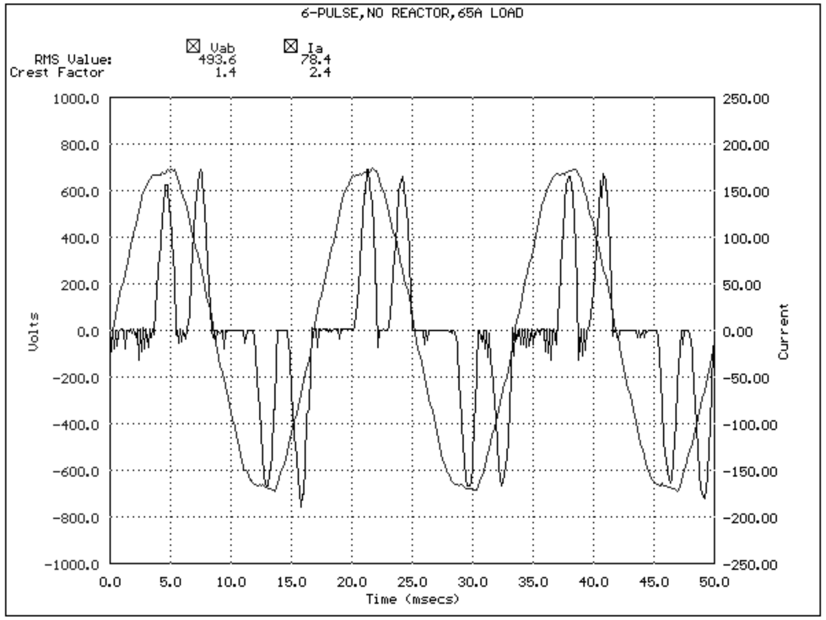
Without Impedance



Impedance reduces the distorted current demanded from the AC line

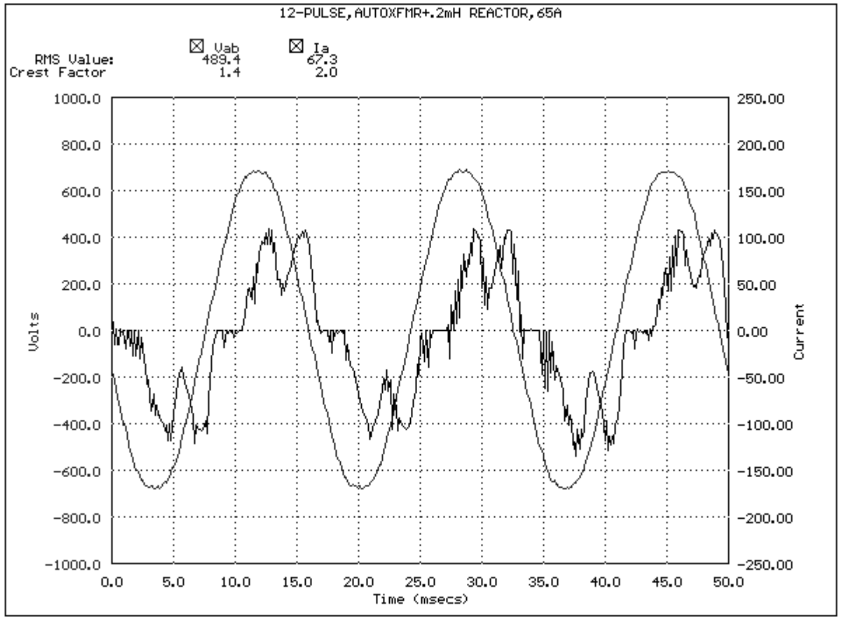
"Stiff" Distribution feeder (High Fault Current)

Without Impedance



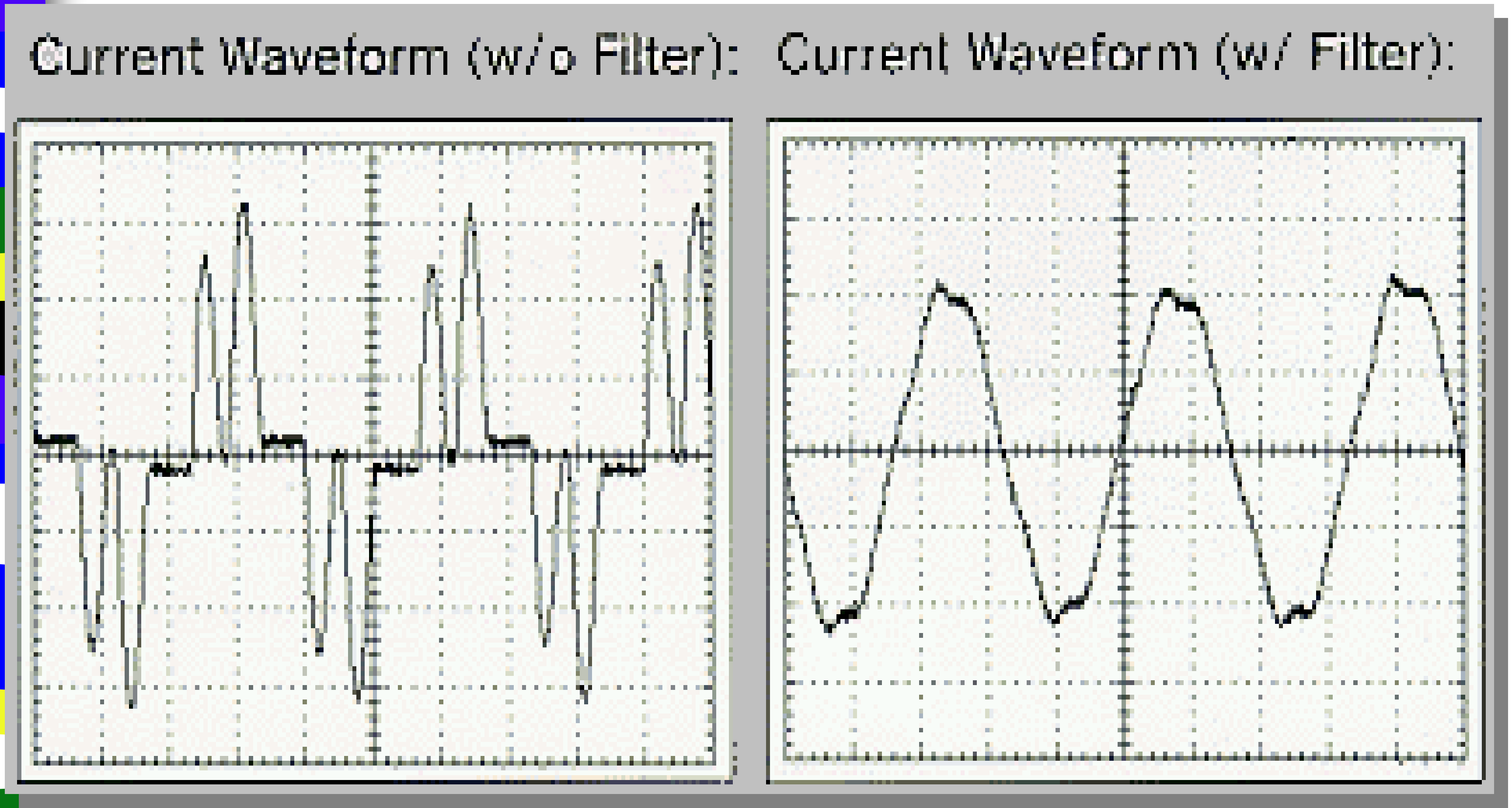
"Soft" Distribution feeder (Low Fault Current)

With Impedance

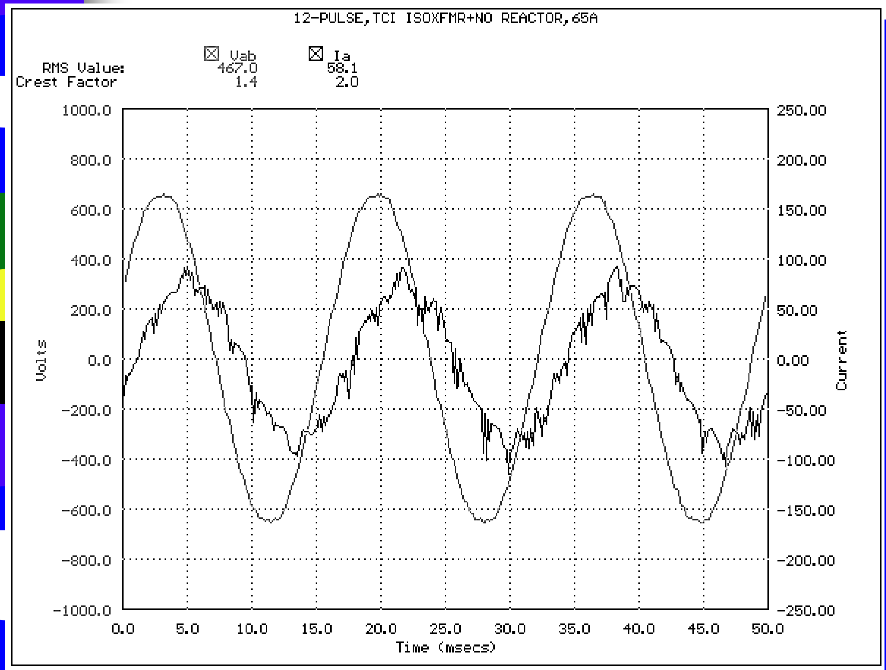


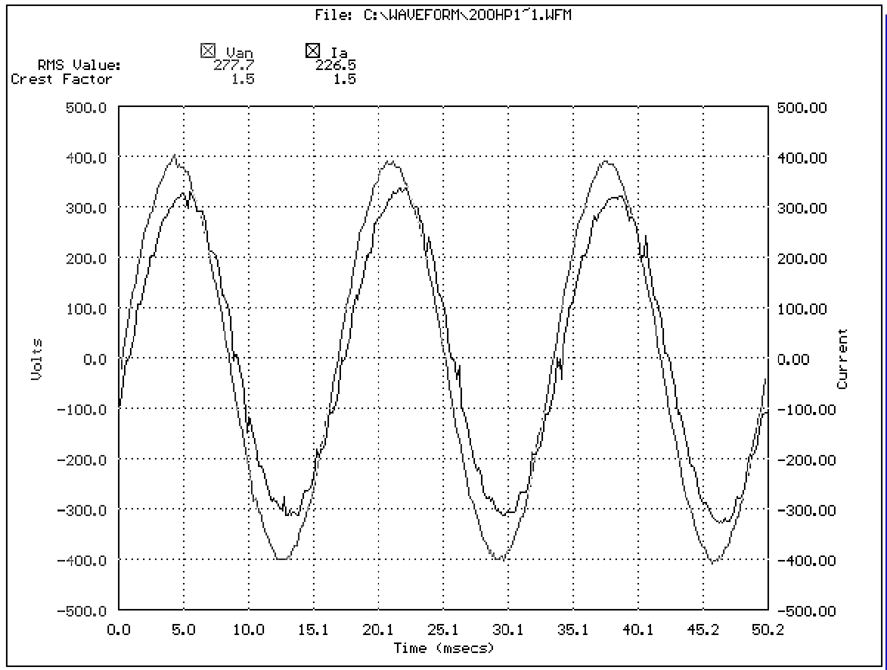
Passive Filter (con't)

Source: *MTE, Corp.*



Multi-Pulse/Active Filter Waveform Comparisons





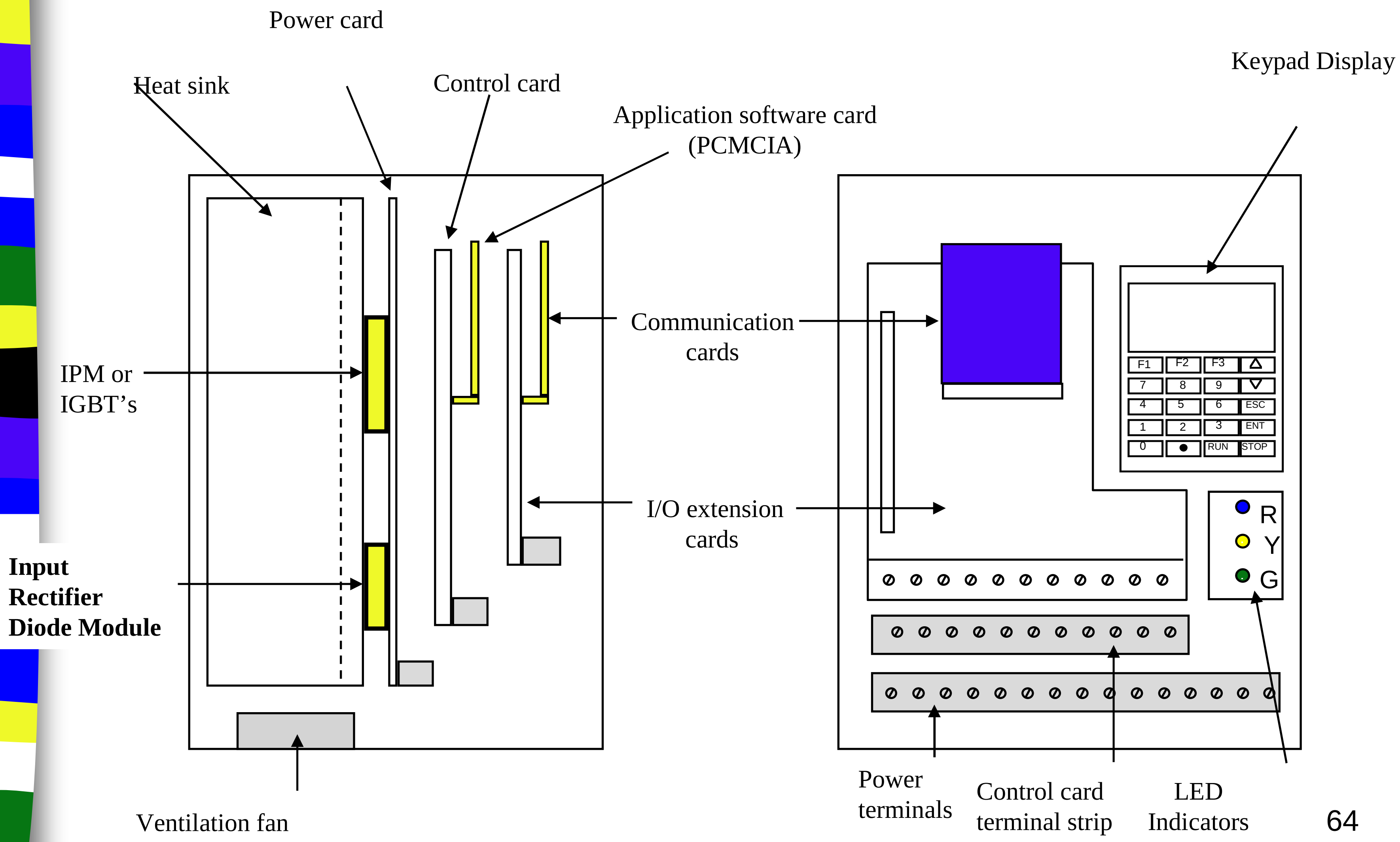
12-Pulse with separate 3-winding Isolation Transformer
12-Pulse with Auto-transformer same as input reactor

18-Pulse with integral mounted Fork Transformer or Active Filter

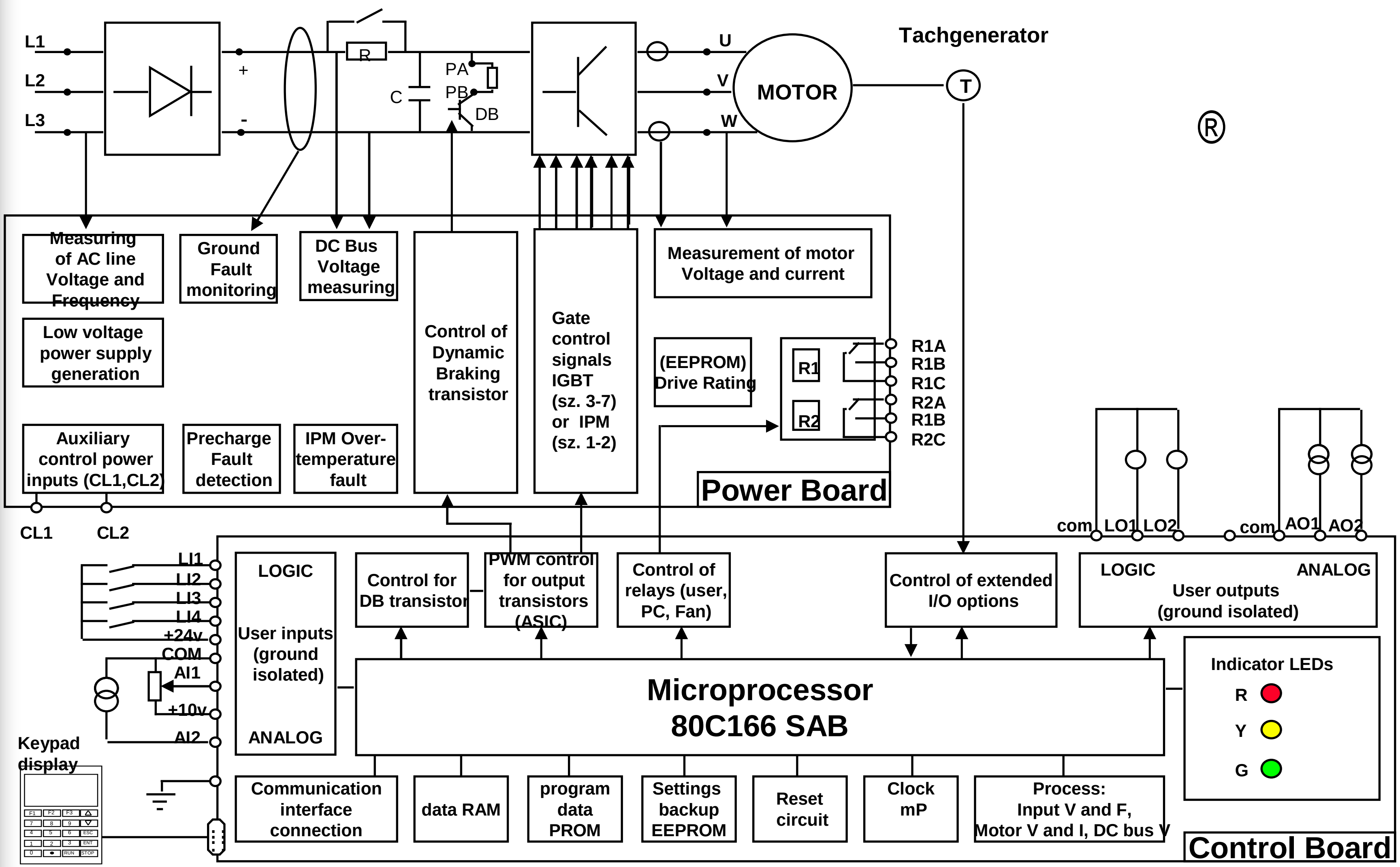
AC Drive Troubleshooting Techniques

Thank You for YOUR Time!

Typical Technology : layout of elements

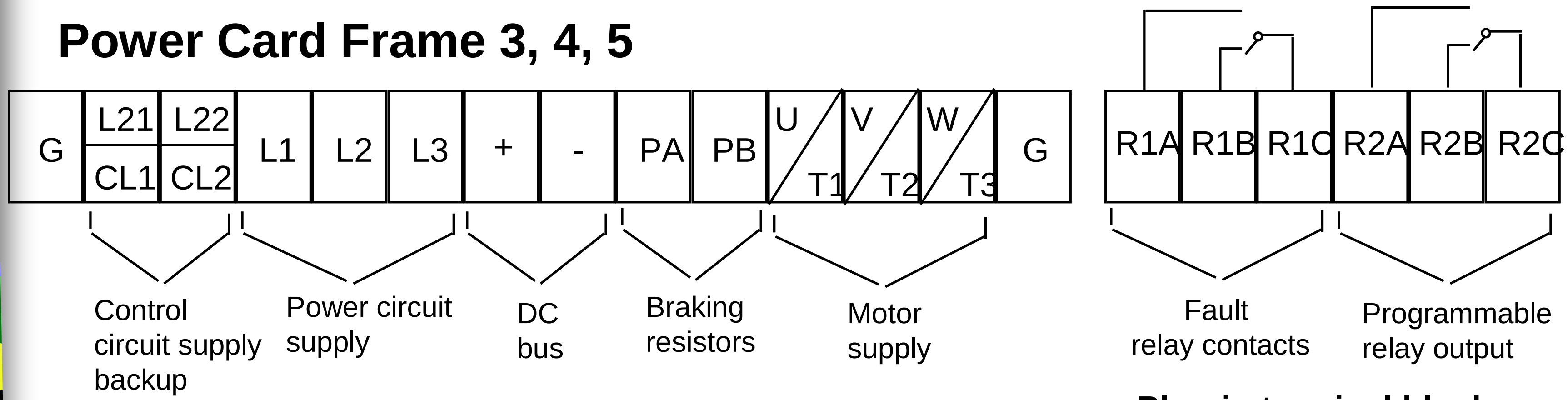


Typical Block Diagram of an AC Drive



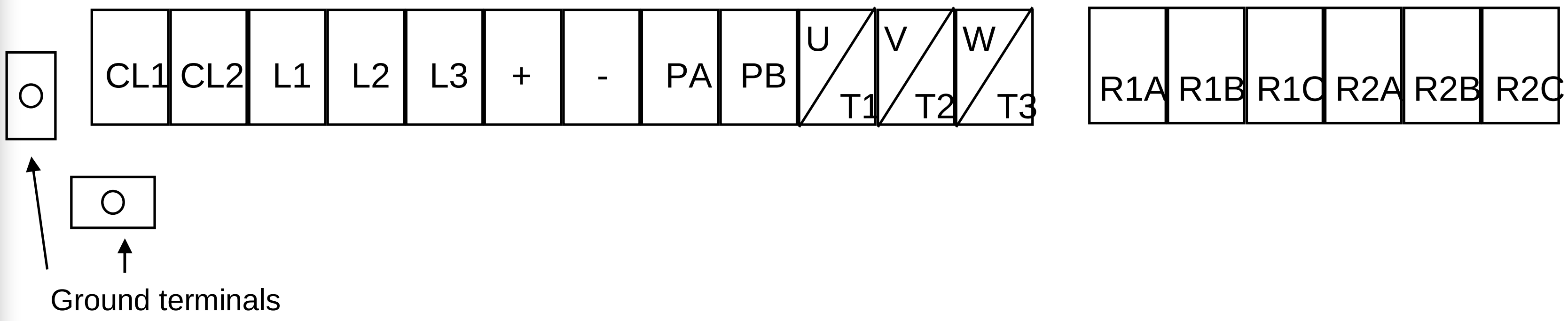
Power terminal blocks

Power Card Frame 3, 4, 5



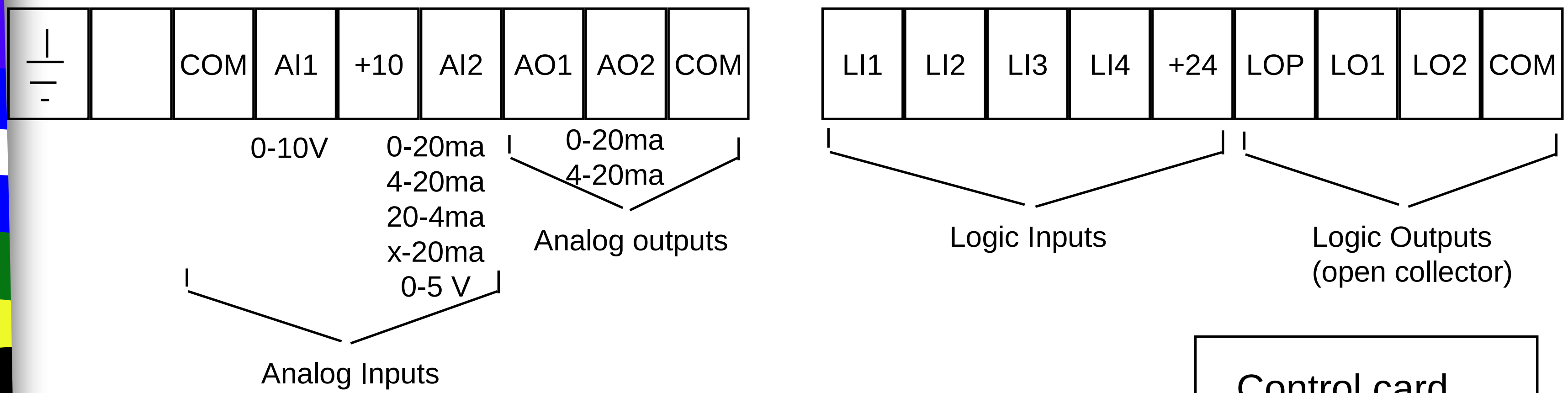
Plug-in terminal blocks

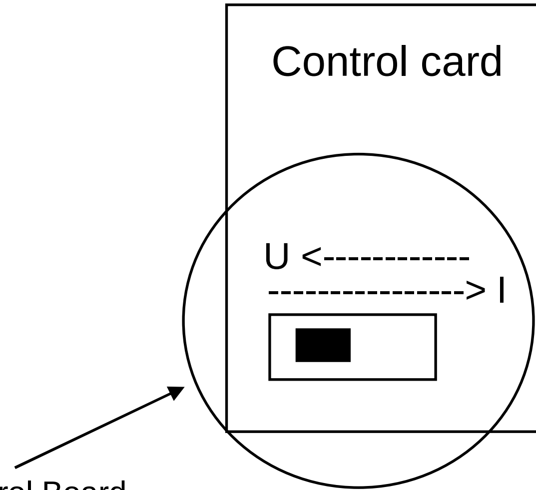
Power Card Frame 1 and 2



Control terminal blocks

Control card





* AI2 can be operated at 0 - 5 V by using the slide switch on the Main Control Board.

Things to look for in an installation that may cause AC drive nuisance tripping and/or failures

AC Drive Installation and Wiring

- All wiring to and from the drive should be in metallic conduit
- Each drive's output power wiring must be run in it's *own* metallic conduit
- Do not run Drive input and output power wiring in the same conduit

AC Drive Installation and Wiring

- Cross wiring of different classes at right angles to each other to eliminate capacitive effects and coupling of electrical noise between circuits.
- In-line filtering of conducted emissions (EMI) may be required in some installations.
- RFI - AC Drive not in metallic enclosure

AC Drive Installation and Wiring

Power System Branch Circuit Connections

- Size feeder cables, disconnects, and protective devices per *drive input* current, *not* motor FLA

Example:

20 HP Drive input current = 44.8 amps on 65K amps fault current feeder.

20HP Motor FLA = 27 amps

with an input reactor or higher input impedance (lower fault currents), input amps will be 27 amps.

The feeder and disconnect means should then be sized per NEC Art. 430-2 using the Drive Input Current Rating

As impedance of system increases, input current decreases.

AC Drive Installation and Wiring

Control Wiring Precautions

- Any relay coils or solenoids connected to the output of the Drive should be supplied with <u>transient suppressers</u>
- Analog inputs and outputs required twisted pair or shielded cable. Terminate shield at Drive terminal marked “S” (ground potential).
- Input sequencing contacts or signal switching contacts, must be rated for proper voltage and amps. (High and low).

AC Drive Installation and Wiring

Output Wiring Precautions

- *Do not* connect lightning arrestors or Power Factor Correction capacitors on the output of the drive
- Output cable lengths greater than 100 Ft. may require a load (output) reactor
- Do not use mineral impregnated cable on the drive output as it has a very high self-capacitance

AC Drive Installation and Wiring

Grounding

- **Use one grounding conductor per device**
- **Do not loop ground conductors or install them in series**

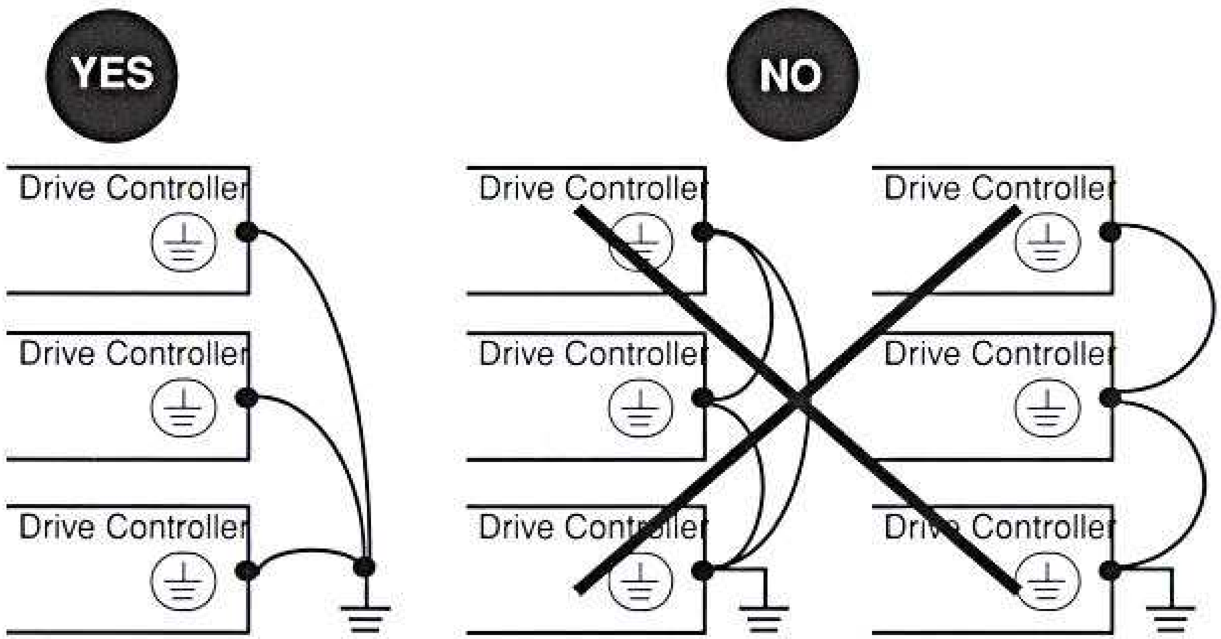
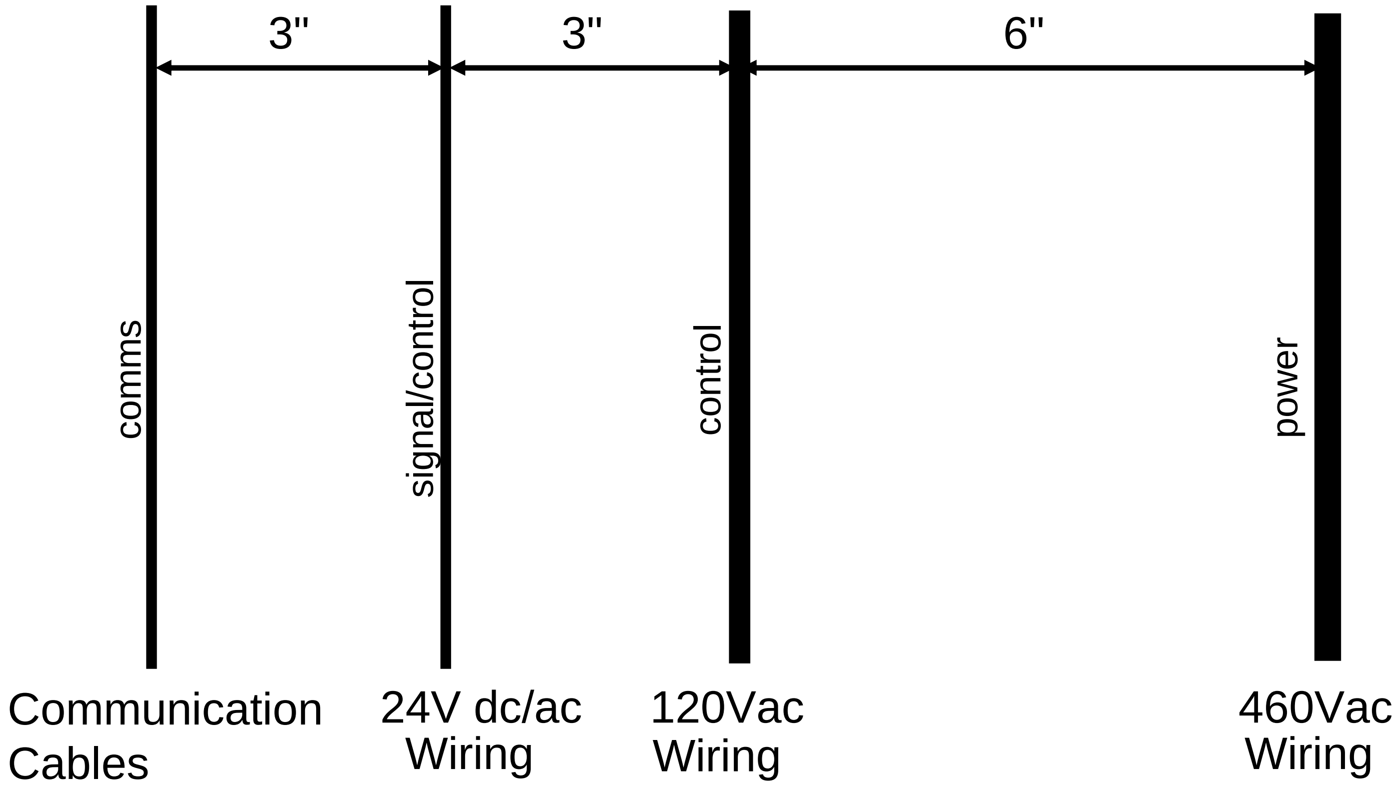


Figure 12: Grounding Multiple Drive Controllers

Verify resistance from the drive ground terminal to the power system ground point is less than one ohm

Separation of VFD Wiring in Cable Trays:

* Separate conduit runs if not using cable tray.



Wiring Practice Overview:

Remember the “DO’s and DON'Ts” in wiring Drives:

- **<u>DO’s</u>:**
  - **Understand the different wiring classifications i.e. power, control, signal level, and communications**
  - **Separate control wiring from power wiring.**
  - **Separate low level analog signals from control and power wiring.**
  - **Use shielded cable for all analog signals.**
  - **Cross wire runs of different wiring classes at right angles.**
  - **Run a ground wire from the origin of the power source to *<u>each</u>* drive**
- **<u>DON'Ts</u>:**
  - **Do not run multiple output power cables from multiple VFD’s in the same conduit.**
  - **Do not ground the shield of analog signal shielded cable at both ends.**

AC Drive Preventative Maintenance

- Check the condition and tightness of connections.

- Make sure ventilation is effective and that the temperature around the drive is at an acceptable level.

- Remove dust and debris if necessary.

Basic Troubleshooting

Troubleshooting Process

1. Gather Information
2. Locate System Equipment
3. Analyze System Faults
4. Determine Malfunctioning Sub-system
5. Perform Sub-system Diagnostics
6. Repair or Replace Sub-assembly
7. Verify System Operation

Safety Considerations

- **Read and heed the Danger, Warning, and Caution labels in the Drive User's manuals**
- **Insure that the equipment is properly grounded**
- **Use only "known-good" test instruments and probes; no frayed or broken test leads**
- **Wear protective eyewear, thick rubber soled shoes, and no jewelry**
- **Beware of ground "floated" test equipment**
- **<u>Remember: a small drive is equally as dangerous as a bigger one</u>**

Fault Indicators Messages

Check in your manual for these fault codes and/or corrective actions.

LIST OF FAULTS AND CORRECTIVE ACTION

Faults cannot be reset until the cause is removed. Faults OHF, OLF, OSF, ObF, and PHF can be reset via a logic input (rSF) if configured for this function. Faults OHF, OLF, OSF, ObF, and PHF can be reset via automatic restart (Atr) if configured for this function and if the drive controller is configured for 2-wire control. Fault USF resets as soon as the fault is removed; neither a logic input nor automatic restart is required for the reset. All faults can be reset by cycling the power.

Table 22: List of Faults

Fault	Probable cause	Corrective Action
- CFF configuration fault		- Restore the factory settings or the backup configuration, if it is valid. See parameter FCS in the FUn menu (see page 57).
- CrF precharge circuit	- precharge circuit damaged	- Reset the drive controller. - Replace the drive controller.
- InF internal fault	- internal fault - internal connection fault	- Remove sources of electromagnetic interference. - Replace the drive controller.
- ObF overvoltage during deceleration	- braking too rapidly or overhauling load	- Increase the deceleration time. - Install a braking resistor if necessary. - Activate the brA function if it is compatible with the application.
- OCF overcurrent	- acceleration too rapid - drive controller and/or motor undersized for load - mechanical blockage	- Increase acceleration time. -Ensure that the size of the motor and drive controller is sufficient for the load. - Clear mechanical blockage.
- OHF drive controller overload	- continuous motor current load too high - ambient temperature too high	- Check the motor load, the drive controller ventilation, and the environment. Wait for the controller to cool before restarting. - Increase ACC for high inertia loads.
- OLF motor overload	- thermal trip due to prolonged motor overload - motor power rating too low for the application	- Check the setting of the motor thermal protection (ItH). See page 41. Check the motor load. Wait for the motor to cool before restarting.
- OSF overvoltage during steady state operation or during acceleration	- line voltage too high - induced voltage on output wiring	- Check the line voltage. Compare with the drive controller nameplate ratings. - Reset the drive controller. - Verify that the wiring is correct (see pages 23–29).
- PHF input phase failure	- input phase loss, blown fuse - input phase imbalance - transient phase fault - 3-phase controller used on a single phase line supply - unbalanced load	- Verify that the input power is correct. - Check the line fuses. - Verify input power connections. - Supply 3-phase power if needed. - Disable IPL (set to nO).

Table 22: List of Faults *(continued)*

Fault	Probable cause	Corrective Action
- SCF motor short circuit	- short-circuit or grounding at the drive controller output	- Check the cables connecting the drive controller to the motor, and check the insulation of the motor.
- SOF overspeed	- instability - overhauling load	- Check the motor, gain, and stability parameters. - Add a braking module and resistor and verify the drive controller, motor, and load.
- USF undervoltage	- input voltage too low - transient voltage dip - damaged precharge resistor	- Check that the line voltage matches the nameplate rating. - Check the setting of parameter UnS. - Replace the drive controller.

Drive Controller Does Not Start, No Fault Displayed

On power-up, a manual fault reset, or after a stop command, the motor can be powered only after the forward and reverse commands are reset (unless tCt = LEL or PFO). If they have not been reset, the drive controller displays "rdY" or NST, but does not start. If the automatic restart function is configured (parameter Atr in the drC menu) and the drive controller is in 2-wire control, these commands are taken into account without a reset.

Common Fault Causes

<u>The AC Drives is where most people point to, however:</u>

- Poor connections or open/broken conductors
- Unintended grounds or ground paths in power and control wiring
- Electrical noise
- Power system disturbances and interruptions
- General incorrect wiring during installation and retrofits
- Motor failure, or other mechanical system problems

Fault Log - Drive Information

- Record Drive Model number including any options
- Find Voltage and Current ratings
- Note software revision level
- Get manufacturing Date Code (6W.... or 86....)
- Record controller, motor, and auxiliary equipment nameplate data
- Record the Faults, including past faults in the fault history.

TROUBLESHOOTING TIPS

Fault Log - Operating Information

- Is the complaint “the drive doesn’t work as expected” or, “the drive trips”?
- What was the machine doing when the drive tripped?
- Had it been working properly?
- Were there any unusual conditions?
  - » Excessive heat, cold, moisture, lightning storms, power surges/glitches, etc.?
- Had the problem occurred before?
- Has the application changed?

Fault Log - Environmental Checks

- Look around and get a feel for the operating environment
  - » Temperature, moisture/condensation, dust, corrosive chemicals, etc.
- Observe the unit for physical deterioration: rust, melted parts, burn marks, etc.
- Check for proper installation of unit
- Check fans for operation; listen for any strange sounds during operation
- Verify drive settings are correct for the application

TROUBLESHOOTING TIPS

CALL TECHNICAL SUPPORT AFTER YOU HAVE DONE ALL OF THE INFORMATION GATHERING!

Electrical Checks

Thank You for YOUR Time!

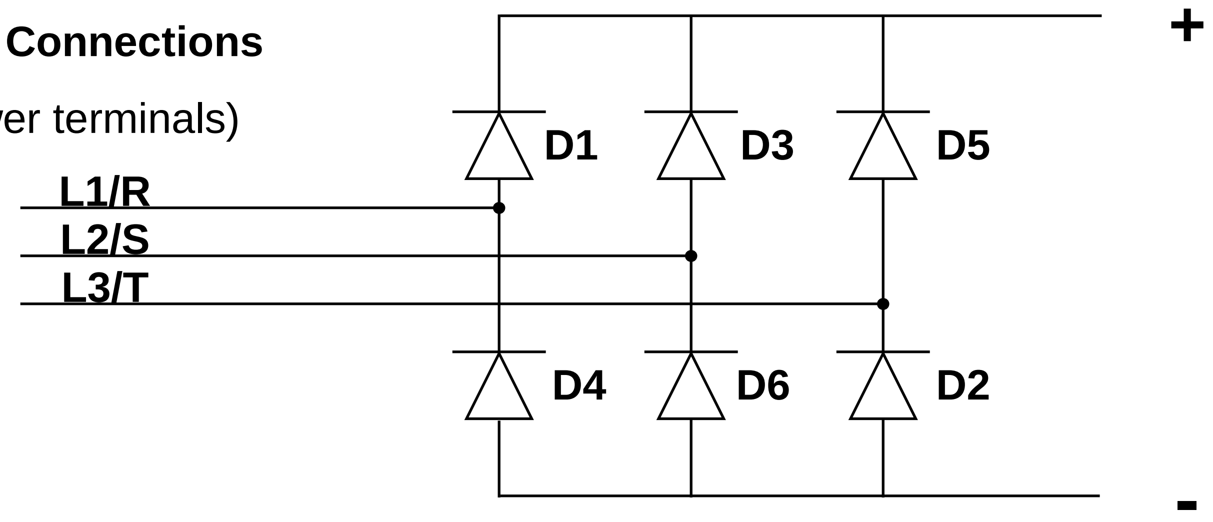
No Power Checkout

- *Test the power circuits/components with No Power applied using a multi-meter set to measure resistance or a P-N junction (diode symbol)*
- *We'll see how to check the:*
  - » Input rectifier diodes
  - » DC bus
  - » Pre-charge resistor and DB transistor
  - » Inverter transistors and "free-wheel" diodes
  - » Snubber circuits

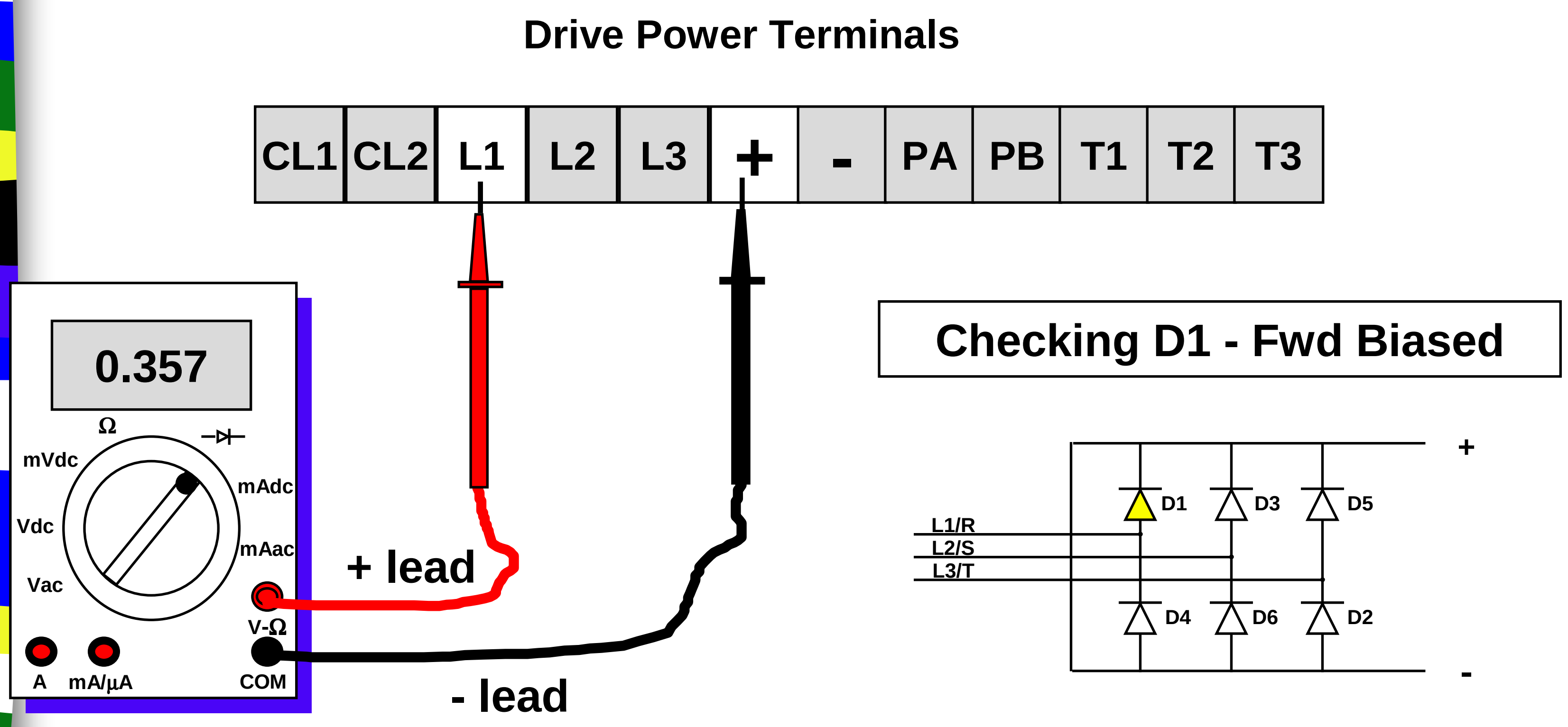
Drive Input (Converter) Section Schematic

Drive Connections

(power terminals)

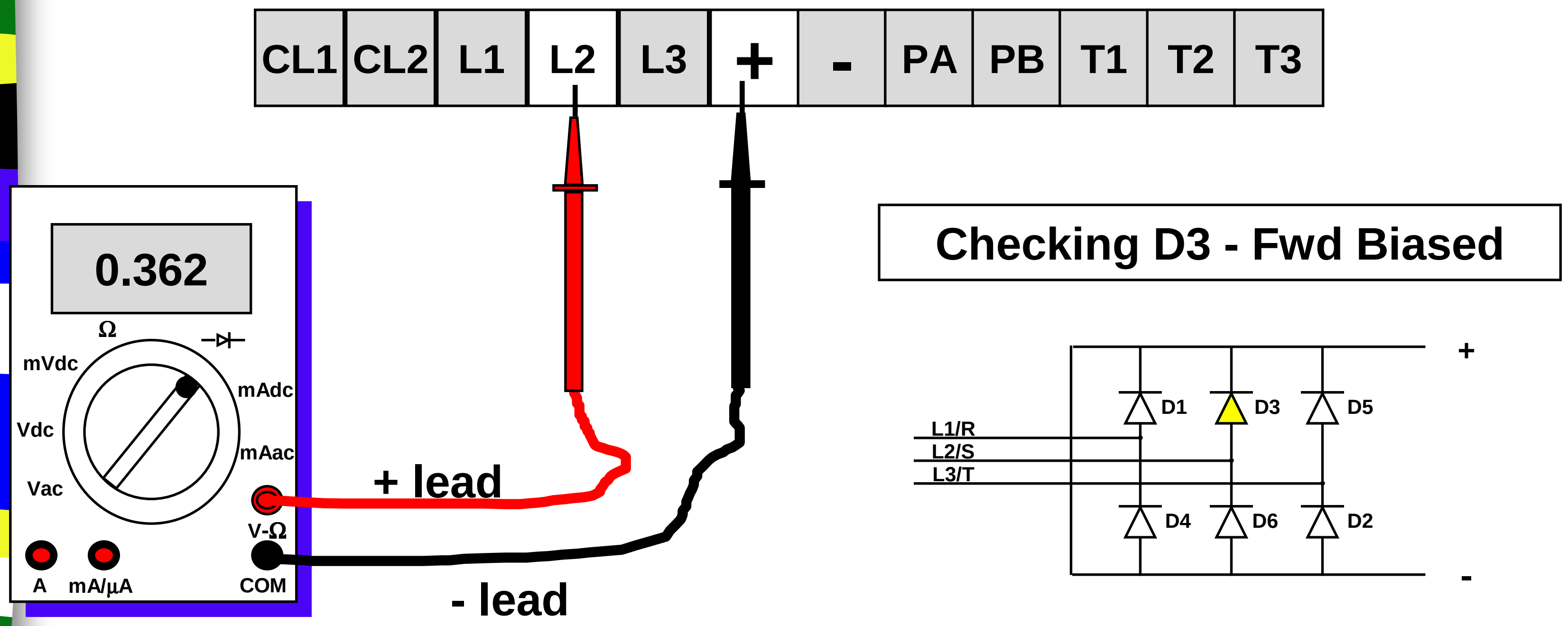


HOW TO CHECK THE CONVERTER DIODES



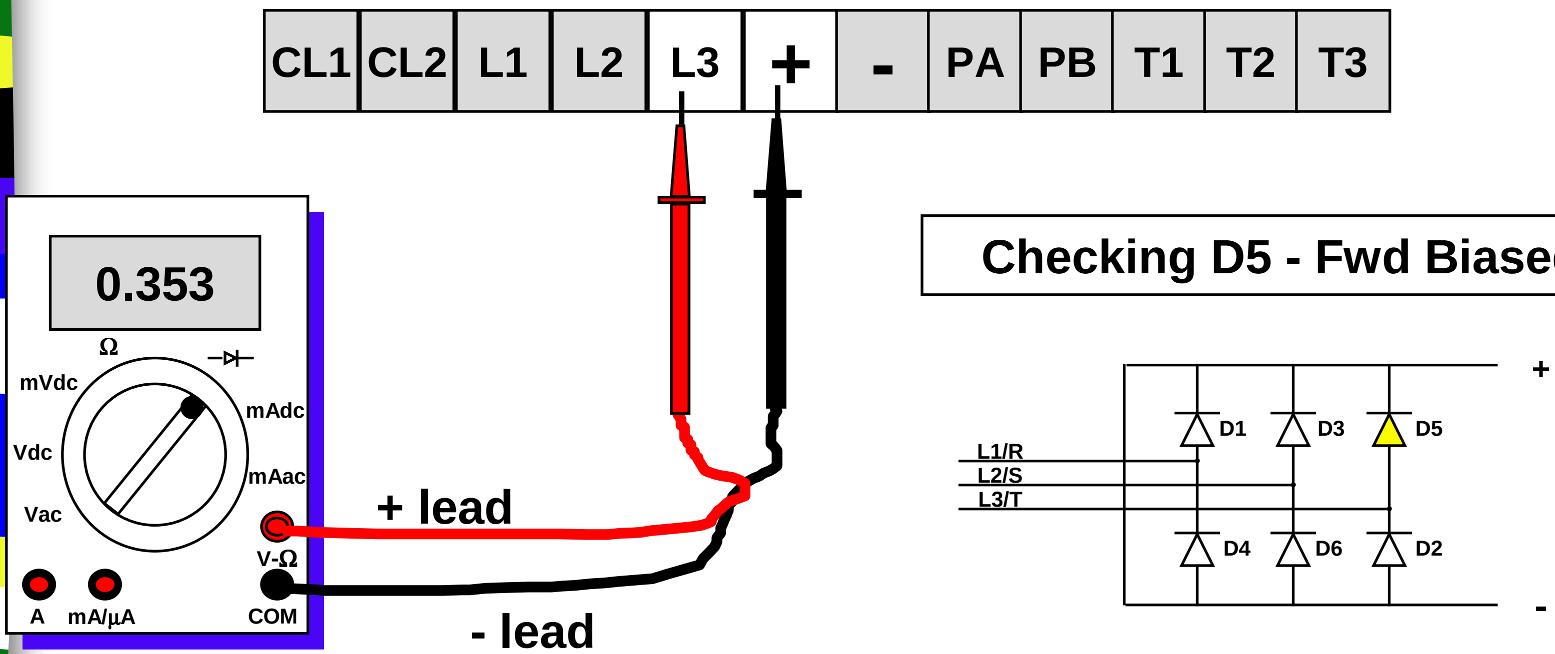
HOW TO CHECK THE CONVERTER DIODES

Drive Power Terminals



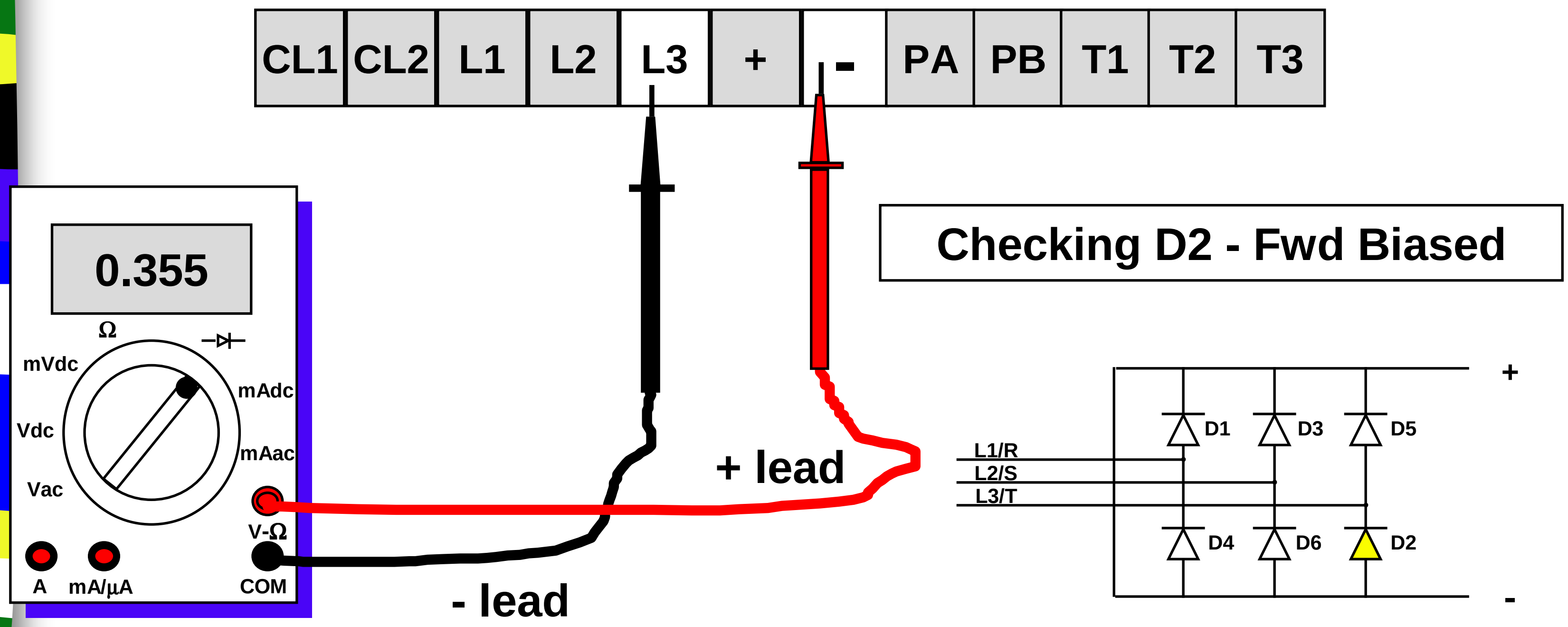
HOW TO CHECK THE CONVERTER DIODES

Drive Power Terminals



HOW TO CHECK THE CONVERTER DIODES

Drive Power Terminals



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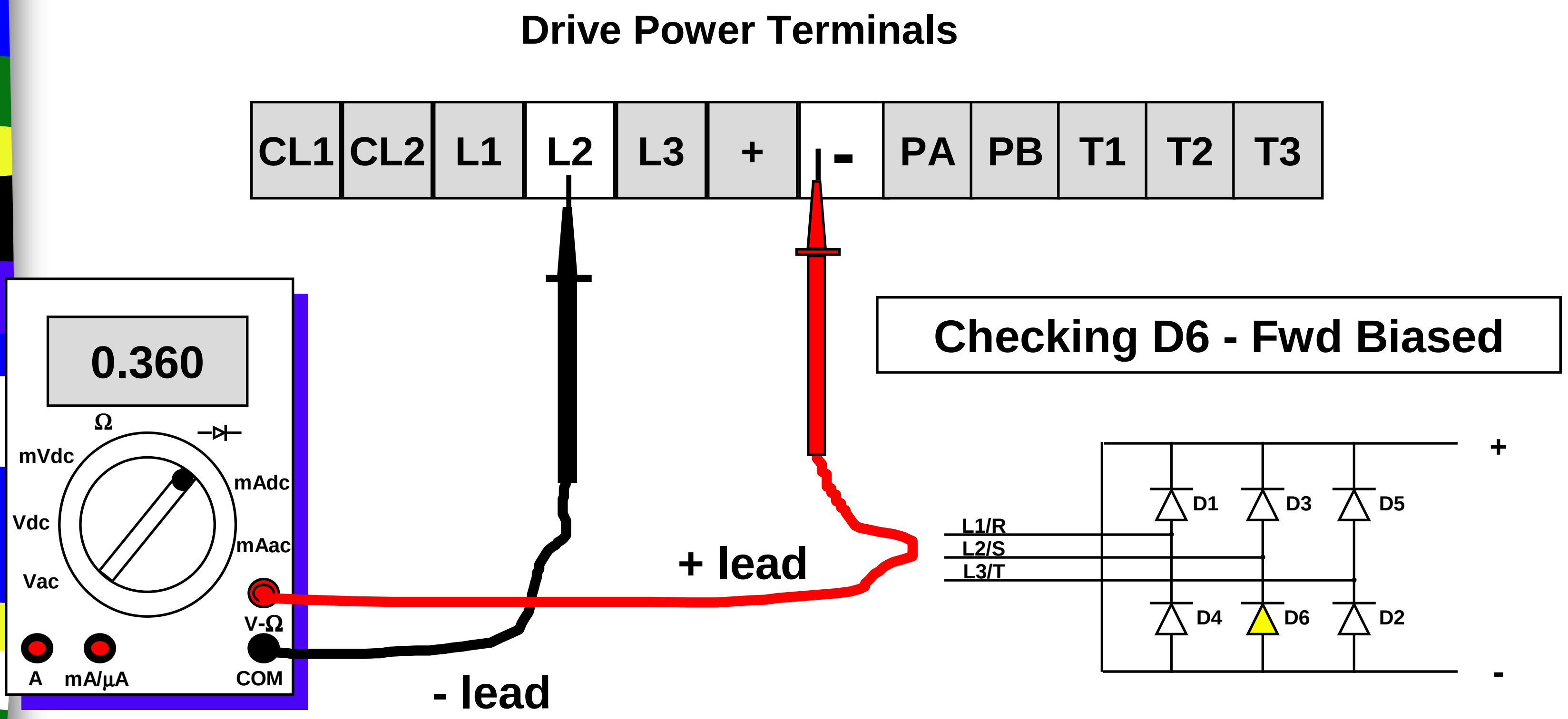

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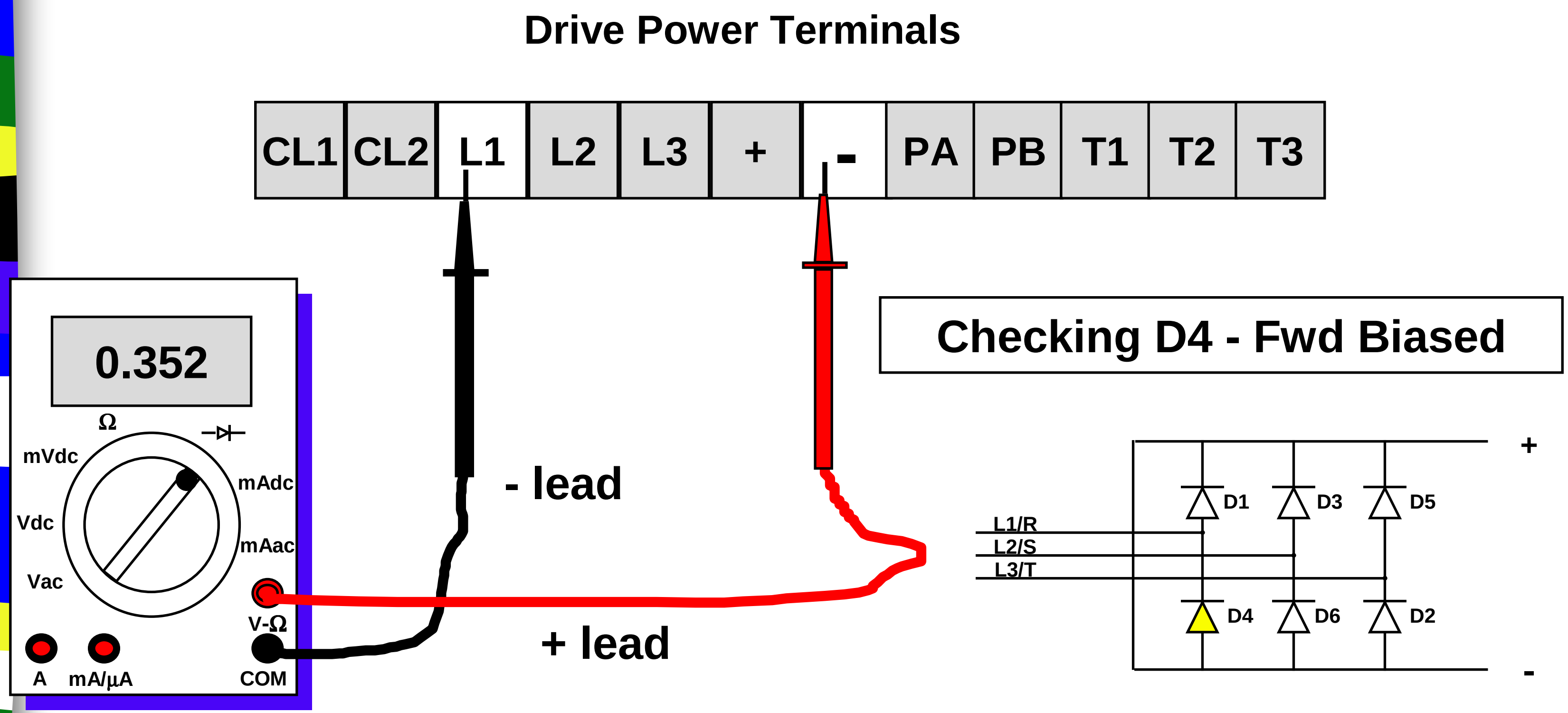
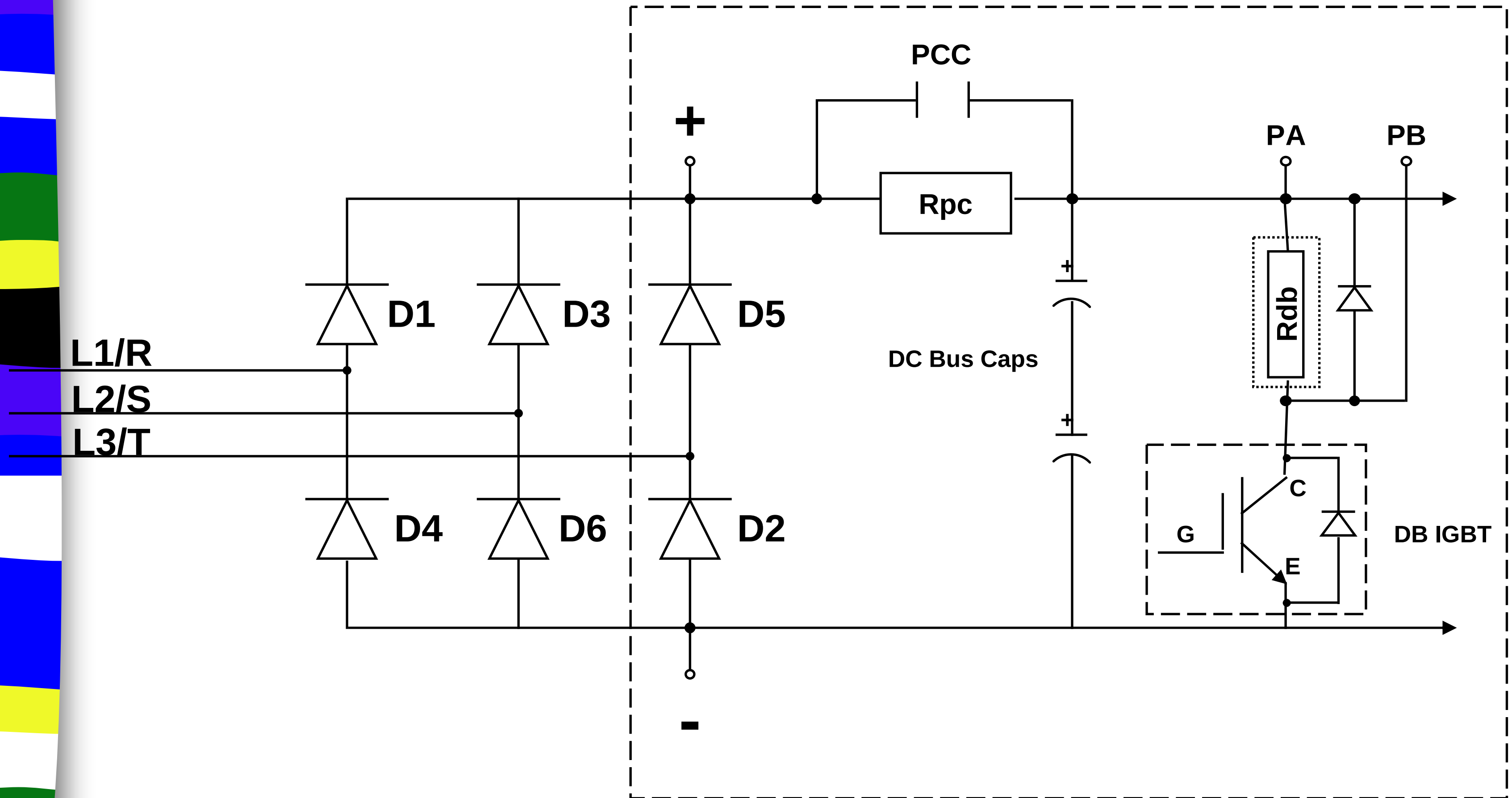
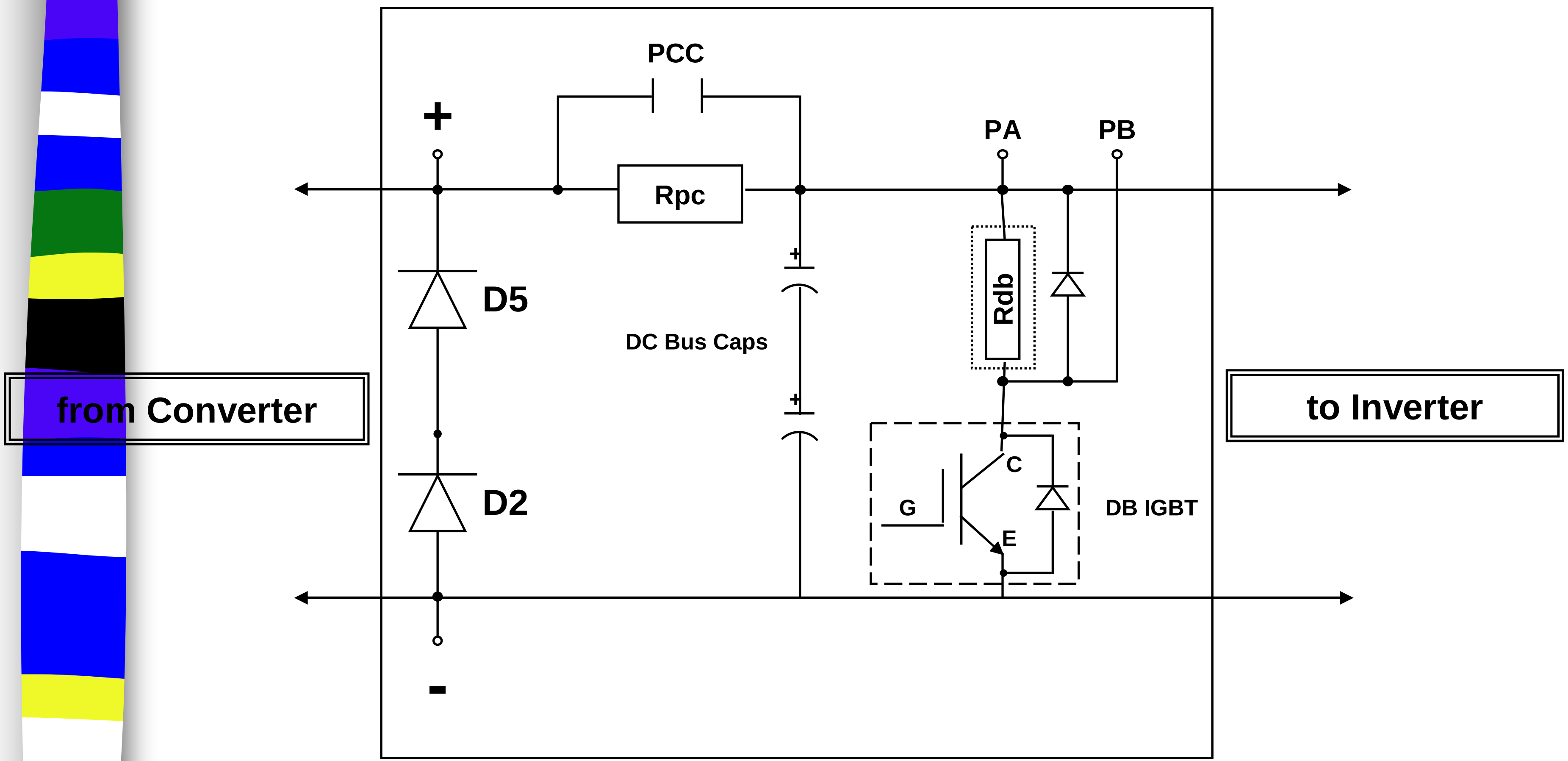


Drive DC Bus Section Schematic



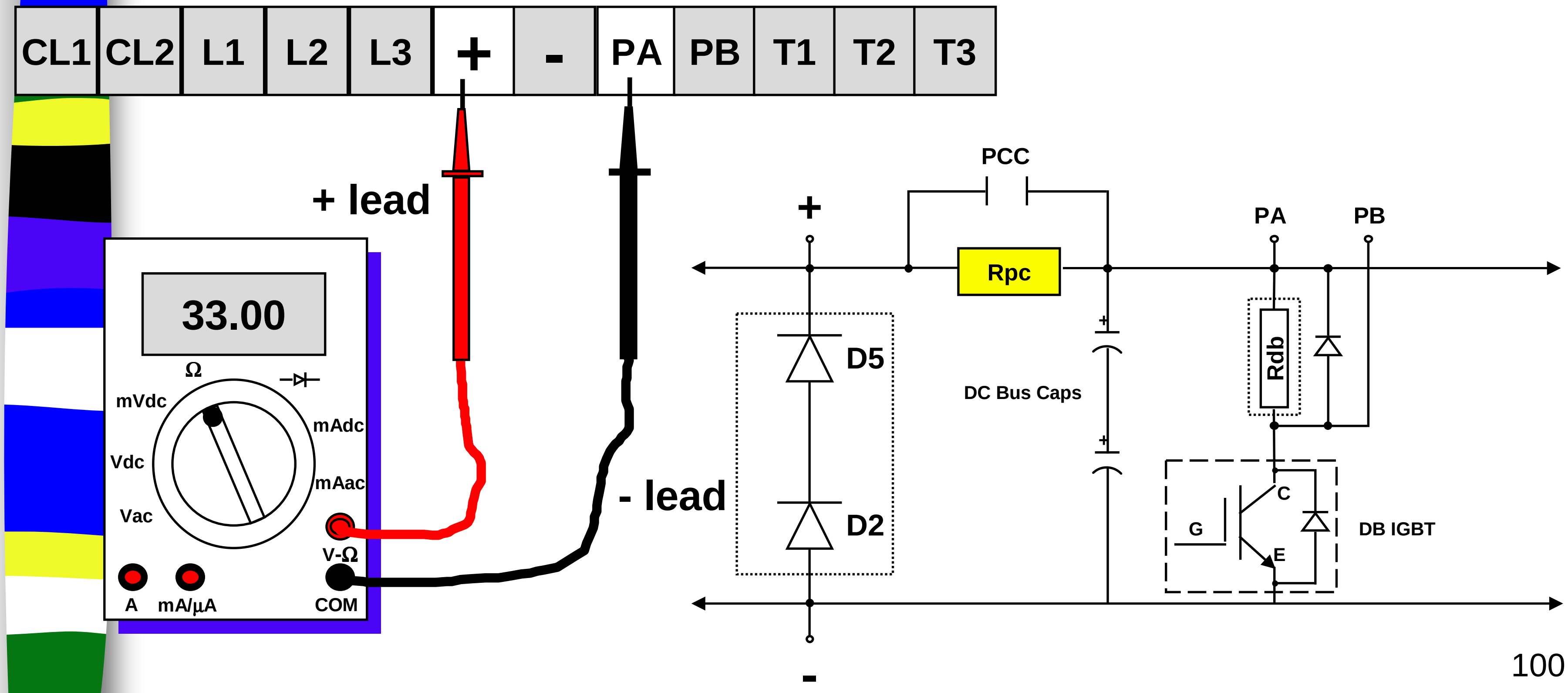
Drive DC Bus Section Schematic



∘ (open circle) indicates conection on power terminal strip

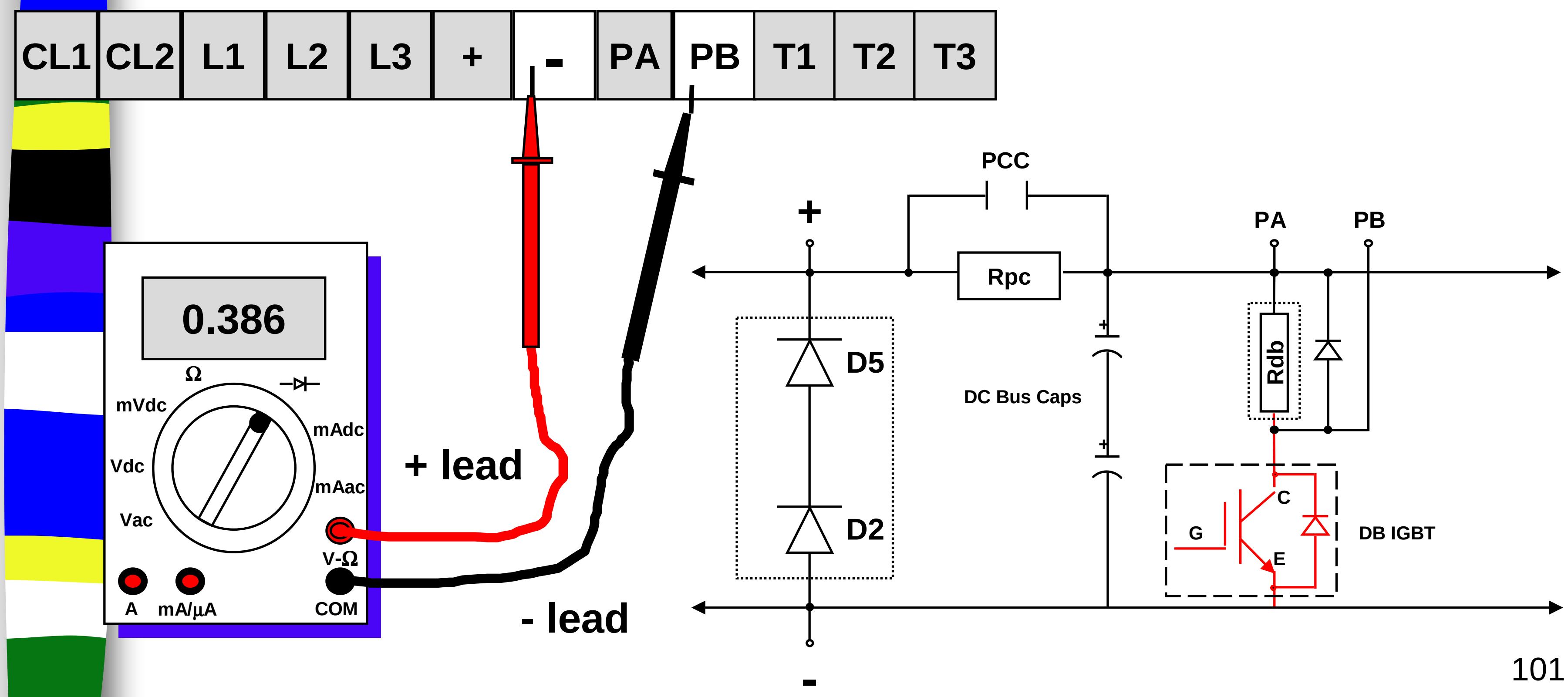
HOW TO CHECK THE PRE-CHARGE RESISTOR

Drive Power Terminals



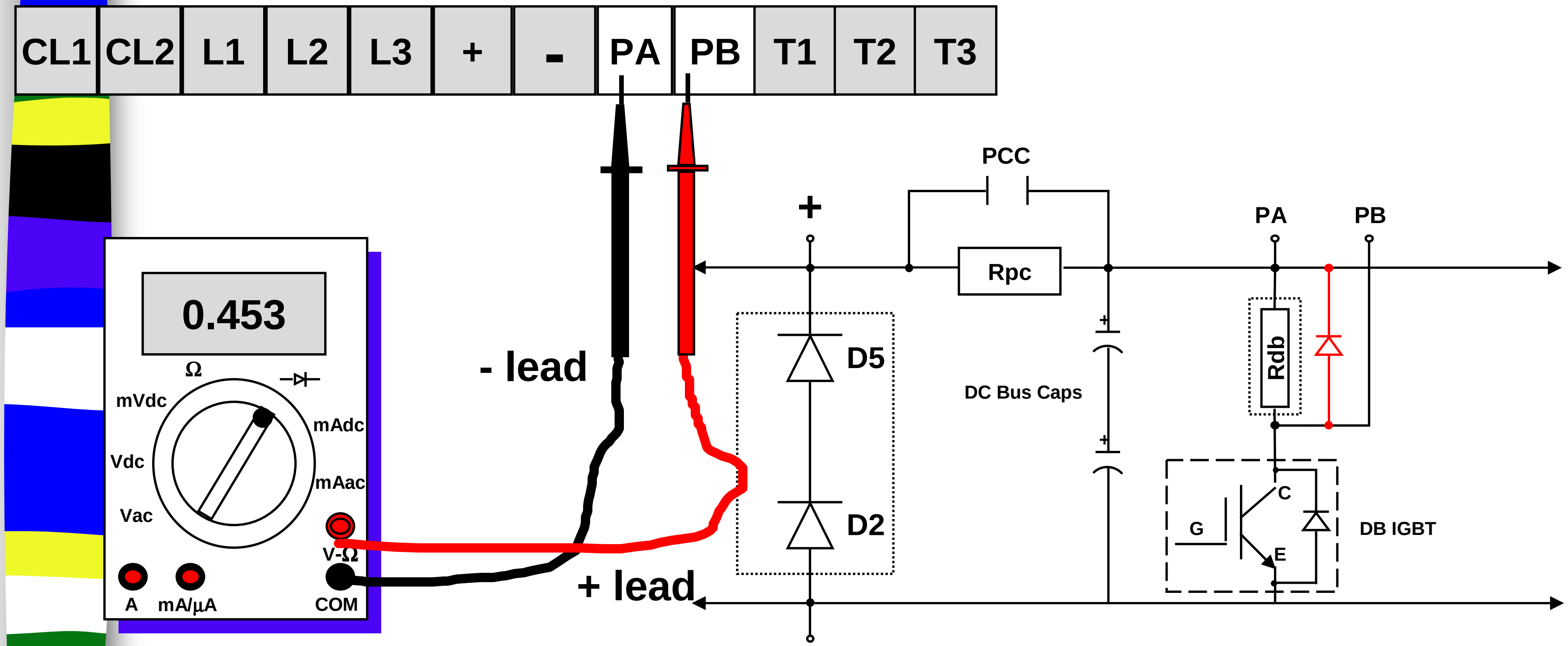
HOW TO CHECK THE DYNAMIC BRAKING TRANSISTOR

Drive Power Terminals

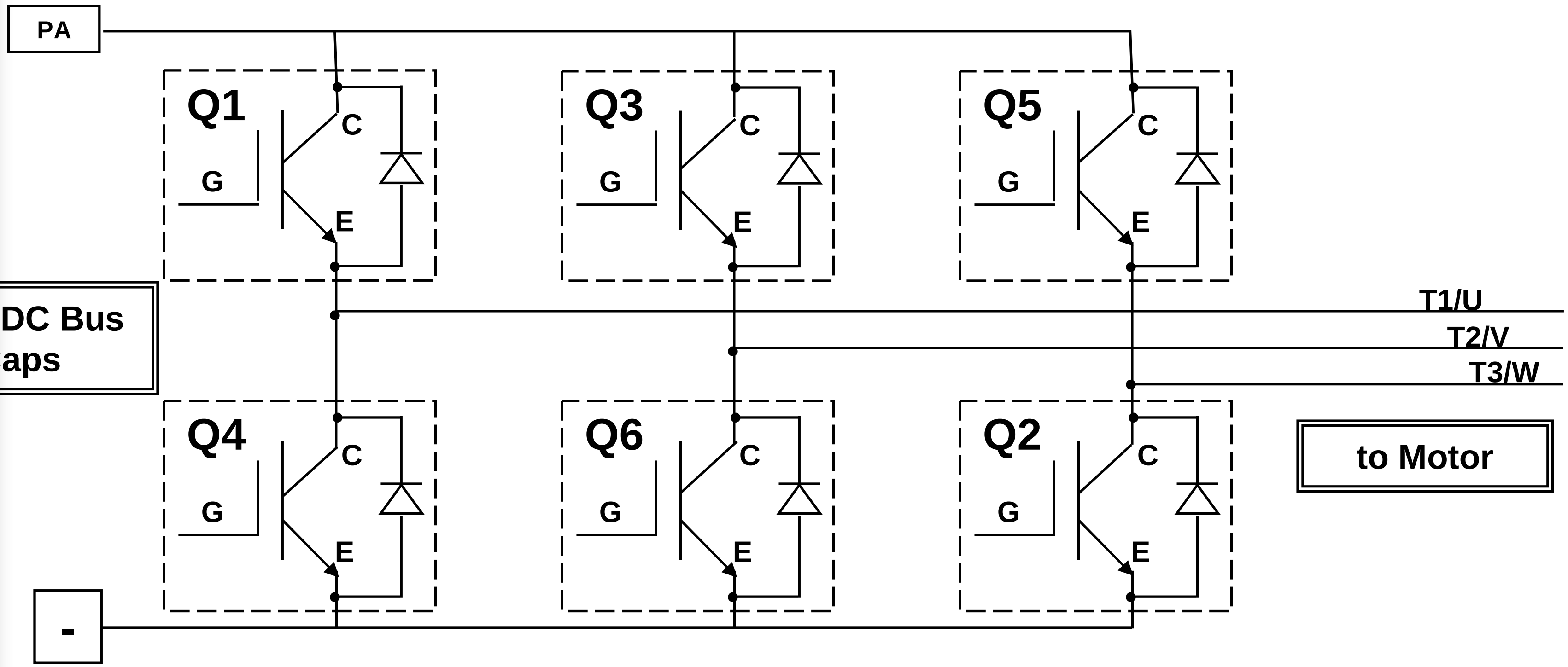


HOW TO CHECK THE DB RESISTOR FLYBACK DIODE

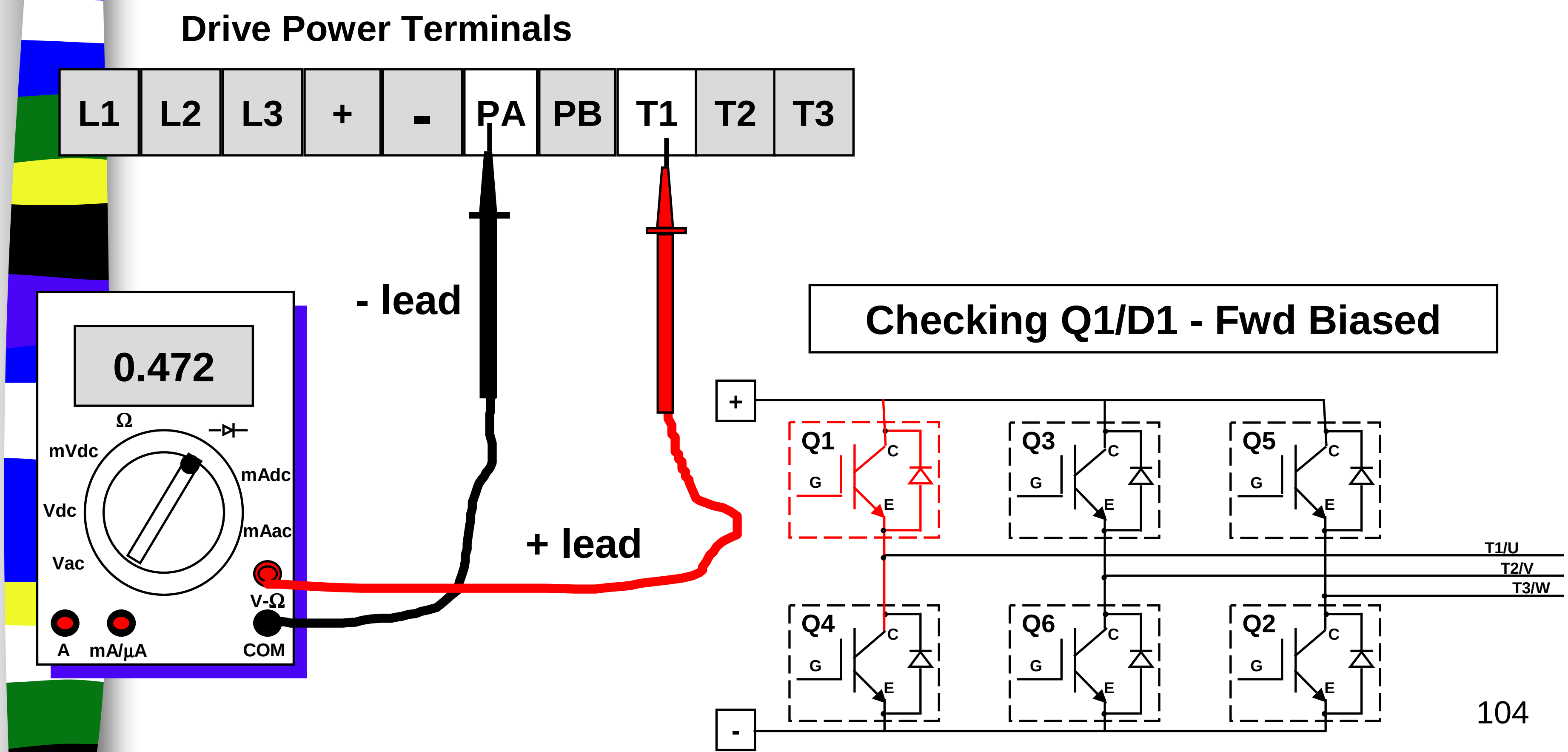
Drive Power Terminals



Drive Output (Inverter) Section Schematic

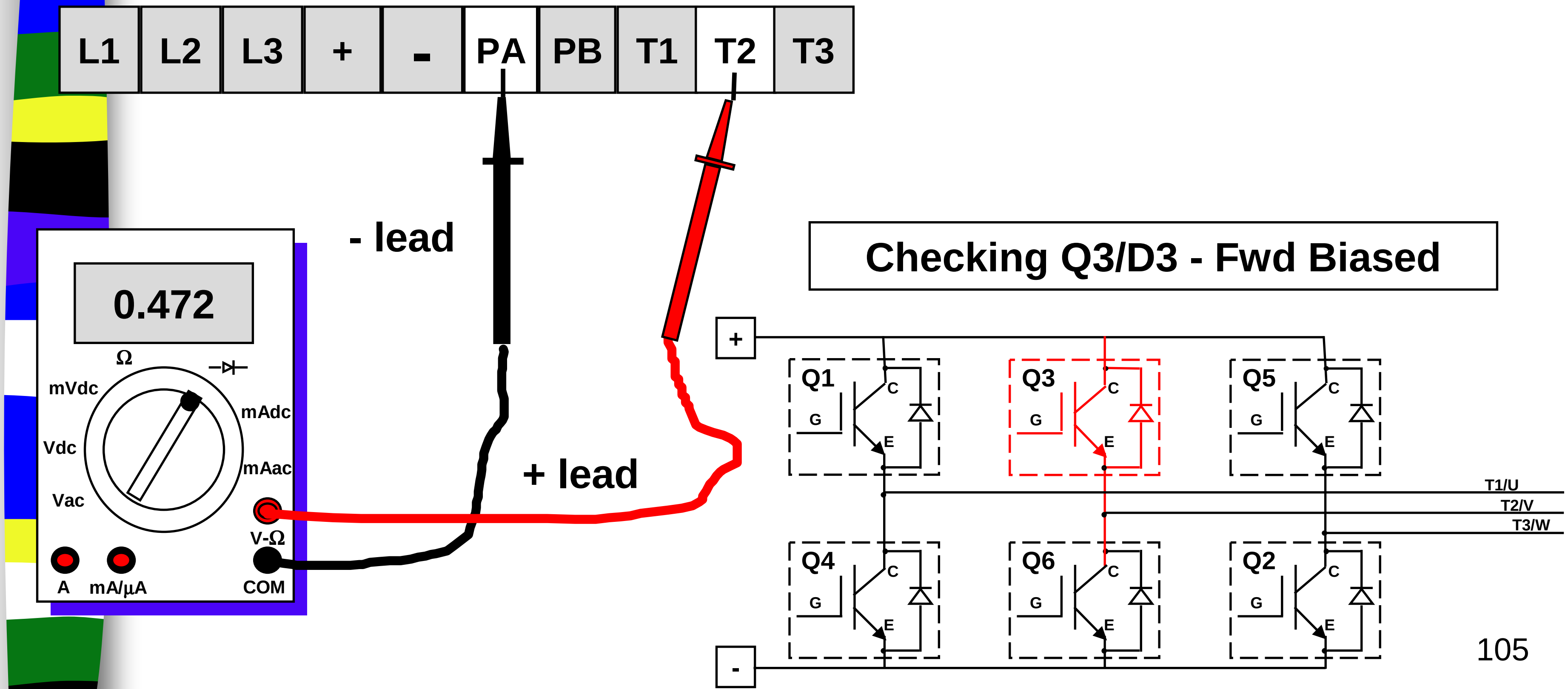


HOW TO CHECK THE INVERTER TRANSISTORS (IGBT's) AND FLYBACK DIODES



HOW TO CHECK THE INVERTER TRANSISTORS (IGBT's) AND FLYBACK DIODES

Drive Power Terminals



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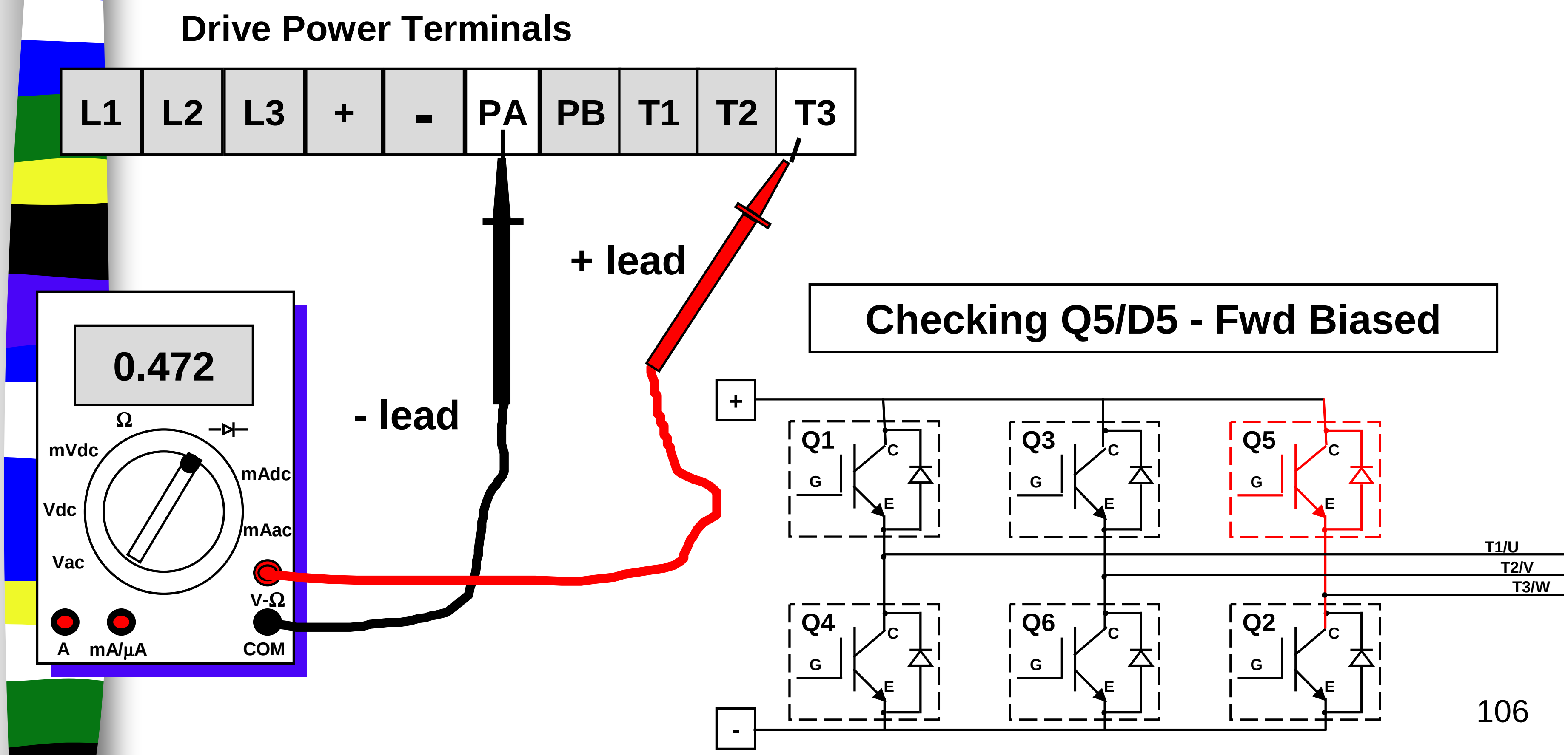

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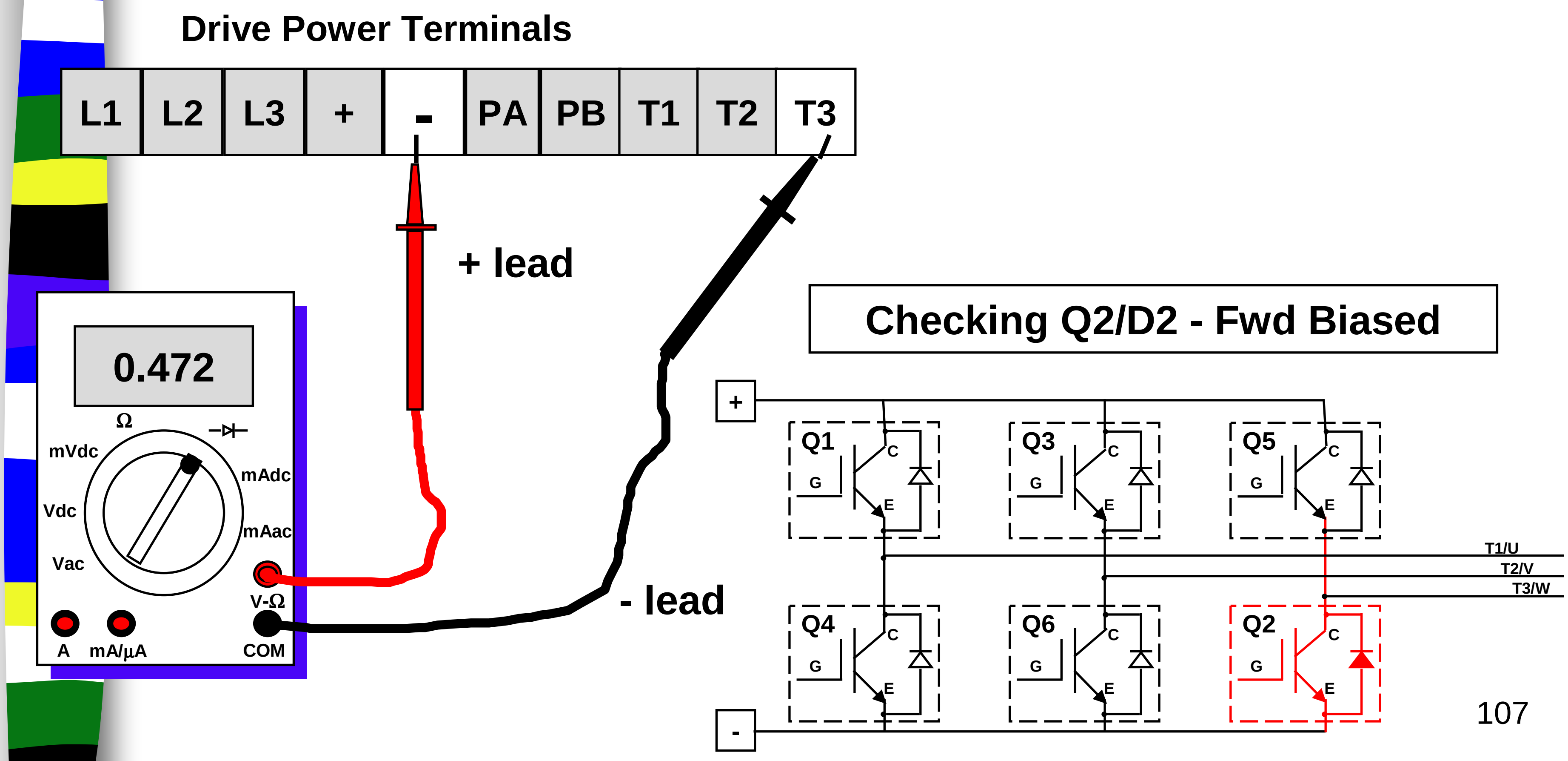

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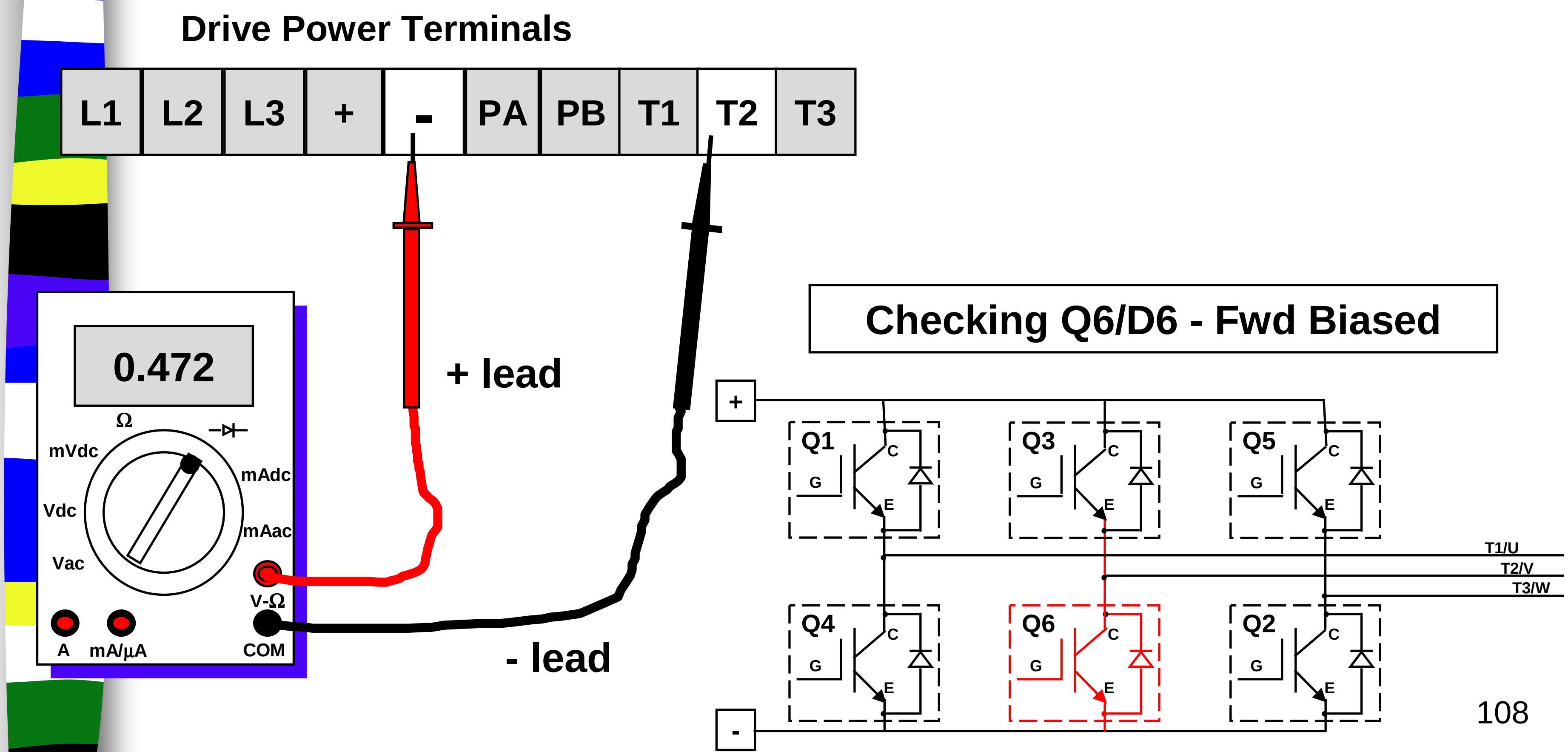
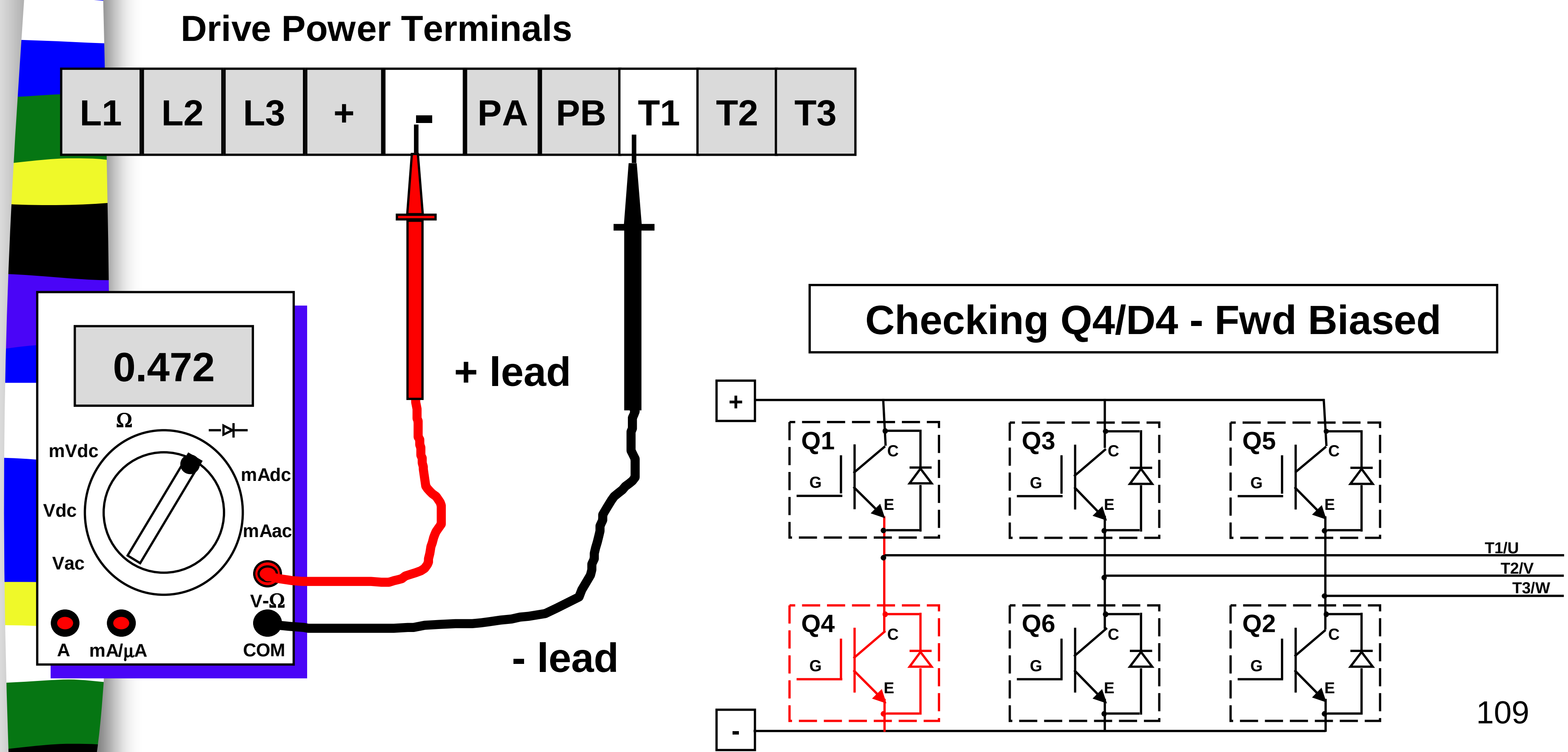


HOW TO CHECK THE INVERTER TRANSISTORS (IGBT's) AND FLYBACK DIODES



Drive Input Measurements

- AC Mains voltage
  - – Use true RMS meter for accurate readings
  - – Measure and verify voltage balance between L1&L2, L1&L3, L2&L3; less than 5% is good
  - – Verify amplitude is within range(460V +/-15%)
- AC Mains current
  - – Must use true RMS meter with current probe
  - – Check for balanced currents in each phase
  - – Imbalance indicates poor connection or bad input rectifier section

Full Power Checkout

DC Bus Measurement

- Any meter capable of measuring up to 1000Vdc should read accurately
- Verify that level is 1.4x AC RMS level of the input
- If input rectifier bridge is suspect, voltage ripple may be checked with an oscilloscope
- Check that voltage is below 50V before touching any components or performing ohmmeter testing

Full Power Checkout

Drive Output Measurements

- Voltage measurement
  - Accurate voltage measurements can only be had using an Harmonic signal analyzer or a bandwidth limited true RMS meter; an averaging meter gets close
  - Typical true RMS meter will tend to read high; balanced voltages are the key
- Current measurement
  - Any type meter and a current probe should give accurate output current reading; check balance of output currents with motor connected and running. Verify currents are < drive/motor rating.
  - beware of low frequency limitation of probe

Full Power Checkout

Control Circuit Measurement

- Includes: Power supplies, logic inputs/outputs, analog inputs/outputs, feedback measurements, logic states
- All control circuits should be able to be accurately measured with any type of multi-meter
- This is also where an oscilloscope can be used most effectively

SIGNALS NEEDED FOR DRIVE TO RUN

- Logic Input 1
  - This input must be closed (active high) to enable the drive. also known as the “run permissive” input. input makes the drive “ready” to run. Tie LI1 to + power supply (ATV11/+15VDC)
- Auto-start contact
  - This input gives the “start running” command to the drive. this input must also be closed (active high) to start the drive.
- Speed reference signal (ANALOG INPUT 1 and/or 2)
  - Drive needs to be told how fast to run. signal comes from ucm or some other source. typically a 0-10v, 2-10v, or 4-20ma signal is used. (Or set Low speed to 20 hz)

AccuSine

Harmonics Solution

and/or

Power Correction System

Federal Pioneer
Merlin Gerin
Modicon
Square D
Telemecanique

Schneider Electric

More Advanced Training

- If after this course you are interested in more advanced training, please let us know.
- We have in depth Hands-on VFD and PLC training done by our Training Department.

Thank You for YOUR Time!

Thank You for YOUR Time!