

Grid-tie & AC Coupling Options for Small Wind Turbines

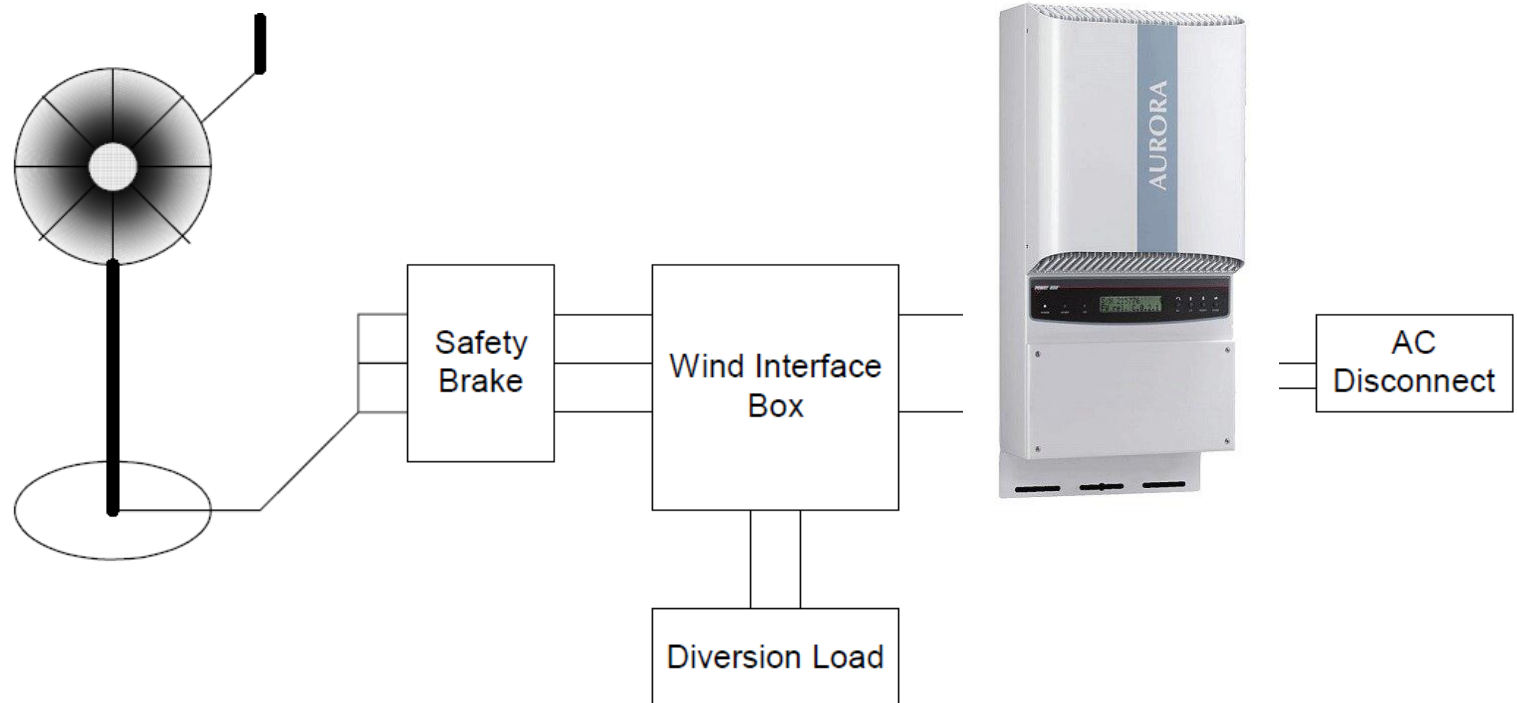


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History of Electronics for Synchronous Generators

- Turbine connected to rectifier/dump load controller
- Voltage based power curve stored in inverter managed turbine loading and power conversion
- Later, with PVI inverters, frequency power curve option was added



History of Electronics for Synchronous Generators

- Dump load was hysteresis, typically switching on at 530V and off at 430V
- At 530V switch on load would typically be 6kw – often doubling or trebling load on turbine at that voltage
- In practice, in high winds, switching would be at 5hz to 10hz
- Taxing on turbine, electrolytic capacitors and inverter

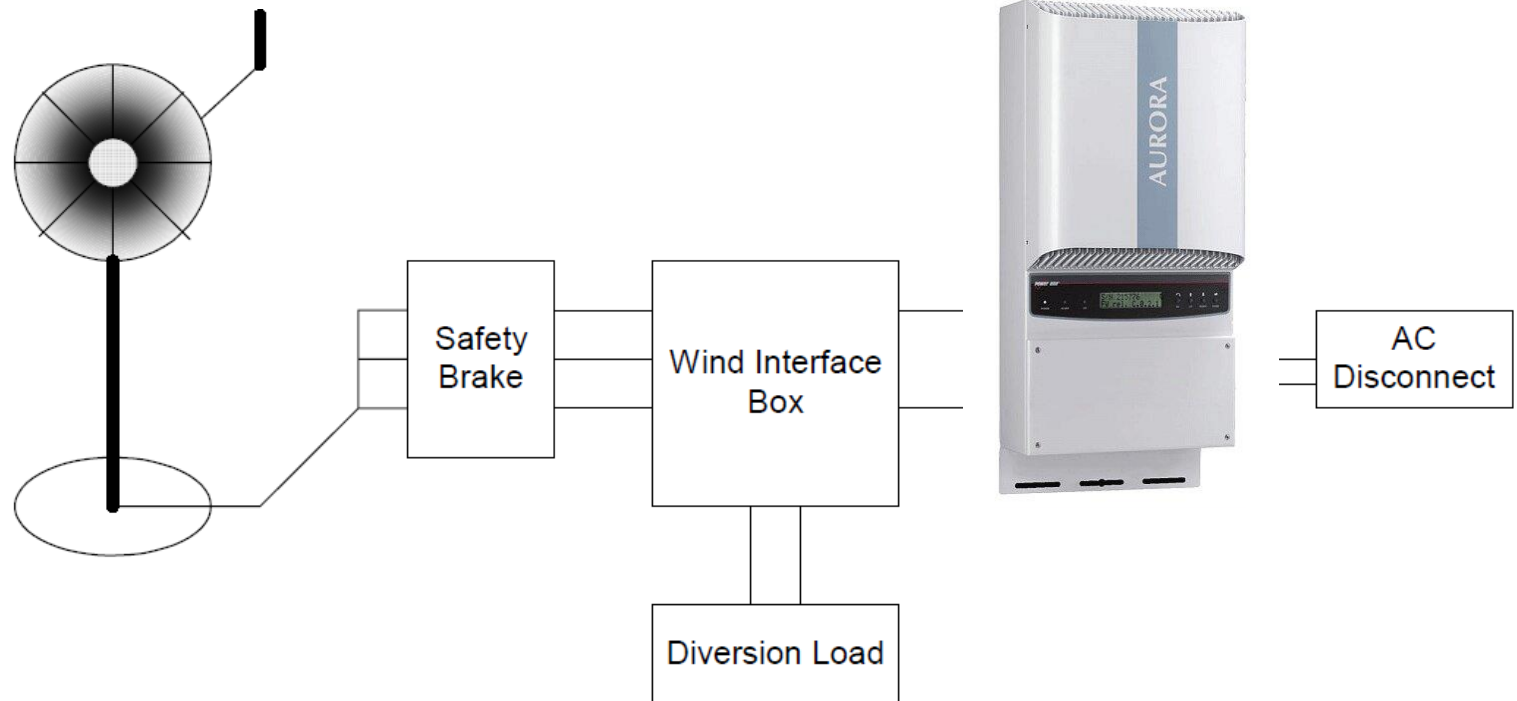


ABB / Aurora produces wind interface to control a wind version of its Trio 30kw Inverter

- Wind version of Trio was controlled by 25kw wind interface
- Interface stored power curve and sent a frequency signal to Trio
 - 50hz = 0 Watts
 - 150hz = 30kw
- **Power curve logic was in the interface**, not the inverter
- Dump load was **PWM** so easier on caps etc.



Wind interface discontinued by ABB

- In cooperation with ABB, Voltsys designs microprocessor based rectifier / dump load controller
- Controller stores power curve and sends appropriate frequency signal to Trio



Three major brands of wind inverter, SMA, ABB (Power-one) & Ginlong all cease production and support of wind models

Companies all had exponential growth in solar PV along with a drop-off in small wind turbine production



Voltsys produces modified controller to work with solar inverter via MODBUS

- In cooperation with ABB, Voltsys controller modified to operate with solar version of Trio inverter.
- Power curve stored in controller as before
- Inverter power conversion is managed via MODBUS instead of frequency

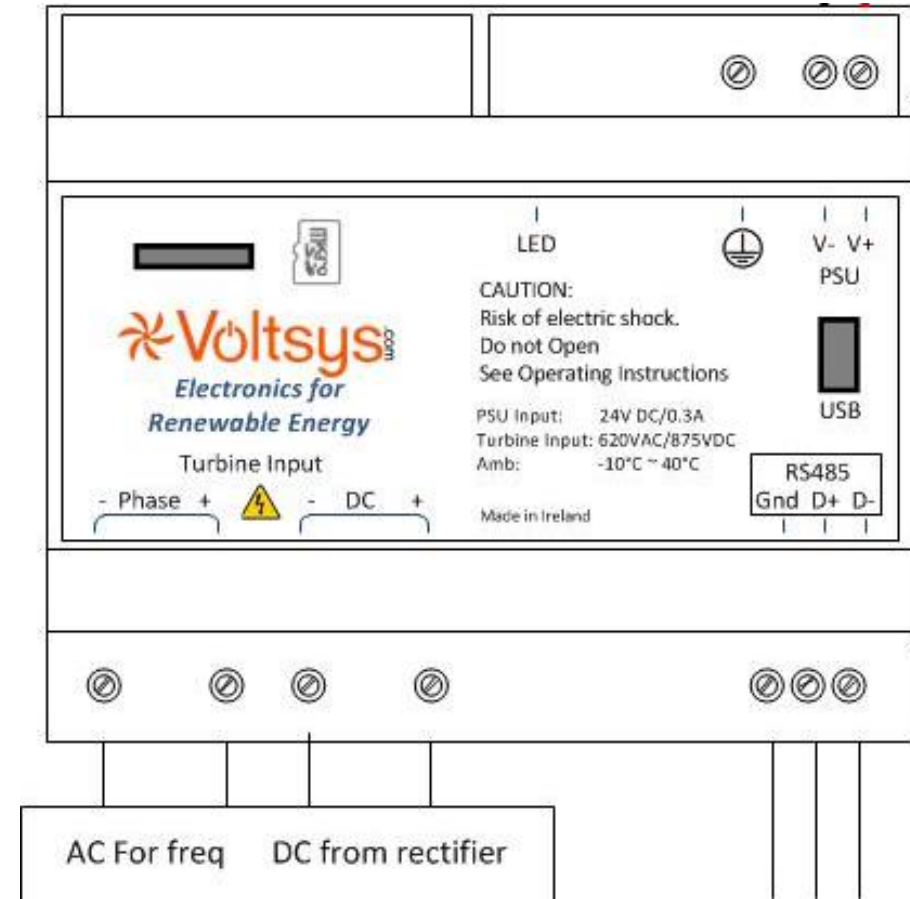


20A/40A unit made for Smaller turbines 3kw to 10kw

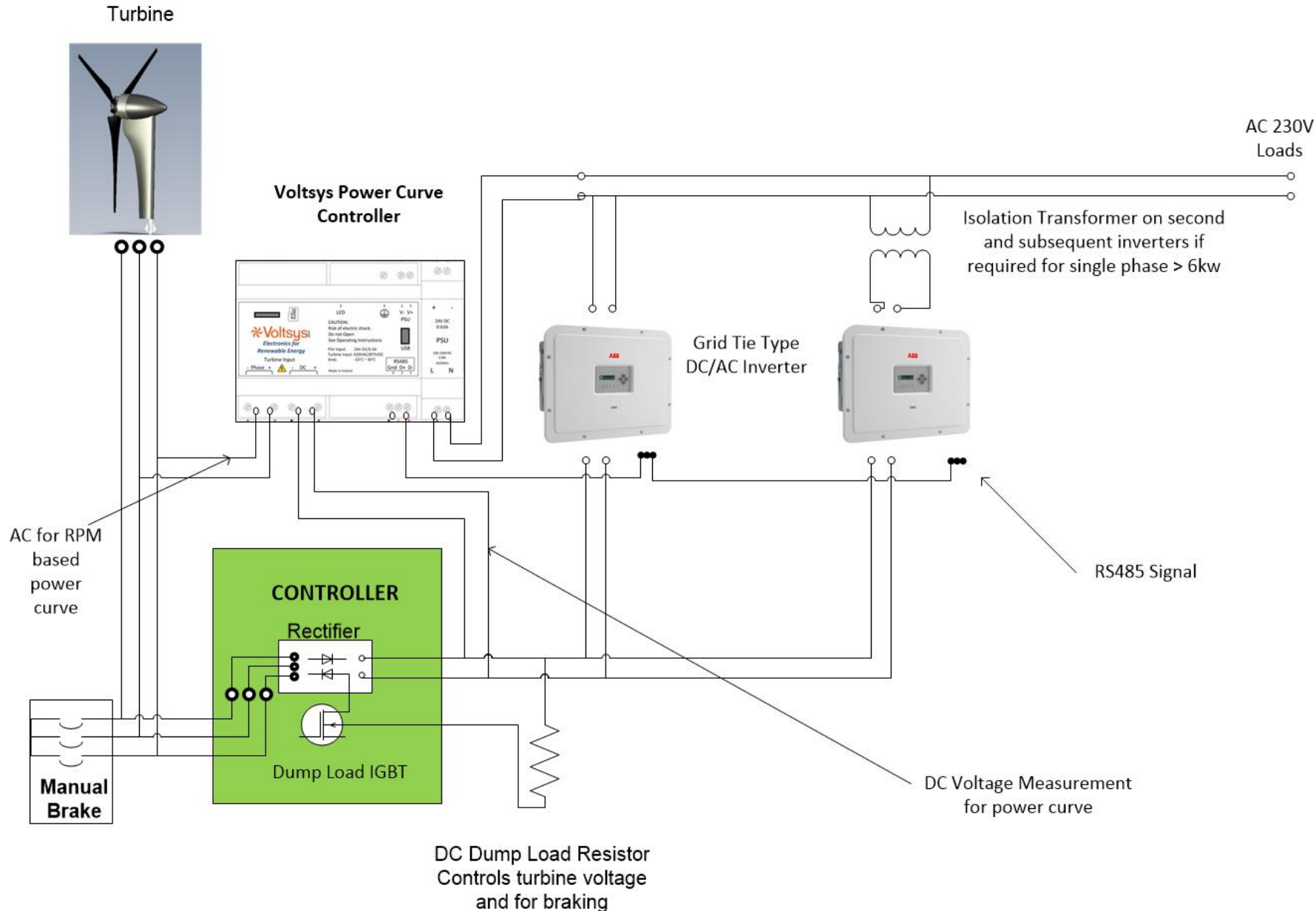


Power Curve Controller

- Stores power curve
- Reads turbine voltage (DC)
- Optionally reads turbine AC frequency for RPM
- Manages solar inverter export via modbus
- Data logs to uSD card recording;
 - RPM (as frequency)
 - Turbine voltage
 - Inverter parameters (Vgrid, power, Vfreq etc)



Small DIN rail mounted power curve controller for turbines with their own rectifier / dump load mechanism



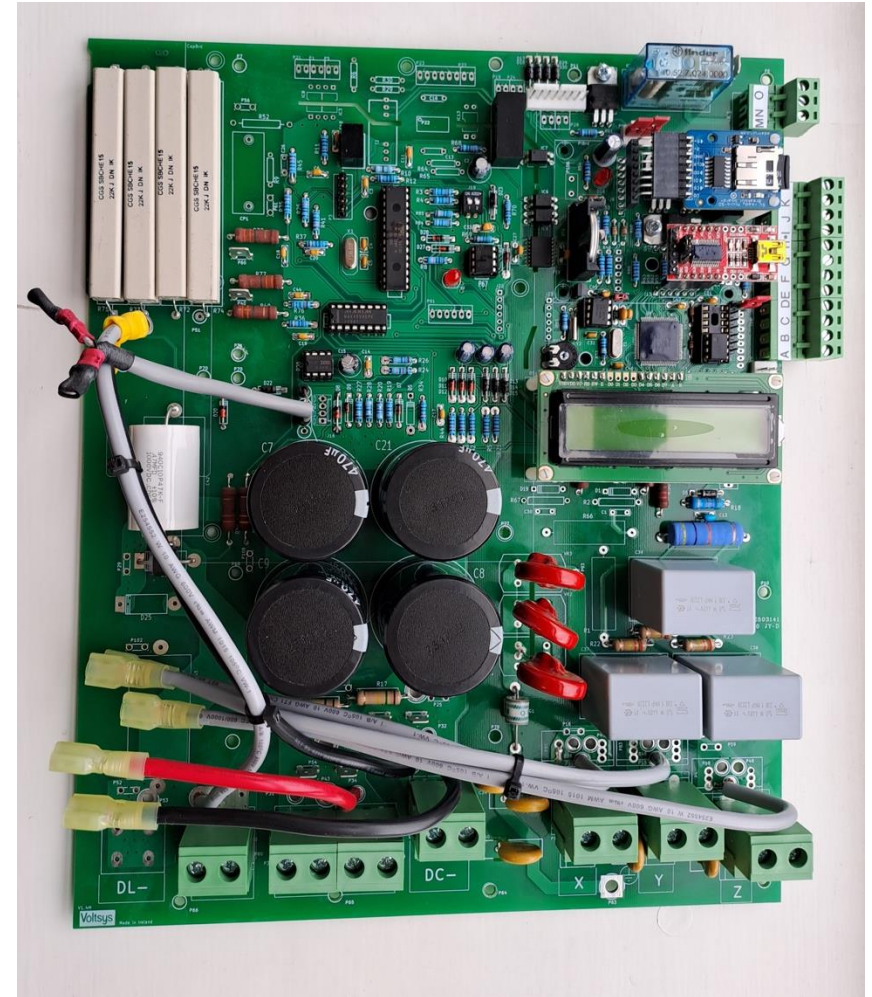
20A/40A/80A Controller

- Rectifies wild AC to DC and provides smoothing capacitors (various options)
- Stores power curve
- Overrides MPPT tracking and manages solar inverter export based on either frequency or voltage power curve via modbus
- Variable dump load management using either hysteresis or PWM
- Also provides DC dump load during grid failure (hysteresis only)



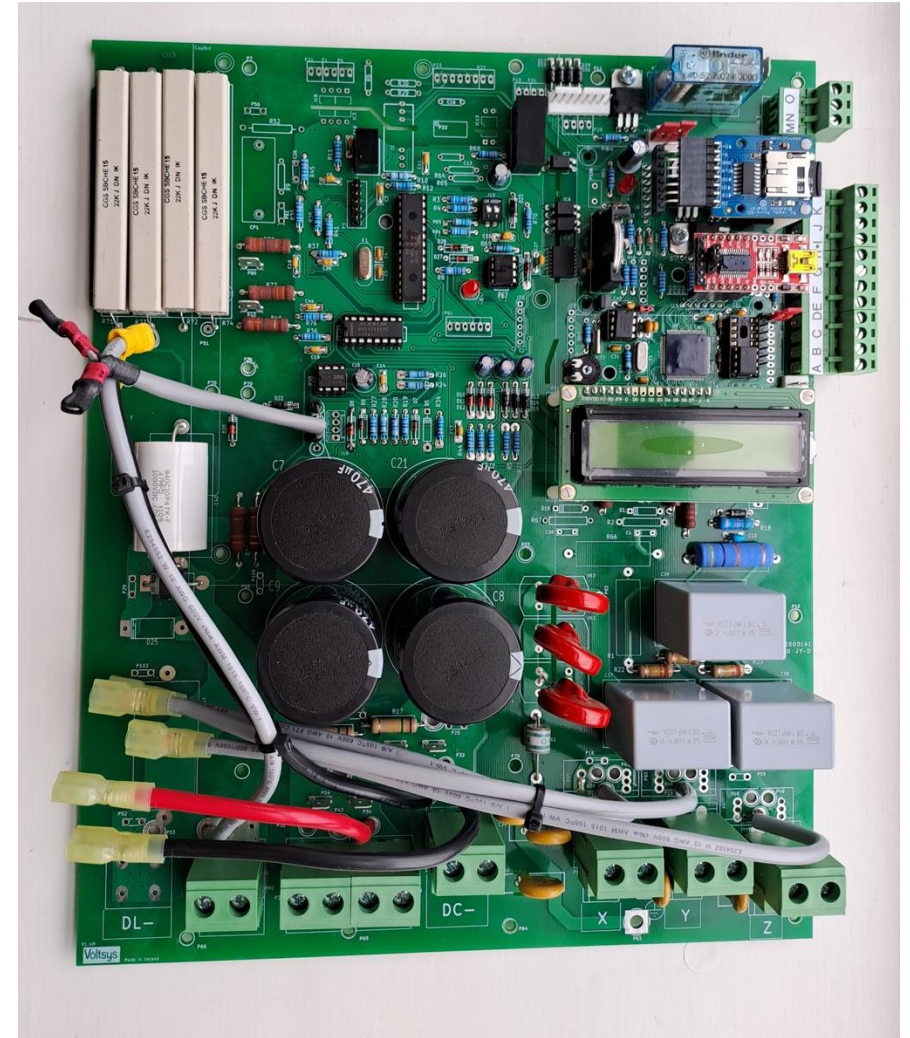
20A/40A/80A Controller

- Internal LCD screen with basic information
- Anemometer input for data logging and turbine control
- General purpose relay can be triggered by over-voltage, over-speed, or wind speed to operate external braking system. Can apply dump load and short at <math>< 50\text{rpm}</math>. Use turbine as anemometer for restart etc.
- Hydro power curve optimisation under development.



20A/40A/80A Controller

- Modbus for external monitoring – protocols available on request
- Data logs to uSD card for up to 1 year recording;
 - RPM (as frequency)
 - Turbine voltage
 - Inverter status including AC & DC voltage and status, errors etc.
 - Wind speed
- Turbine phase loss detection (especially for frequency based power curve)



PCB FOR EXPORT MARKET

uSD Card

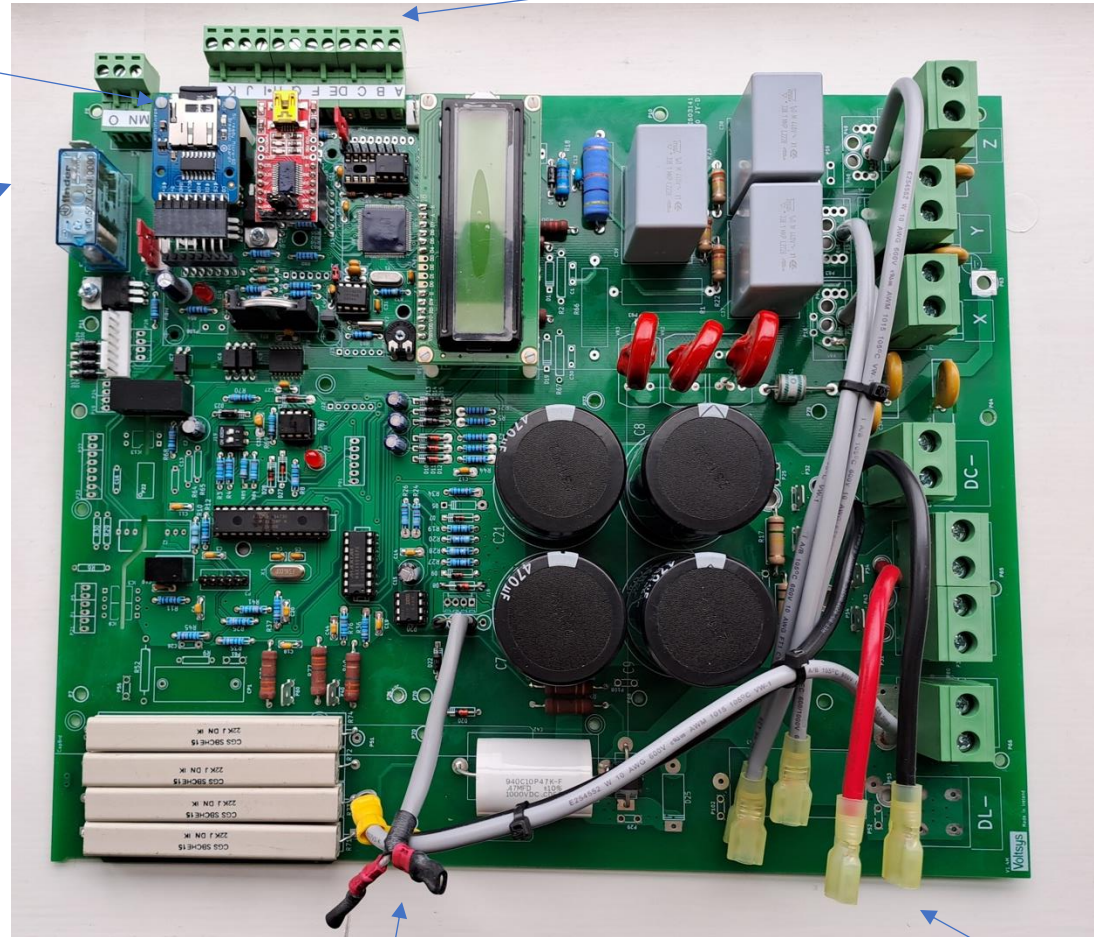
Multipurpose Relay

Modbus and anemometer connections

3 Phase from PMG

DC to inverter(s)

DC to Dump Load



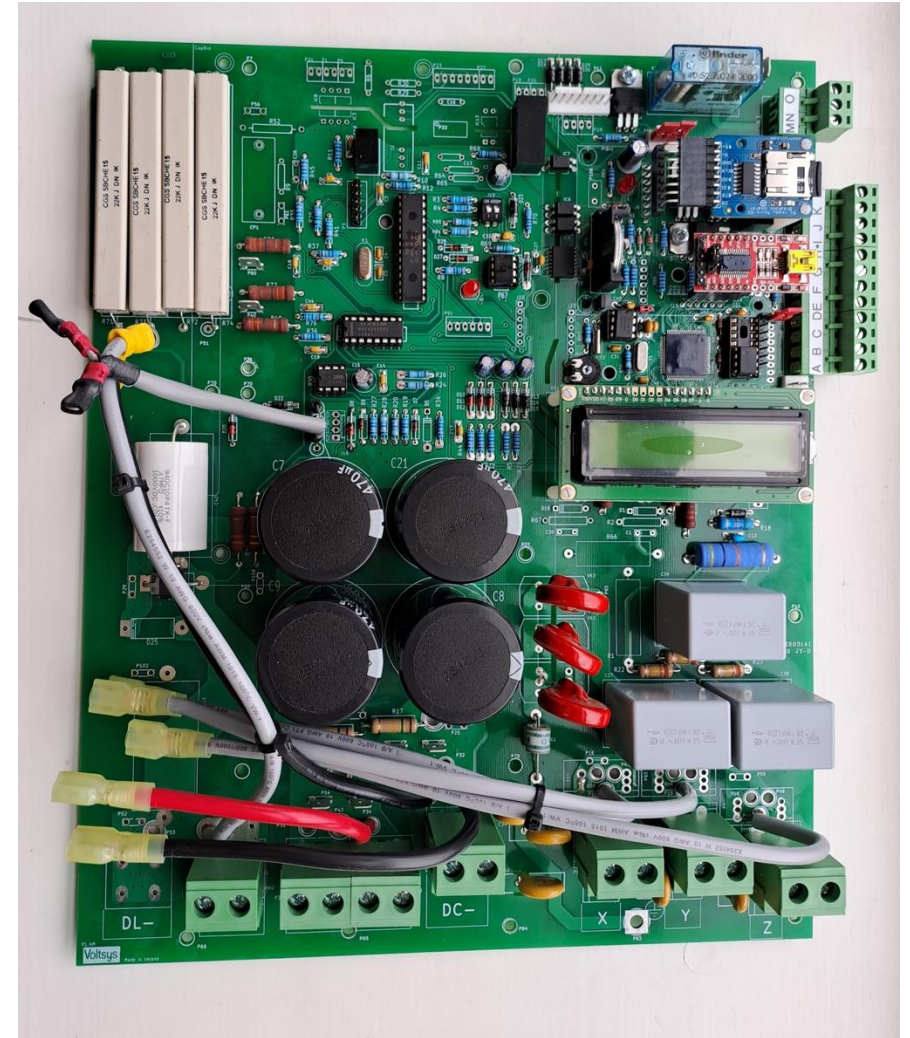
To IGBT on heatsink

To rectifier on heatsink

Smaller 20A/40A unit made for Smaller turbines 3kw to 10kw

Features added in over time;

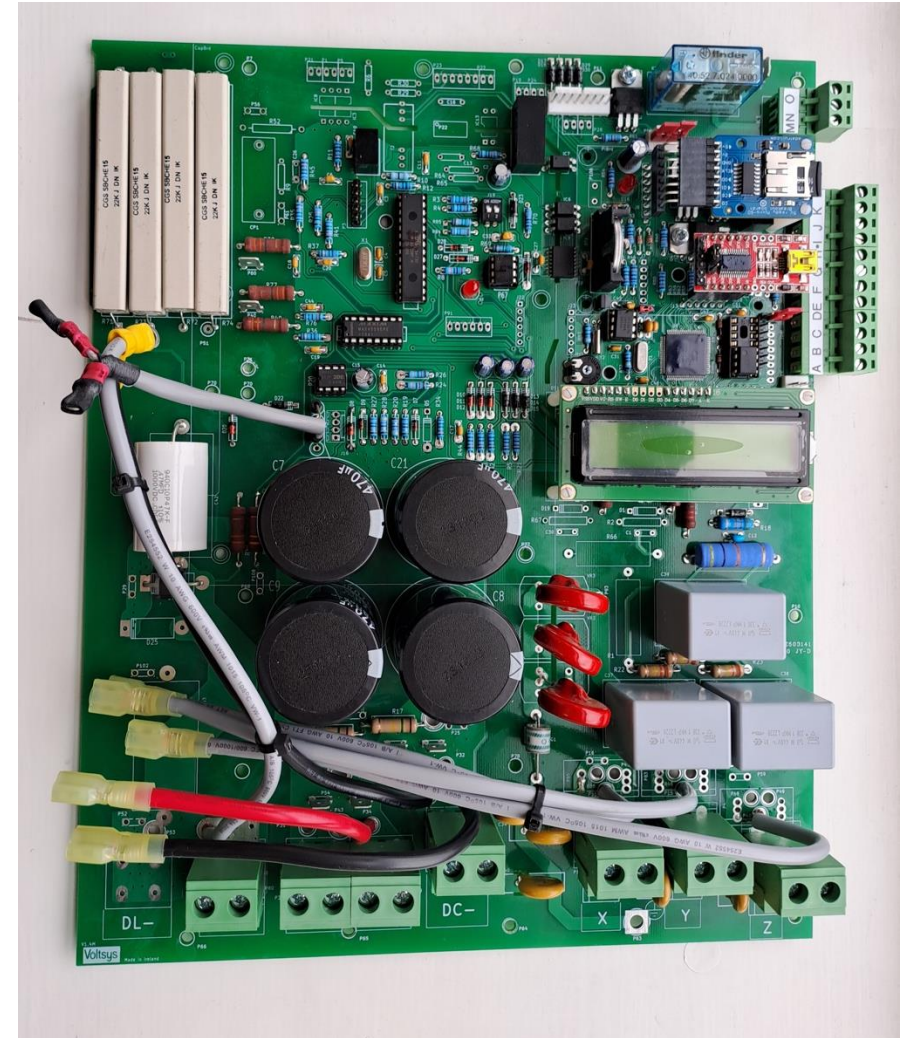
- PWM dumpload control for turbine load testing.
 - Linear Ramping or Power Table Style Programming allows new turbines to be tested for power production off-grid
- G100 Export Limitation
 - Monitors Modbus meter on grid to ensure exported power is within permitted limits
 - If power is exceeded, controller applies partial dump load while simultaneously reducing inverter output to ensure torque on turbine shaft remains appropriate for wind speed
- Power Limiting based on analog input



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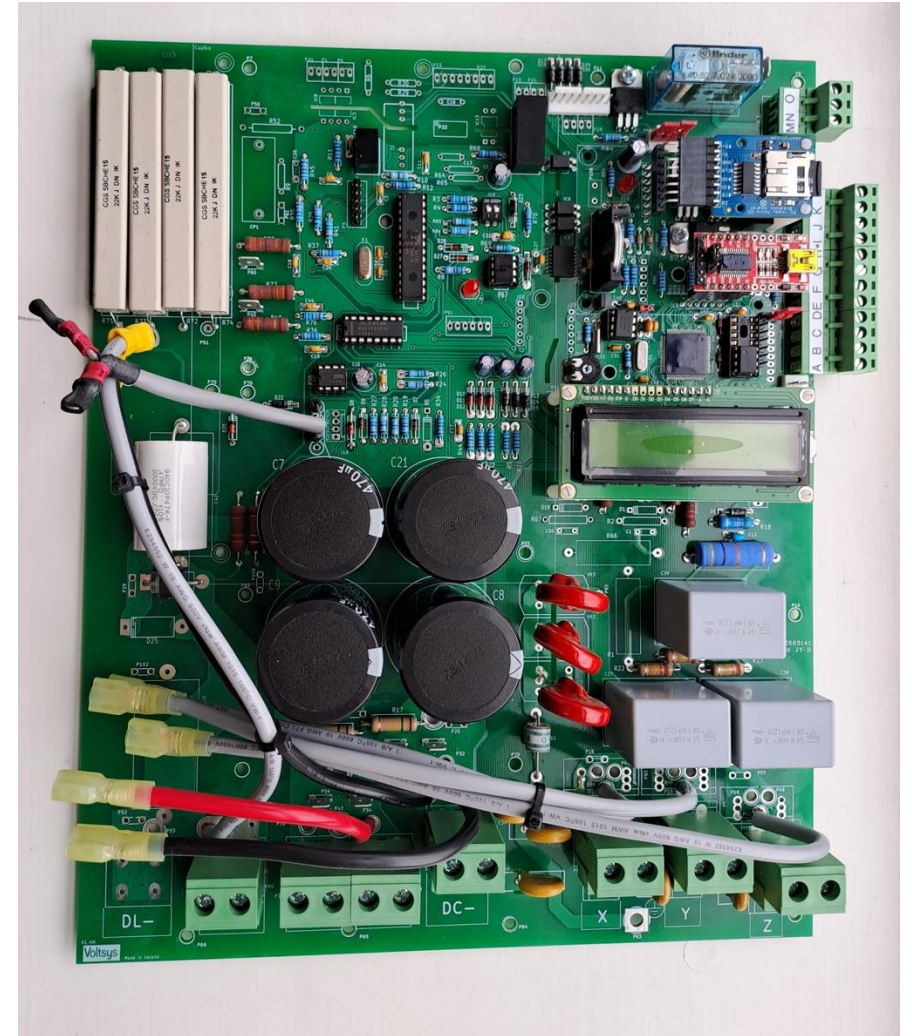
- For offgrid systems (e.g. Sunny Island / Victron) Frequency shift is detected in the inverter. System responds by reducing inverter output and simultaneously partially applying dump load to maintain normal torque
- For Sol-Ark, can compare meter data to power curve and apply dump load to maintain normal turbine loading
- Hysteresis AC load switching based on inverter power. Could also be used if grid is approaching over-voltage or exports are getting close to G100 limits
- Delayed relay switching for 2 stage turbine braking based on voltage and turbine speed



Smaller 20A/40A unit made for Smaller turbines 3kw to 10kw

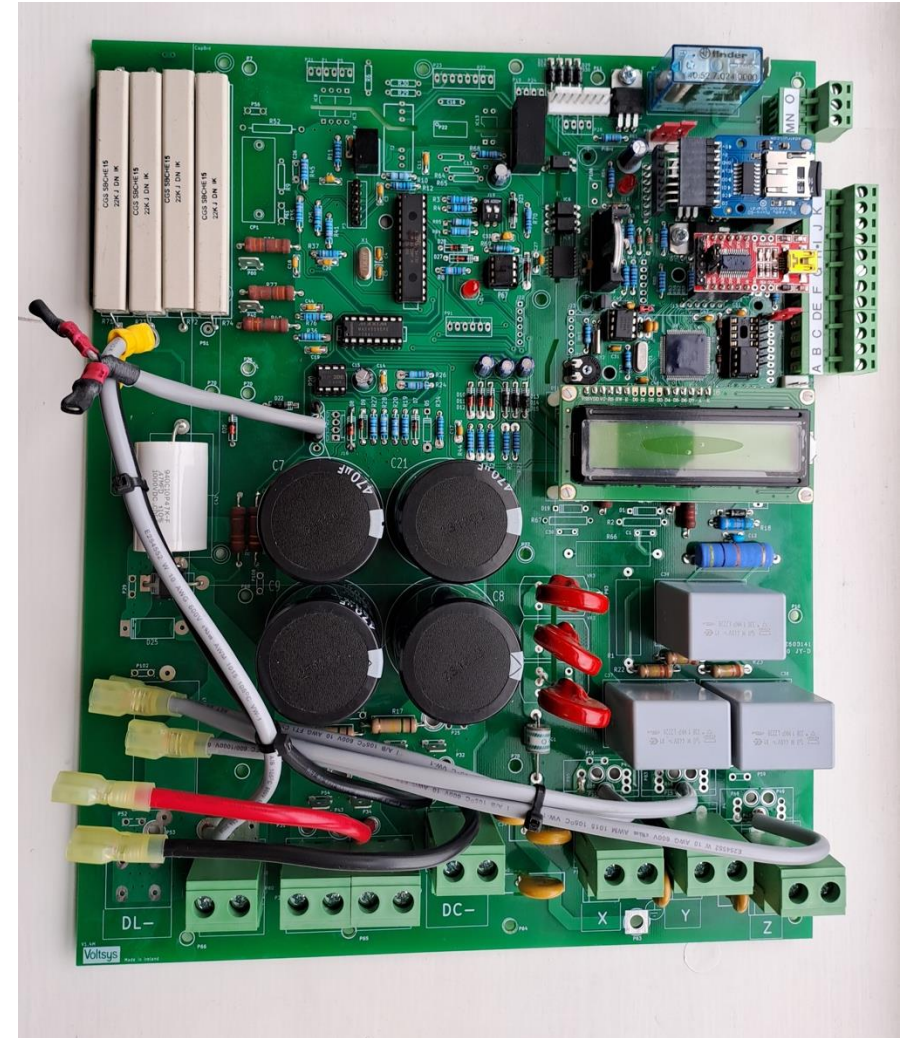
Features added in over time;

- Options for adding temperature monitoring
- Options for driving 1 onboard relay or 7 external relays
- Configurations for Split rectifier parallel controllers to increase power rating
- Possible to brake at times of potential shadow flicker
- Configurations for dual small turbine input in parallel or series



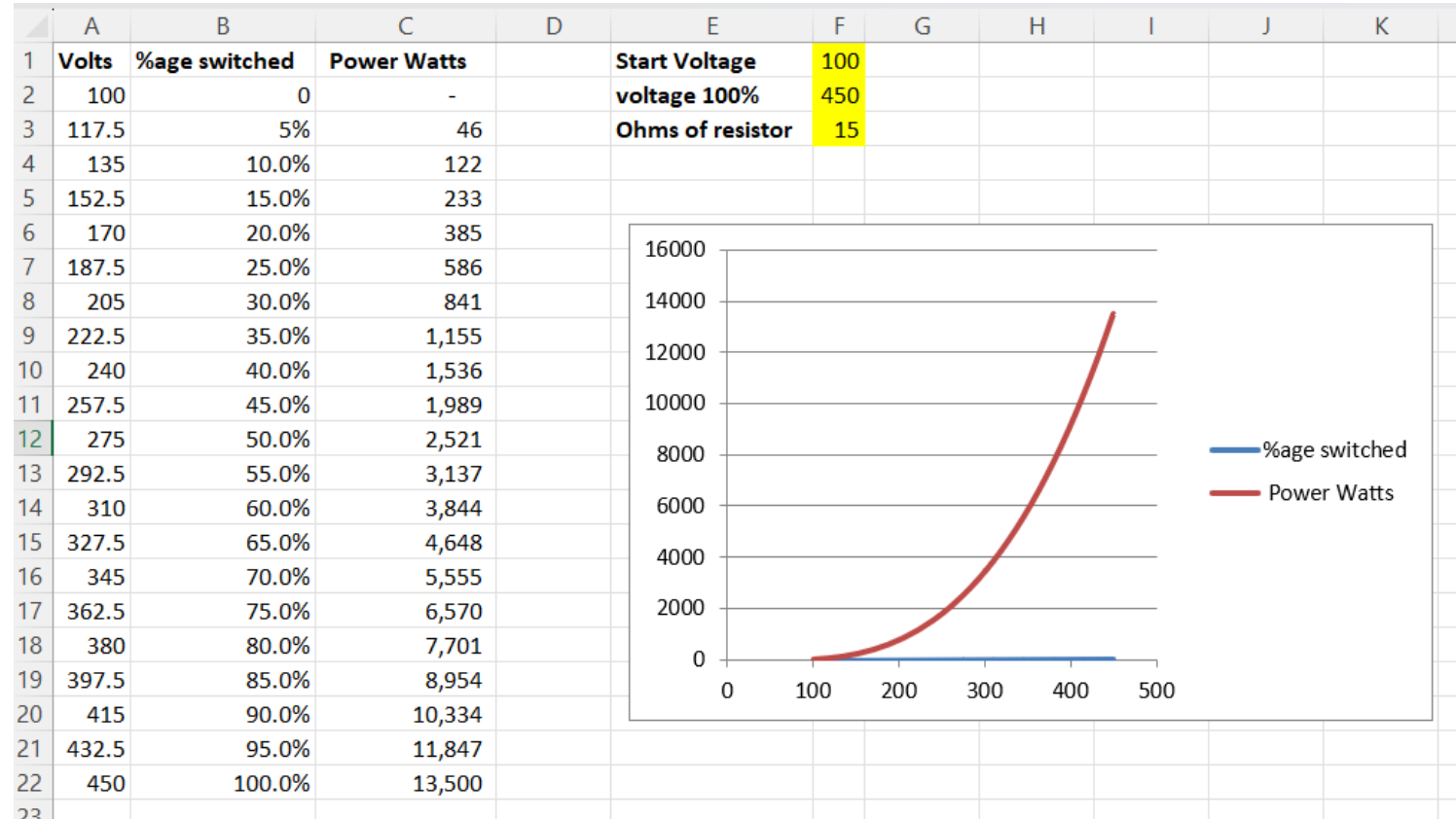
USING ANEMOMETER LOGGING TO IMPROVE POWER CURVES

- Wind speed is recorded along with RPM, power production etc.
- This enables manufacturers to optimise power curves for their turbine easily
- On wind speed / inverter output you need to offset the spreadsheet column for wind speed by 1 to 2 seconds to match response time of TURBINE to increased wind speed (anemometer will speed up more quickly than a turbine)
- Procedure;
 - Use an experimental power curve initially
 - Data log across all wind speeds
 - Try raising power curve by 10% across the board and see if this improves or reduces power production at each wind speed
 - Repeat process trimming power at various RPM to maximise power conversion at different wind speeds

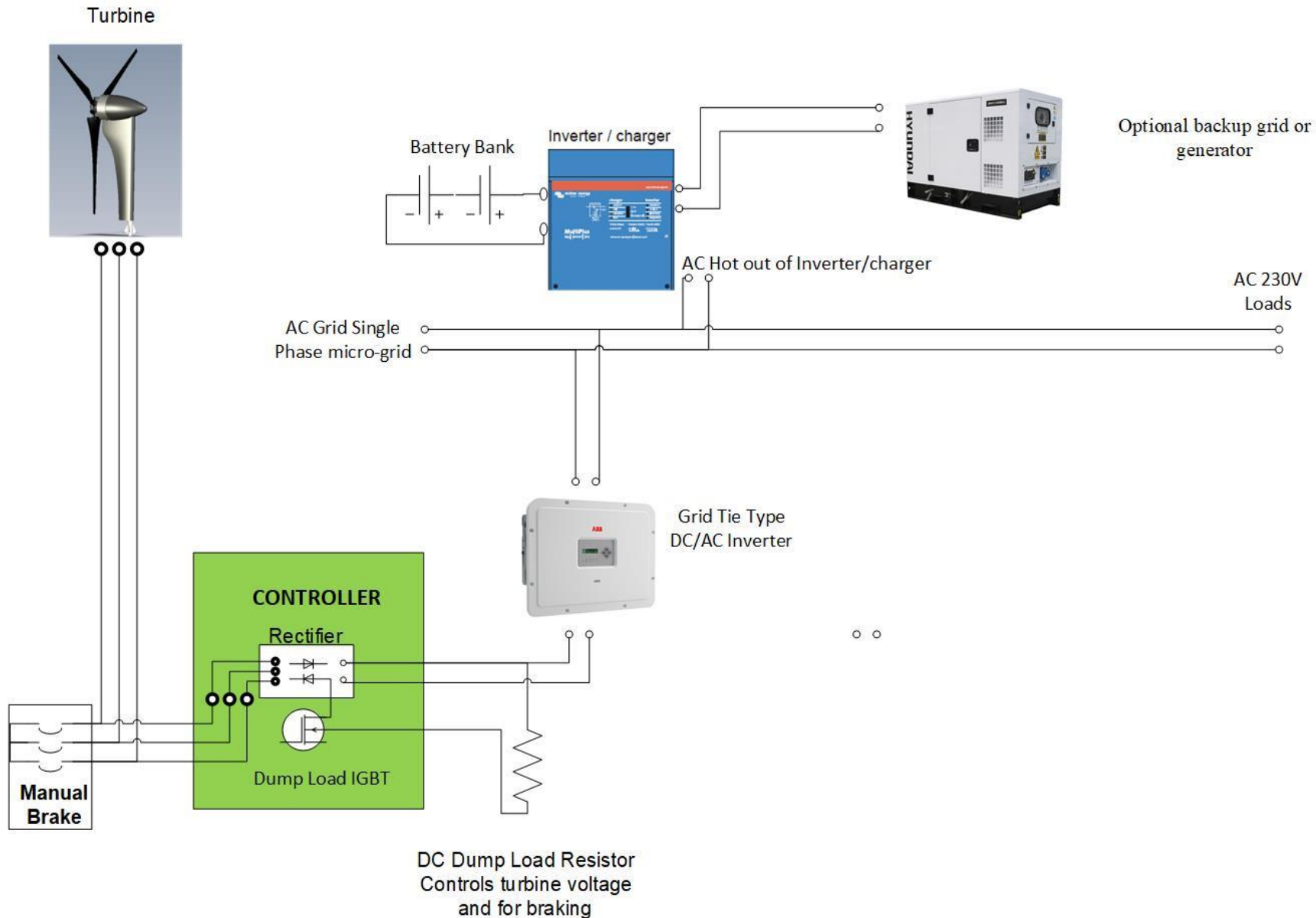


USING DUMP LOAD PWM TO IMITATE AN INVERTER POWER CURVE

- On a remote site without grid, PWM dump load control can be used to imitate a power curve.
- This may be useful during early development of turbines to establish that they actually produce power
- (you'd be surprised at how far along some turbine projects are when they discover that their blade set has no torque...)

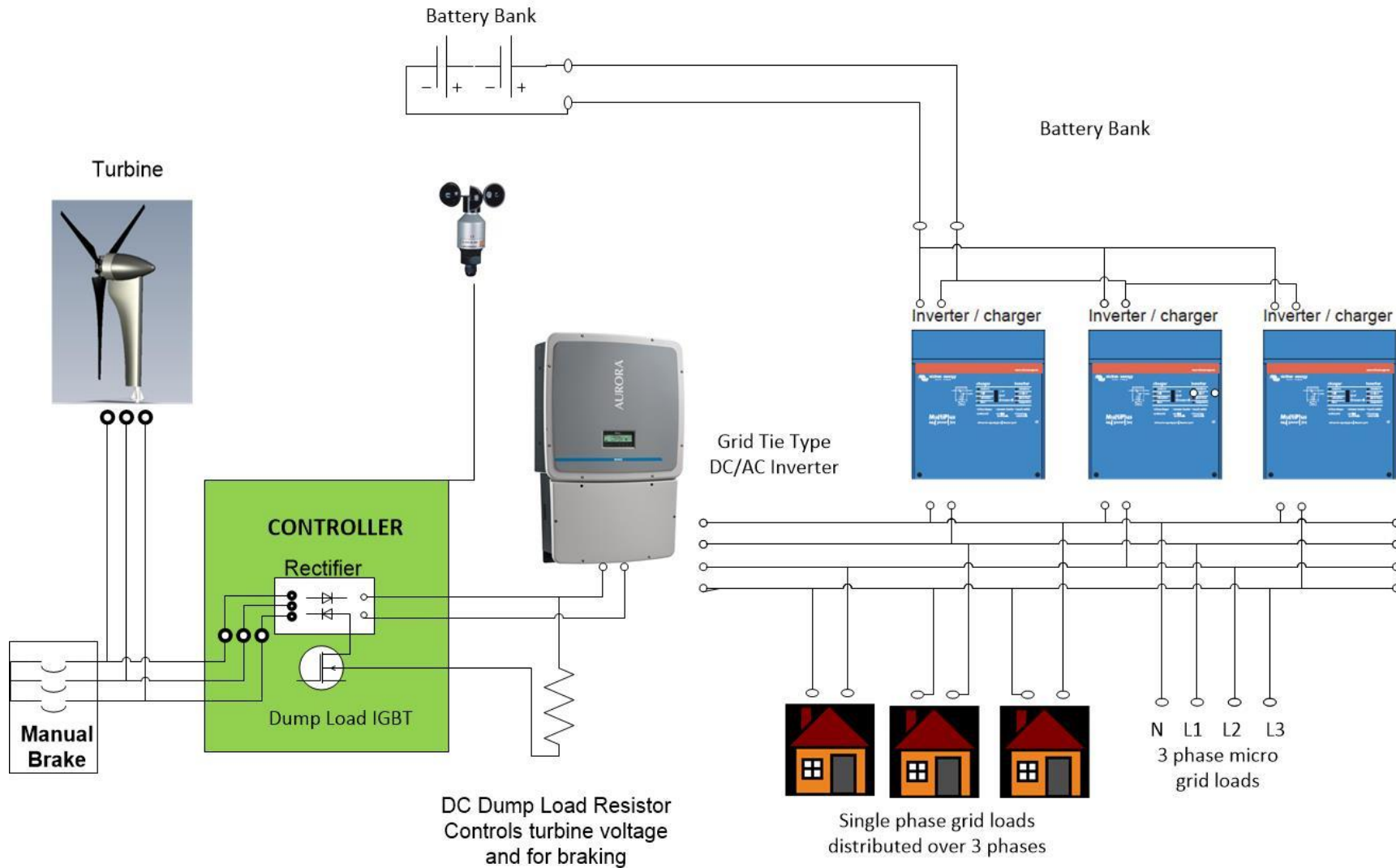


AC Coupled Grid Tie Solutions



- Most loads on grid during production will come directly on the 230v line
- Frequency shift by inverter will cause grid tie inverter to back off.
- When this happens, controller will apply proportional dump load to keep turbine loaded normally
- This prevents overspeed and reduces noise

AC Coupled Grid Tie Solutions – three phase



- Most loads on grid during production will come directly on the 230v line
- Frequency shift by inverter will cause grid tie inverter to back off.
- When this happens, controller will apply proportional dump load to keep turbine loaded normally
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Programming Options (via USB connection to laptop)

Monitor	Settings	Serial	Power Table	Inverter	Advanced
Start Delay in seconds	<input type="text" value="10"/>				
Dumload Low Voltage	<input type="text" value="430"/>				
Dumload High Voltage (100% Dumload)	<input type="text" value="530"/>				
Dumload Ohms	<input type="text" value="45"/>				
Dumload Pwm Start Level(0-255)	<input type="text" value="0"/>				
No Grid Dumload On (Need PSU On to program)	<input type="text" value="400"/>				
No Grid Dumload Off (Need PSU On to program)	<input type="text" value="300"/>				
External Stop Signal (0 Bypass/255 Enable)	<input type="text" value="255"/>				
Over Voltage	<input type="text" value="560"/>				
Over Voltage Timeout (Sec)	<input type="text" value="10"/>				
Over Frequency 1 (Hz)					<input type="text" value="28"/>
Over Frequency 1 for x Sec					<input type="text" value="25"/>
Over Frequency 2 (Hz)					<input type="text" value="30"/>
Over Frequency 2 for x Sec					<input type="text" value="2.0"/>
Over Frequency Timeout (Sec)					<input type="text" value="360"/>
Modbus Address(Add-on Component 255 Disable)					<input type="text" value="255"/>
Anemo Upper Limit (m/s)					<input type="text" value="40"/>
Anemo Lower Limit (m/s)					<input type="text" value="25"/>
Anemo Timeout (sec)					<input type="text" value="600"/>
Anemo Multiplier (m/s/Hz)					<input type="text" value="0.76"/>
RPM Multiplier (rpm/Hz)					<input type="text" value="1.0"/>

Frequency derating for off-grid AC coupled systems

File Tools **Advanced**

COM Port

Monitor Settings Serial Power Table Inverter **Advanced**

Dumpload Mode (0 for Hysteresis / 255 for PWM)

AnemoFix (set to 255)

AnemoOffset (set to 100 no offset)

AnemoLimit (set to 5sec)

Extra debug info on LCD (0=enable)

Inverter Fmr if inverter state >= (0 to disable)

SD Card Delete Log older than x Days(0=till card full)

Grid Above 50Hz 0% Powerlimiting (0.3=50.3Hz)

Grid Above 50Hz 100% Powerlimiting (1.5=51.5Hz)

Short Circuit after X sec (No Timeout if 2550)

Over Voltage - No Restart (V)

Over Freq - No Restart (Hz)

Password VS2598

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