Build better UAVs using modular power

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What to look for in a UAV power delivery network

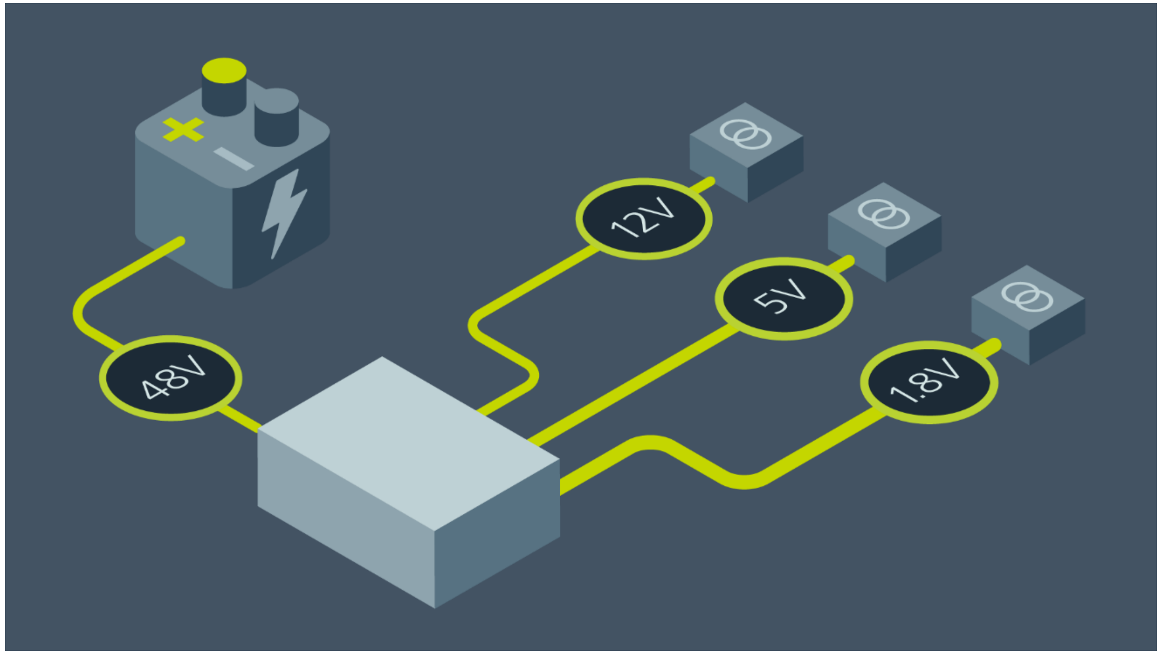
A power delivery network (PDN) is designed to provide specific levels of voltage and current to the various loads within a system derived from a bulk power source(s). What you choose matters.

Power design solutions:

- Silver box
- Discrete design
- Modular design

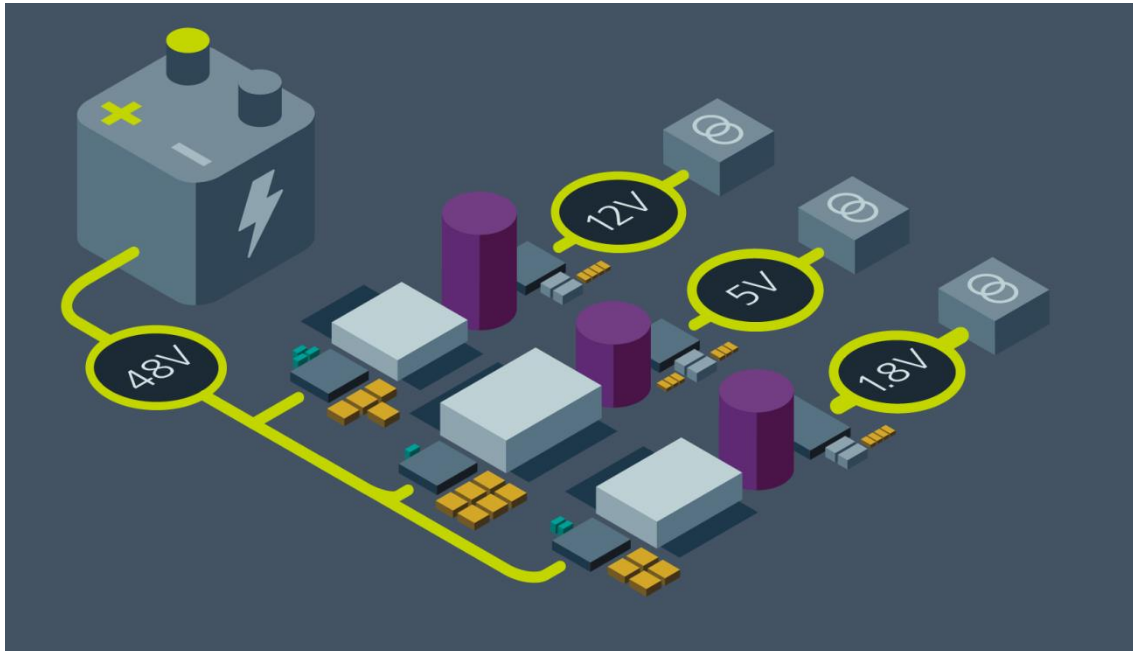
Silver box solution: easy, but limited

- Big, heavy and rigid
- Static in/out interface
- No flexibility
  - Unable to modify design parameters (inputs/outputs)
  - Need a large predetermined space to accommodate footprint
- No scalability
  - Unable to modify design to accommodate change(s) in customer specifications



Discrete solutions: precise, but not easily adapted

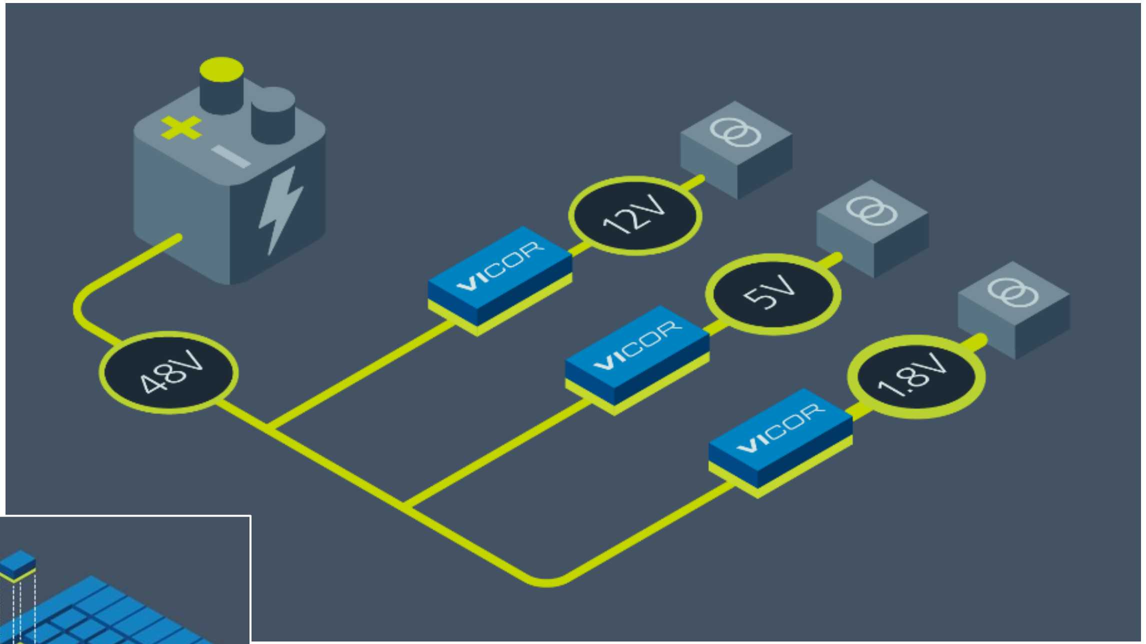
- Design complexity
  - Requires extensive design engineering and testing
  - Longer design, integration times
  - Large bill of materials (BOM)
- Difficult to scale
  - Need to redesign entire system and revalidate
- Lack of design flexibility

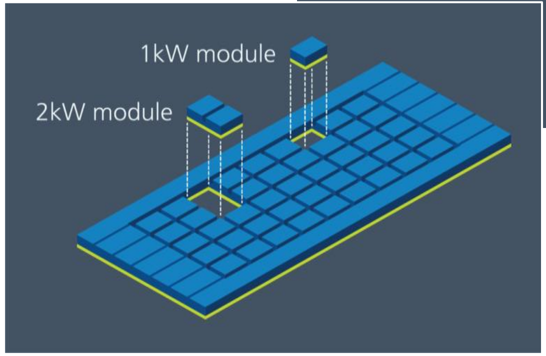


Modular solutions: power dense, scalable

Modular power delivery networks:

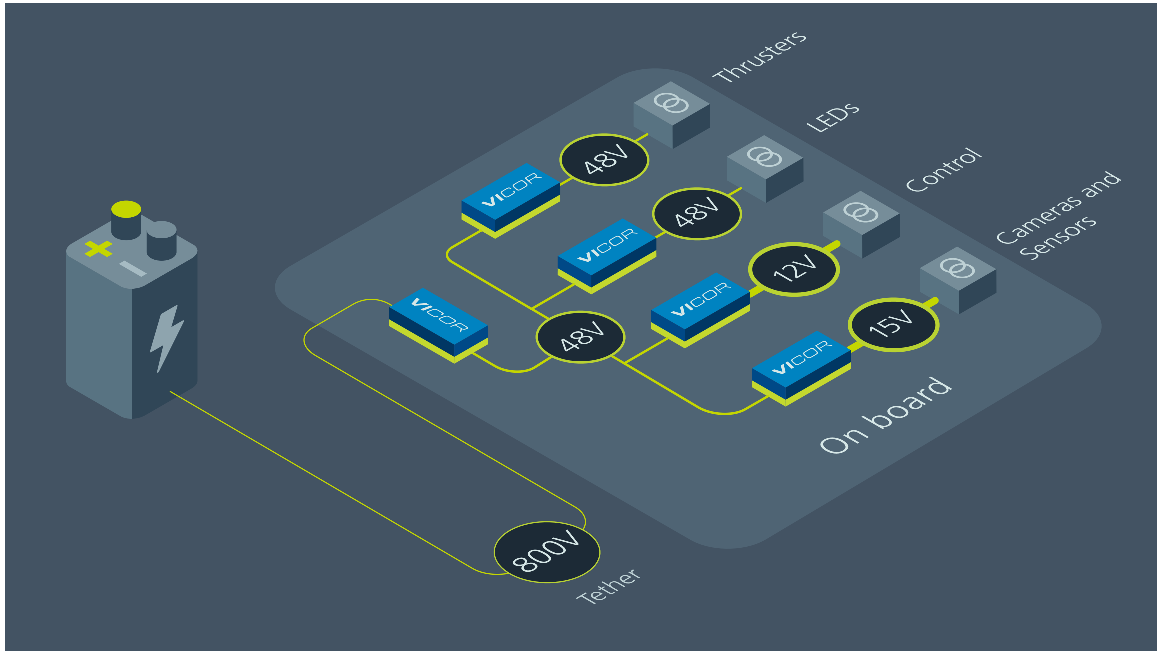
- Require minimal design/ engineering resources
- Are easily designed, supporting faster time-to-market
- Typically need fewer parts, which requires smaller BOM, lower risk
- Are tested and certified ready for use





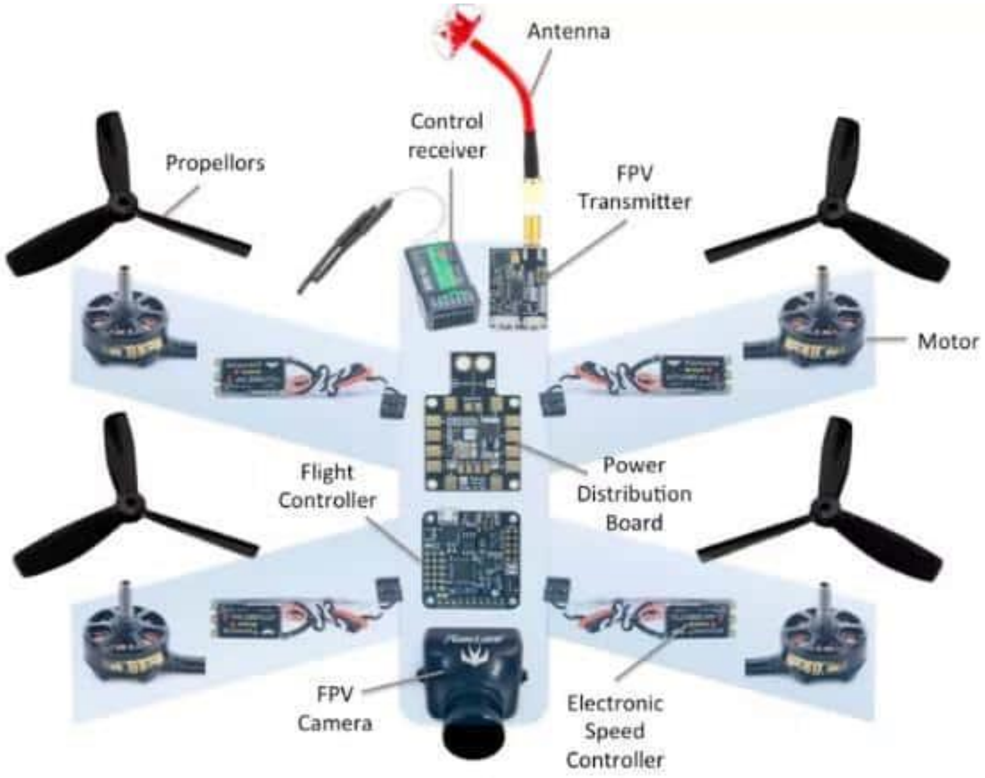
Advantages of a modular PDN

- Improve overall UAV performance
- Optimize system size, weight
- Reduce system costs
- Minimize complexity in your supply chain, reducing risk



Here are the challenges that Vicor high performance, high density modules can solve

- Maximize flight time
- Extend operational range
- Improve safety and reliability
- Upgrade existing functionality
- Increase or add different payloads
- Add new capabilities
- Get it done faster (time-to-market)



Tethered Drone Application

Tethered UAVs: for longer run times, secure data

Common requirements:

- Close to the host vehicle or control base (portable)
- Long operating times
- Hard-to-reach or dangerous environments

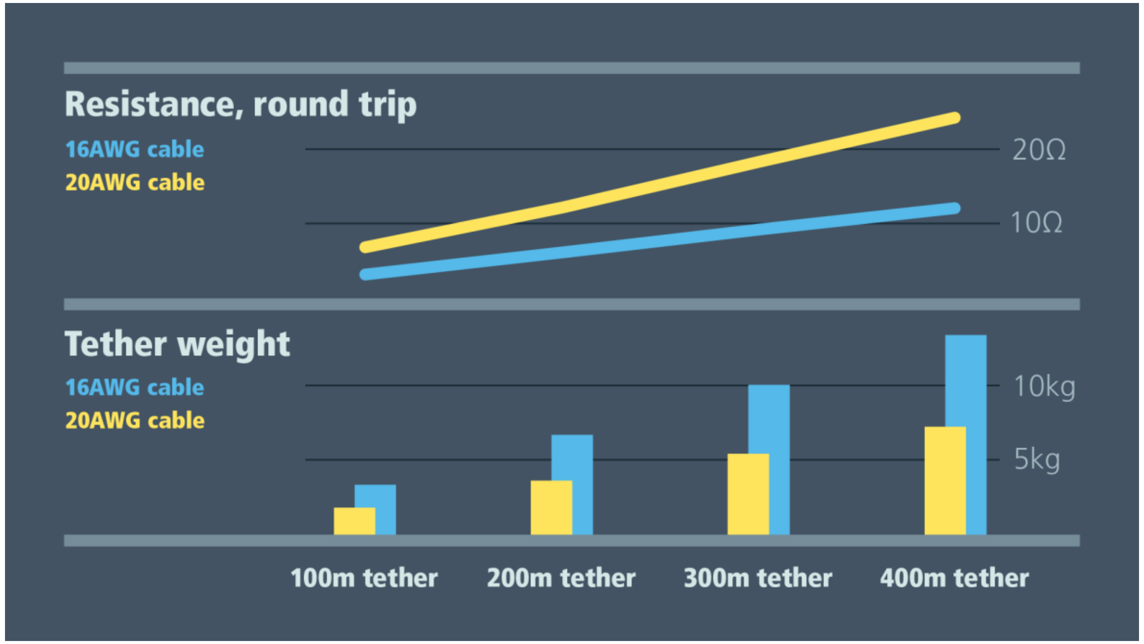
Common use:

- Eye-in-the-sky surveillance
- Construction inspections
- Over line-of-sight communications

Optimizing tethered UAV flight: a tradeoff

To optimize performance, focus on gauge resistance, drag (weight)

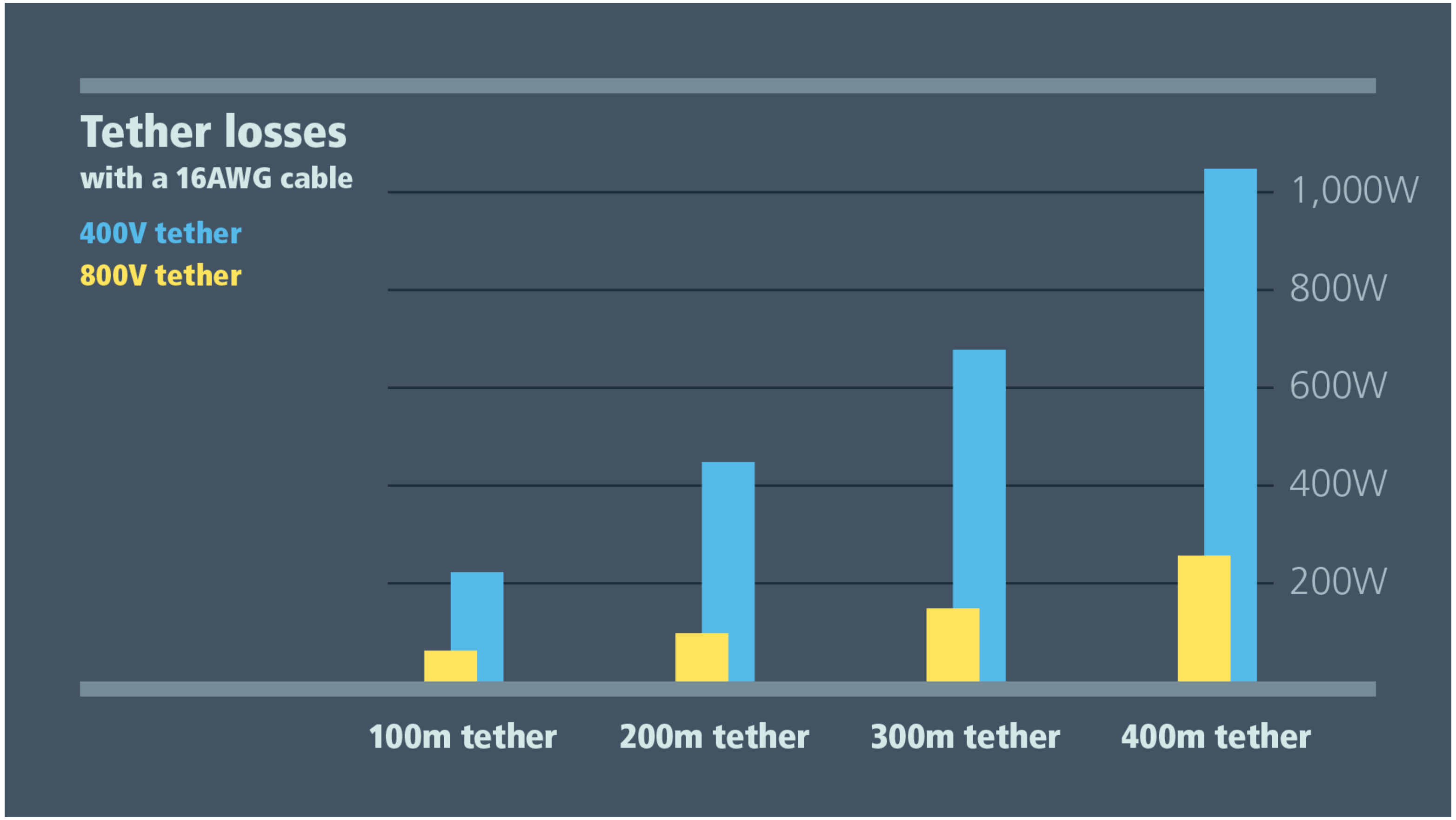
- Reduce tether weight using higher-gauge cable, reducing drag
- Higher-gauge wire has more electrical resistance, incurring more loss
- To achieve low loss and low drag, use high voltage



Higher voltage + lower current = fewer losses

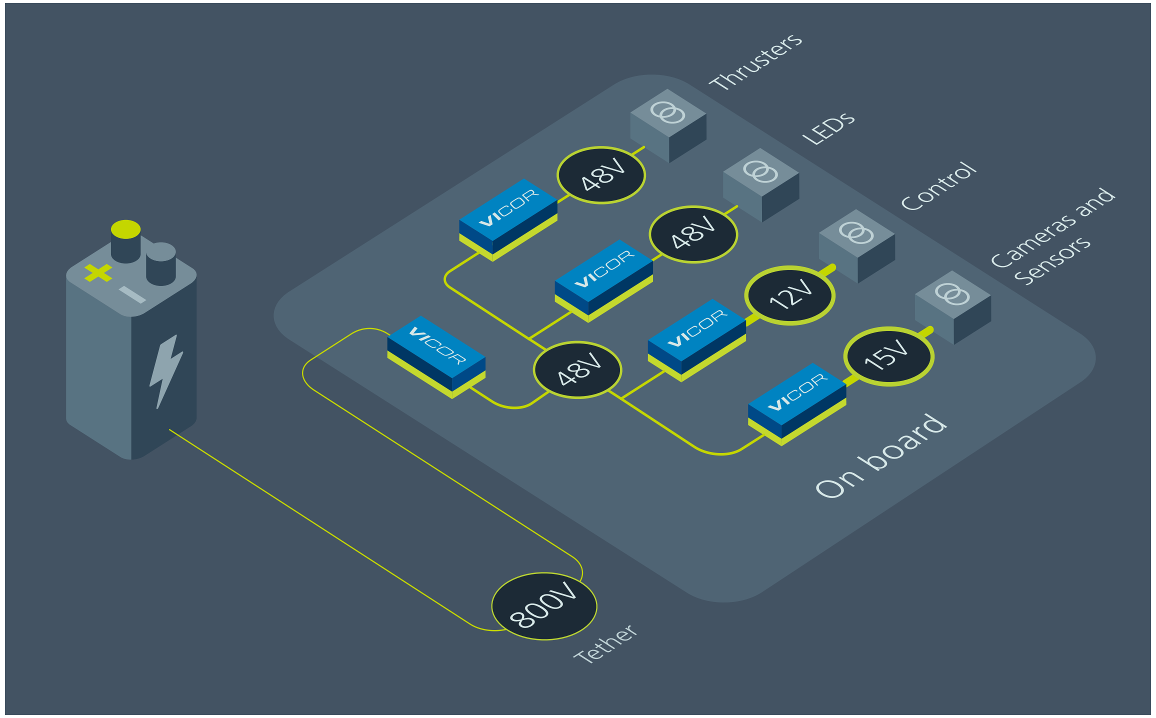
High voltage delivers:

- Lower current
- Fewer losses



Easily scale and add more payload, accessories…and power

- Scalability supports a variety of peripheral functions using different input voltages
- Small modules are easily added



Supporting more functionality, payloads and longer runtime

- Tethered drones provide warfighters with the unique ability for rapid deployment with greater flexibility and C5ISR capability than legacy solutions
- The capabilities of today’s advanced tethered drones allow for greater payload options to support mission success

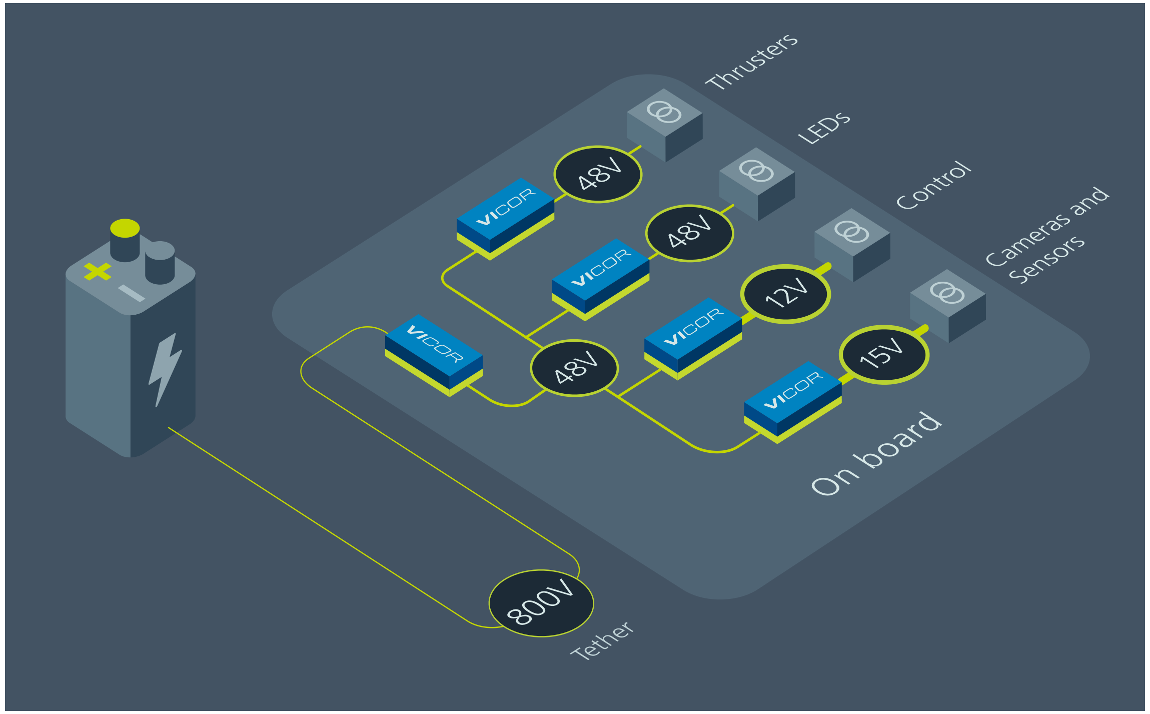
Key goals were

- Capabilities that can be transported by smaller c
- Provide increased payload
- High efficiency for more extensive missions

Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, and Reconnaissance

High-efficiency PDN that can scale

- Loads can be powered by a non-isolated buck or buck-boost converter
- A 48V bus is run to the loads and each has its own converter



Autonomous, battery powered drone applications

Untethered UAV: for independent operation

Common requirements

- Highly maneuverable
- Longer flight times
- Sophisticated accessories

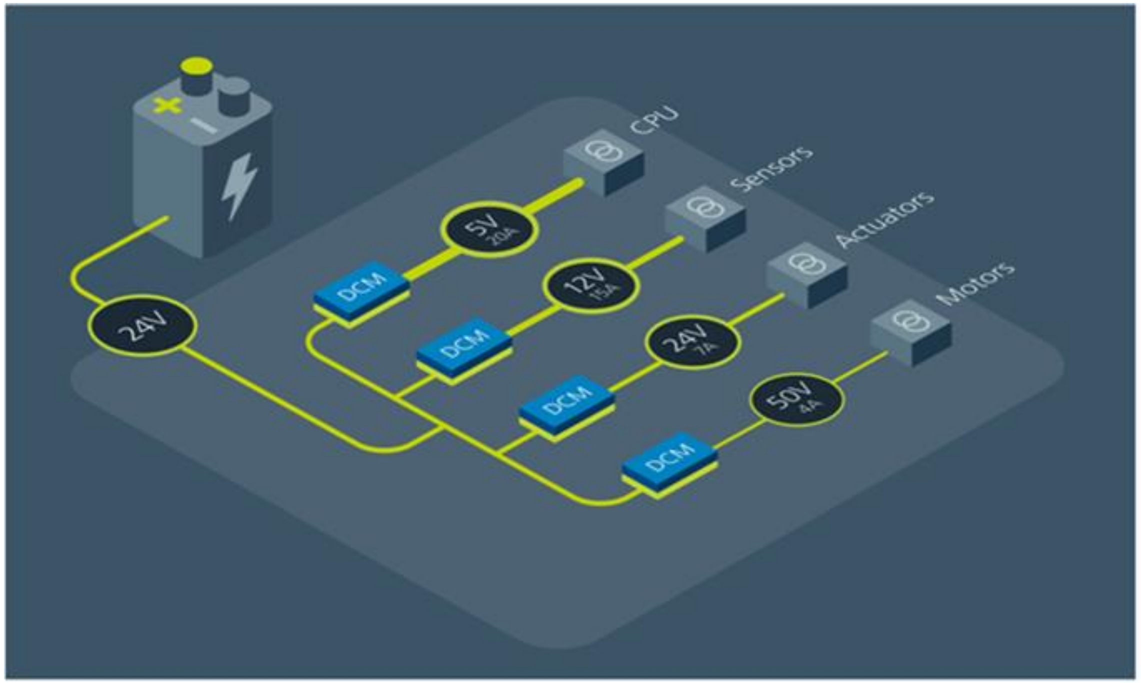
Common application loads

- Control interface
- Sensors
- Cameras
- Wireless communications
- Motors

24V battery drone with a 750W PDN

The 24V battery needs to support not only the motors that propel the drone, but also:

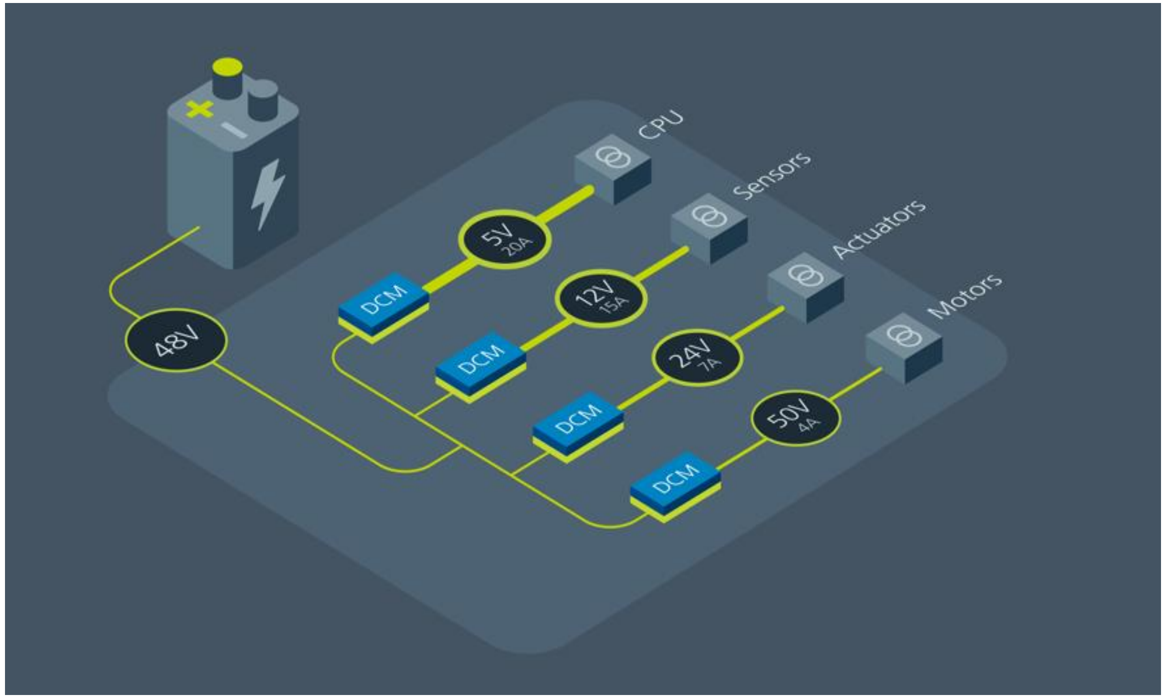
- Inertial sensors such as an accelerometer
- Navigation sensors such as a GPS or magnetic sensors aid the drone to fly along a specific path or to a specific destination



Benefits of upgrading from a 24V to a 48V battery

Advantage of converting to 48V:

- Extend range
- Increase load capacity
- Potentially reduce size and weight
- Better performance in regards to efficiency and power density



Case study – Delivery UAVs

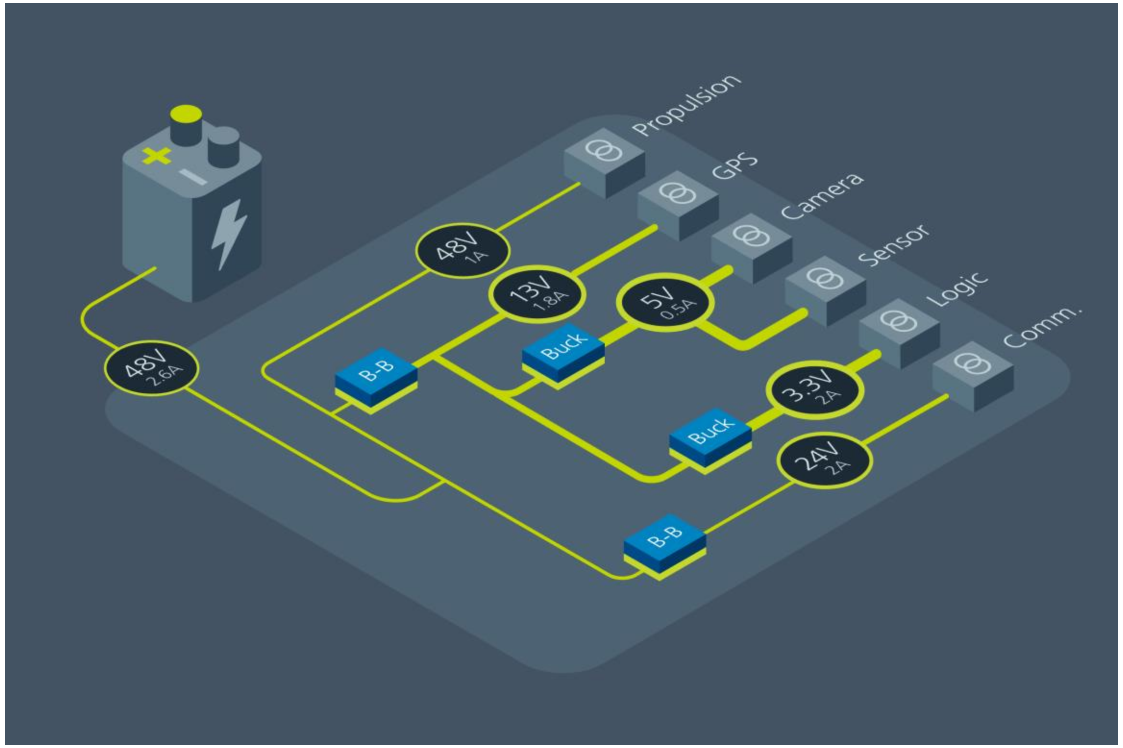
Customer challenges

- Increase flight time to reach greater distances
- Compact and lightweight solution so the UAV can carry heavier loads
- Supporting a variety of point-of-load voltages

Vicor solution

- High-power density – compact and lightweight
- Higher efficiency to extend flight times and range of operation
- Compact Vicor regulators enable redundancy when duplicated at the point of loads

Case study – Delivery UAVs



- Compact and power-dense ZVS buck and ZVS buck-boost regulators allow multiple point-of-load converters to save on cabling while powering multiple devices with multiple power buses to create the redundancy needed to ensure safe and reliable delivery operations

Hydrogen fuel cell UAV application

World's first commercialized hydrogen fuel cell power pack for UAVs

- Doosan Mobility Innovation (DMI), a leader in hydrogen fuel cell technology has developed the world's first commercialized hydrogen fuel cell power pack that delivers breakthrough energy density, about 4 – 5 times that of a battery, enabling drones to fly for up to 2 hours
- With the extended range that the hydrogen fuel cell power pack provides, DMI is delivering global humanitarian relief

Product	DS30W	Size (W x L x H) [1]	1,850 x 1,850 x 815mm
Rated power	2.7kW	Wheelbase distance	1,990mm
System Weight	21.9kg (with 10.8L hydrogen tank) 20.9kg (with 7L tank hydrogen tank)	Maximum take-off weight	24.9kg
		Hydrogen canisters	10.8/7L
Payload (max)	3kg	Working Temperature	- 5 to 40°C
Flight time	120 minutes (without payload)	Wind resistance	12m/s

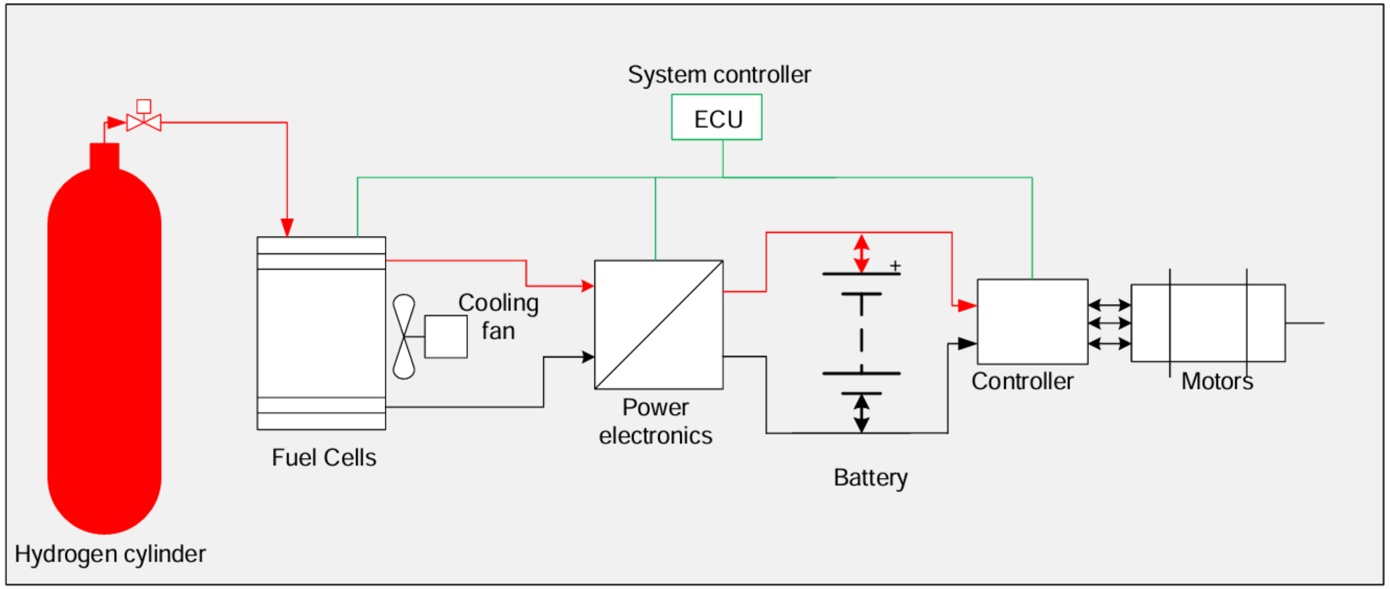
VICOR

Variable wide-range power pack voltage

- DMI’s DP30 power pack has two main power delivery networks (PDNs) that supply power to the drone’s rotors and the intelligent controller for the two stacks
- Due to the wide-range and variable output voltage of the DP30 power pack, from 40 – 74V, the powertrains were designed to ensure a tightly regulated 48V, 12A output to the rotor motors of the drone, plus a 12V, 8A output to the stack controller board and fans.

HFC technology: portability, fast refueling and stealth operation

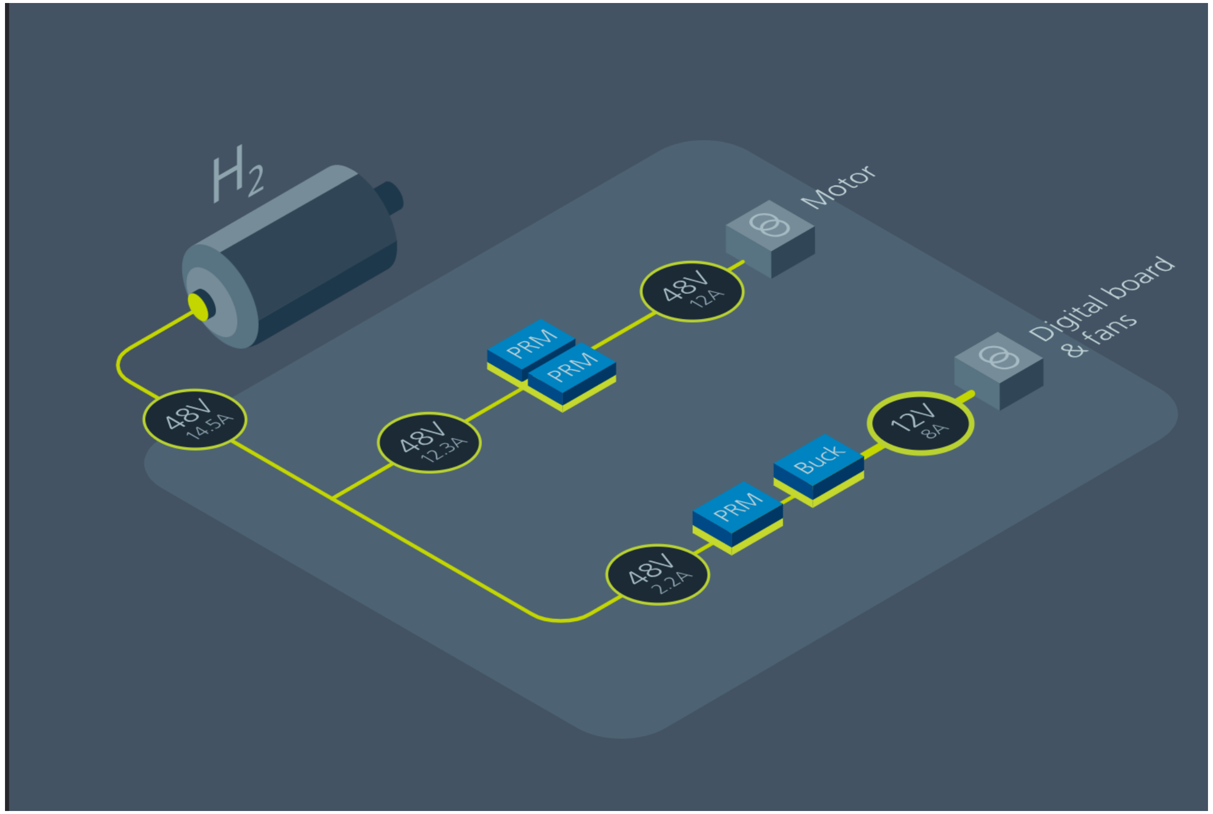
- The major advantage is extended runtime in surveillance missions
- Challenge comes from refueling hydrogen-based drones, new infrastructure is required



- Moving liquid fuel (gas or diesel) is heavy, generators required for in-field battery charging
- The added benefit is these features minimize environmental and operational impact

High-efficiency and high-energy density in the PDN

- The PRM (buck-boost) supports the up to 74V open-circuit voltage of the fuel cell stack providing regulation to 48V
- In the drone's rotor-side PDN, two PRM buck-boost regulators are configured in parallel to supply the 12A
- The digital controller board uses a lower-power PRM followed by a 48V – 12V ZVS buck regulator



Long range UAV applications

Case study – HALE UAVs

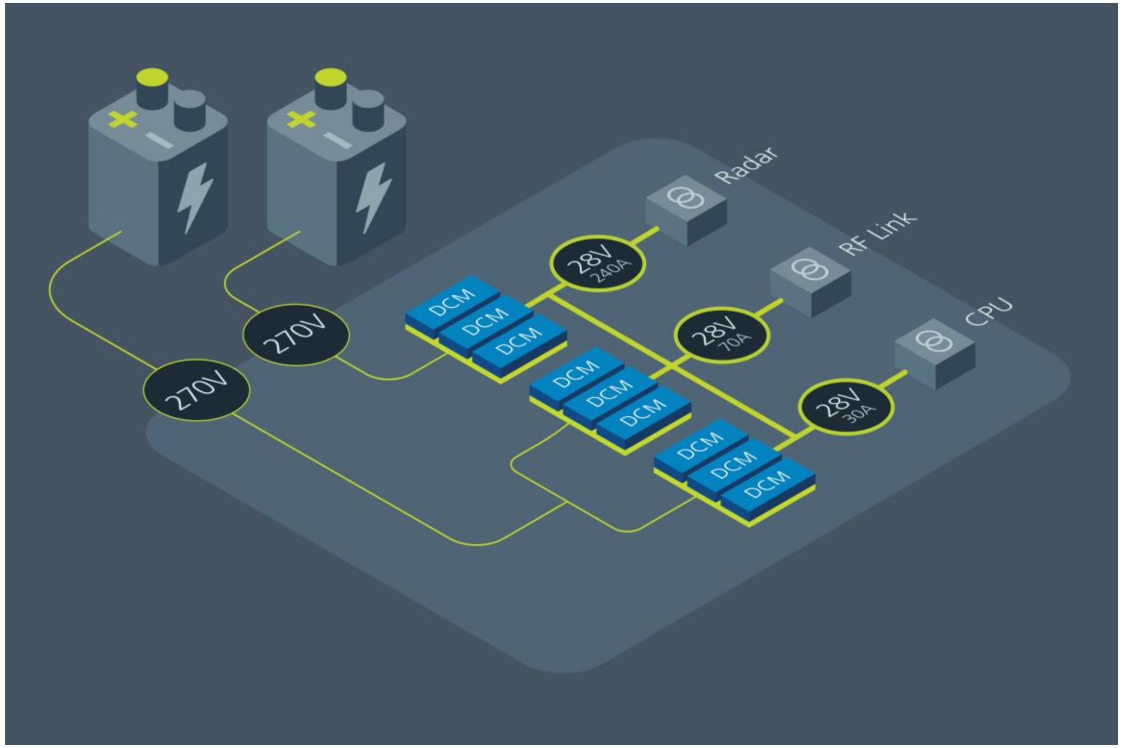
Customer challenges

- Scalable power to adapt to future needs
- A robust and reliable design to maintain continued operation
- A compact and lightweight power supply

Vicor solution

- The DCM™ can be paralleled to accommodate system expansion
- Advanced packaging to manage thermal loads
- An 11kW solution the size of a tablet computer, weighing only 215g

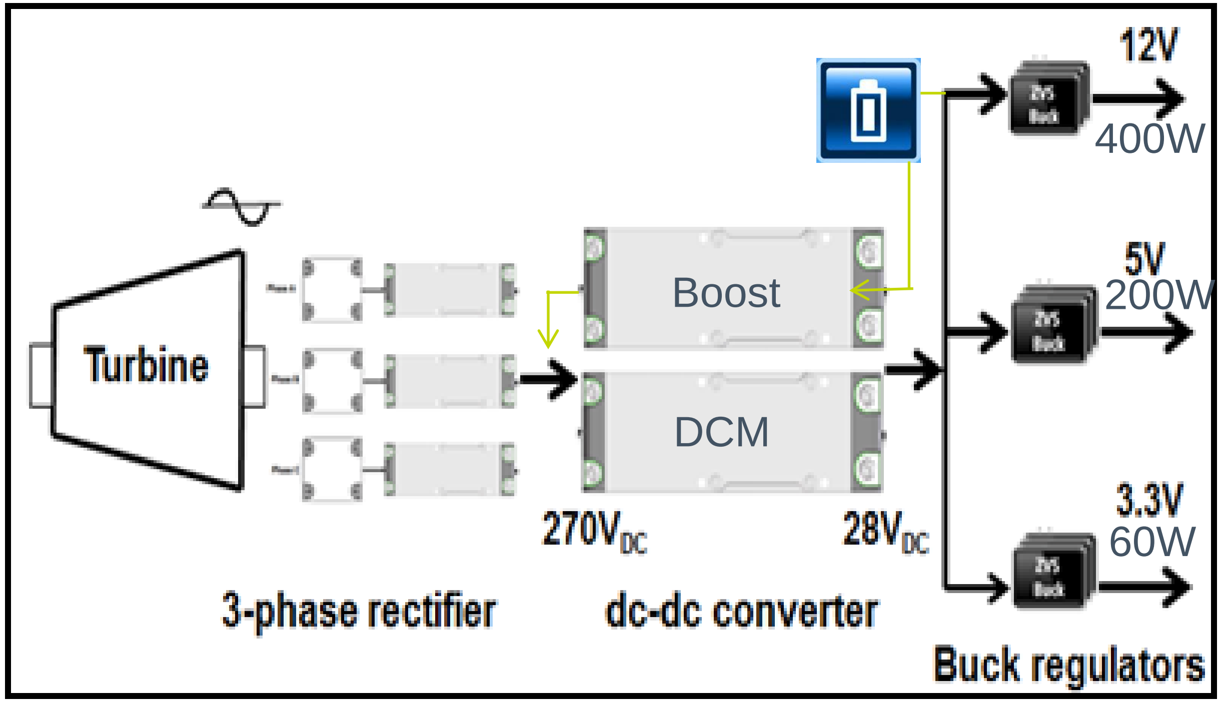
Case study – HALE UAVs



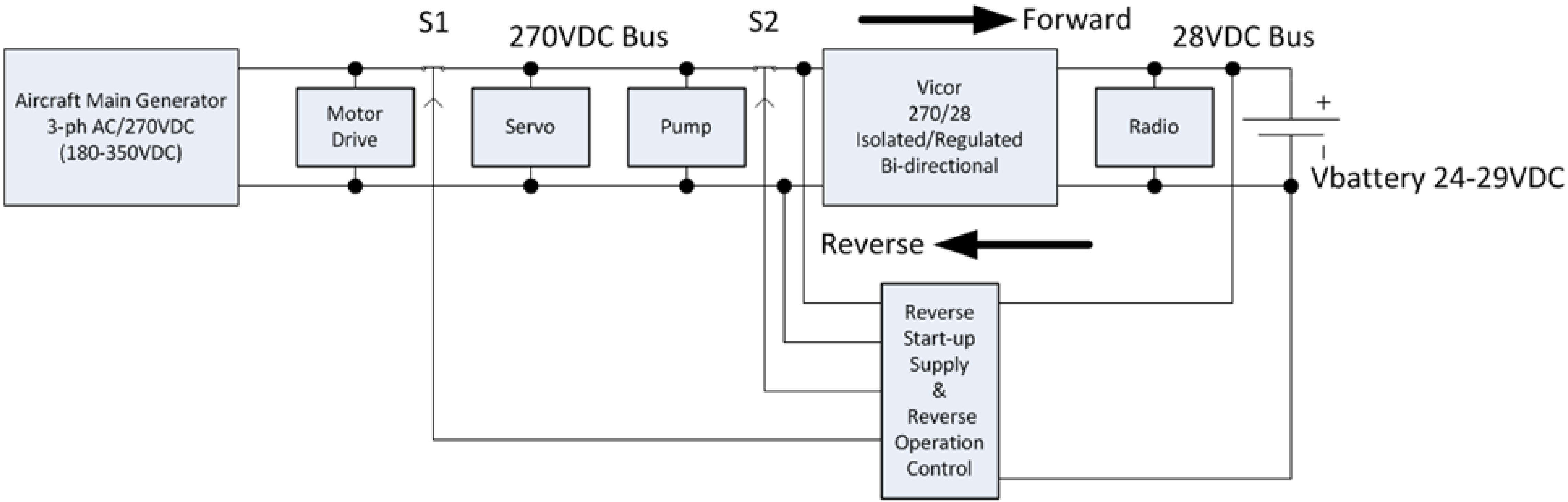
- Three arrays of three 1.3kW DCM5614 converters were paralleled to provide the regulated 28V bus
- Inputs were split between two different generators to provide redundancy of power source.
- The arrays automatically power shared across all nine converters — though their input voltages differed — helping improve system reliability
- Small size, low profile and low weight
- Allows for double the output power without exceeding allocated space constraints
- High efficiency (96%) reduced the size of the heat sink required, saving more space
- Easy to parallel for future increased power needs

Endurance Class UAV Architecture

- SWaP
- Leverage power dense, small form-factor converters with reverse power processing to reduce weight, and increase range and payload capability
- Modular components:
  - 3-phase Front End 400Hz and 270Vout with filter
  - 270Vin to 28Vout @ 1kW
  - 28Vin to 270Vout @ 1kW (demo for customers)



Application: Airborne Vehicle Proposal for Long Range UAVs



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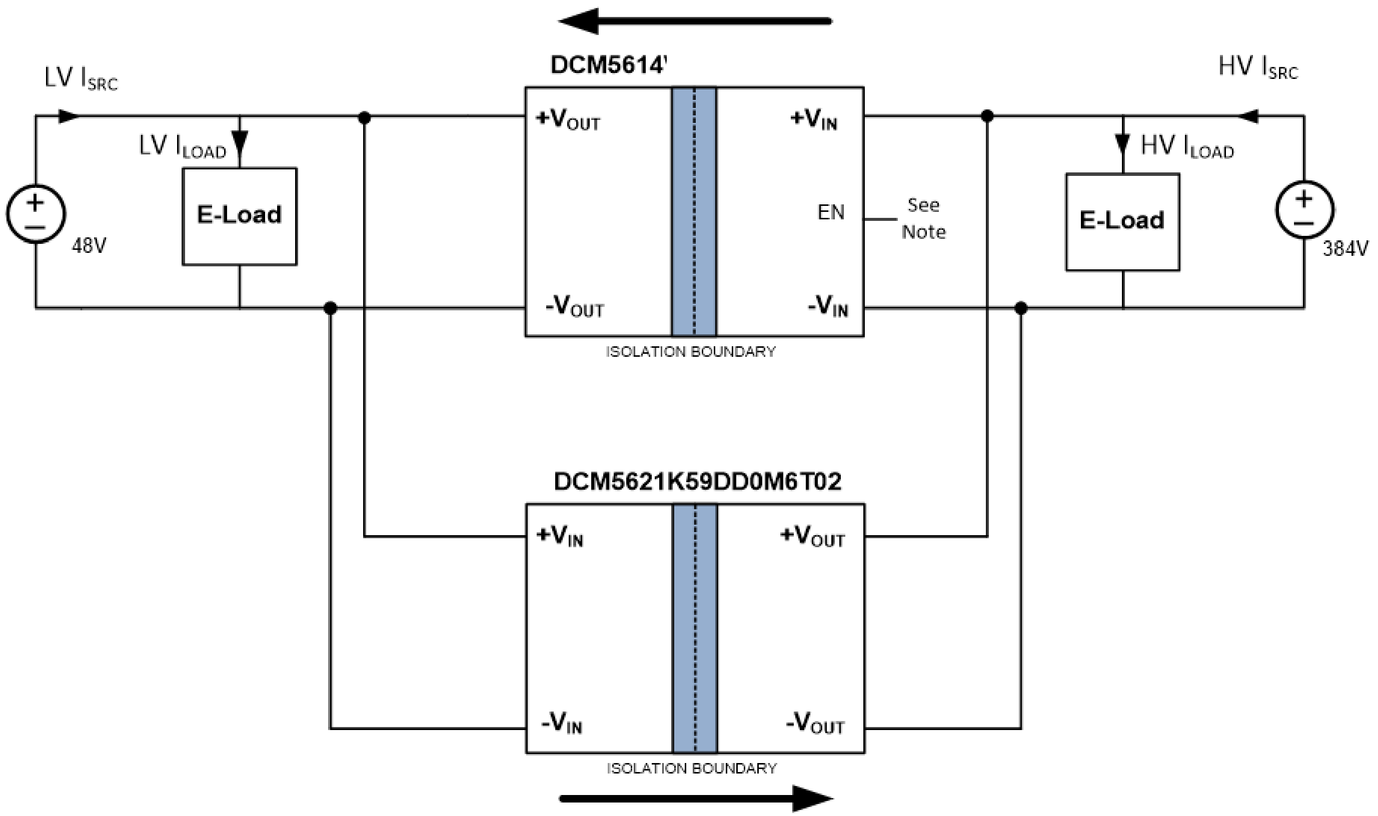
Airborne Vehicle Proposal for Long Range UAVs

- Regulated, isolated bi-directional system hardware demonstration
  - DCM5614VD1E55K8T02 VIA: 384V-48V, up to 1.6kW
  - DCM5621 Super-Brick: 48V-384V, up to 3.6kW
- External voltage sense and logic circuit for automatic control of power flow direction
  - Logic configured to always back up the high voltage bus
  - Avoid condition where both powertrains are active

Operational Overview of bi-directional power train



- External control circuit senses high side bus voltage, and holds DCM5614 EN pin low until DCM5614 V_{IN} > 398
- When DCM5614 V_{IN} < 398, DCM5621 supports high voltage bus

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Examples of Vicor powered UAV applications


Media and entertainment UAVs


Unmanned aircraft for communications


Agricultural UAVs


Surveillance UAVs


Tethered aerial communications UAVs


Tethered aerial vehicles

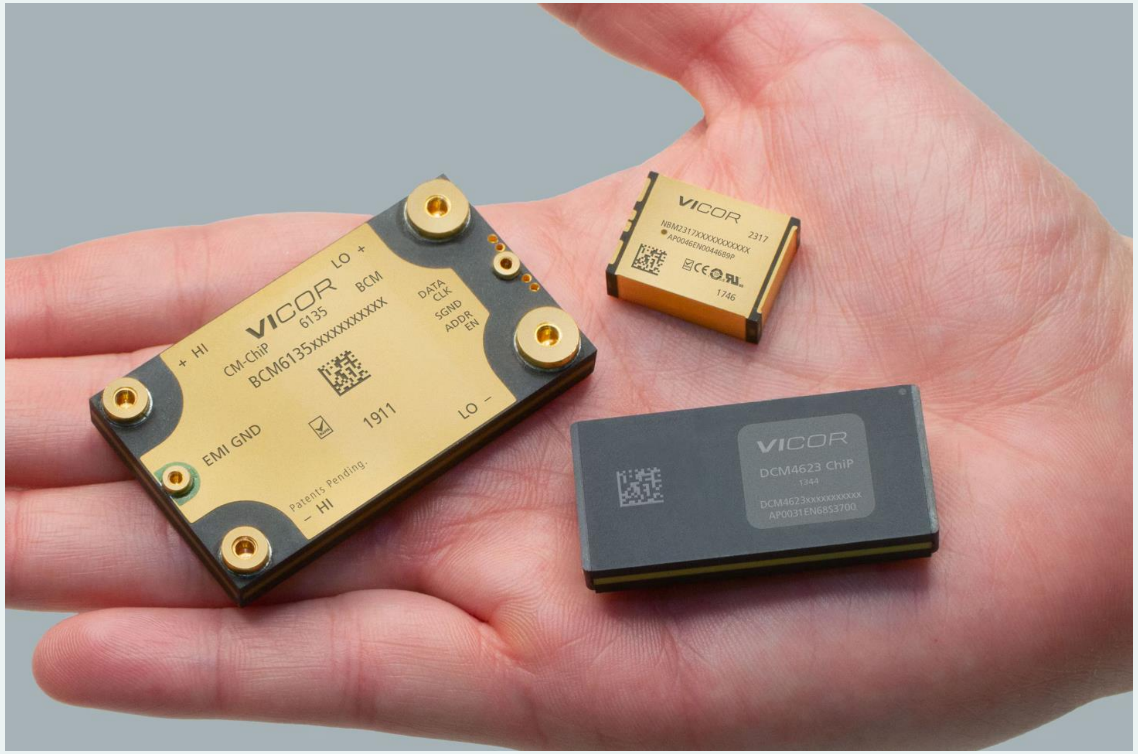

Delivery UAVs


Inspection UAVs


Hydrogen fuel cell-powered UAVs


UAVs with wireless charging

Power-dense modules deliver flexibility, scalability



Thank you

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