



# Intelligent Power & Sensing Solutions for Drones

## An in-depth tutorial

 For more detail, watch the full webinar



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## A Robot that Flies

From a purely mechanical perspective, very little differentiates an airborne drone from an autonomous mobile robot. Brushless DC motors (BLDC) are most often associated with a drone's propeller mechanisms. However, many modern AMR designs also use BLDCs for their mobility as well. Replace the AMR's wheels with propellers, add the guidance and control mechanisms necessary for those propellers to keep the device aloft, and for all intents and purposes, the AMR becomes a drone. A "hybrid" robot with ground and air mobility is not such a far-fetched thing.

This fact can guide you substantially when designing both the power and the sensory systems for a drone. Much of the work has already been done. Your main power source for both devices will very likely be lithium-ion batteries in series. You'll need DCDC power converters to execute the main power rail split for the motors and the electronics. Even the drone's gimbal may not be all that different from the components of an AMR's navigational and positioning sensors.

onsemi is a leading global supplier of intelligent power and intelligent sensing components for both drone and robotic technologies. In this tutorial, you'll see onsemi's best-in-class components for powering every active component of a modern autonomous drone.

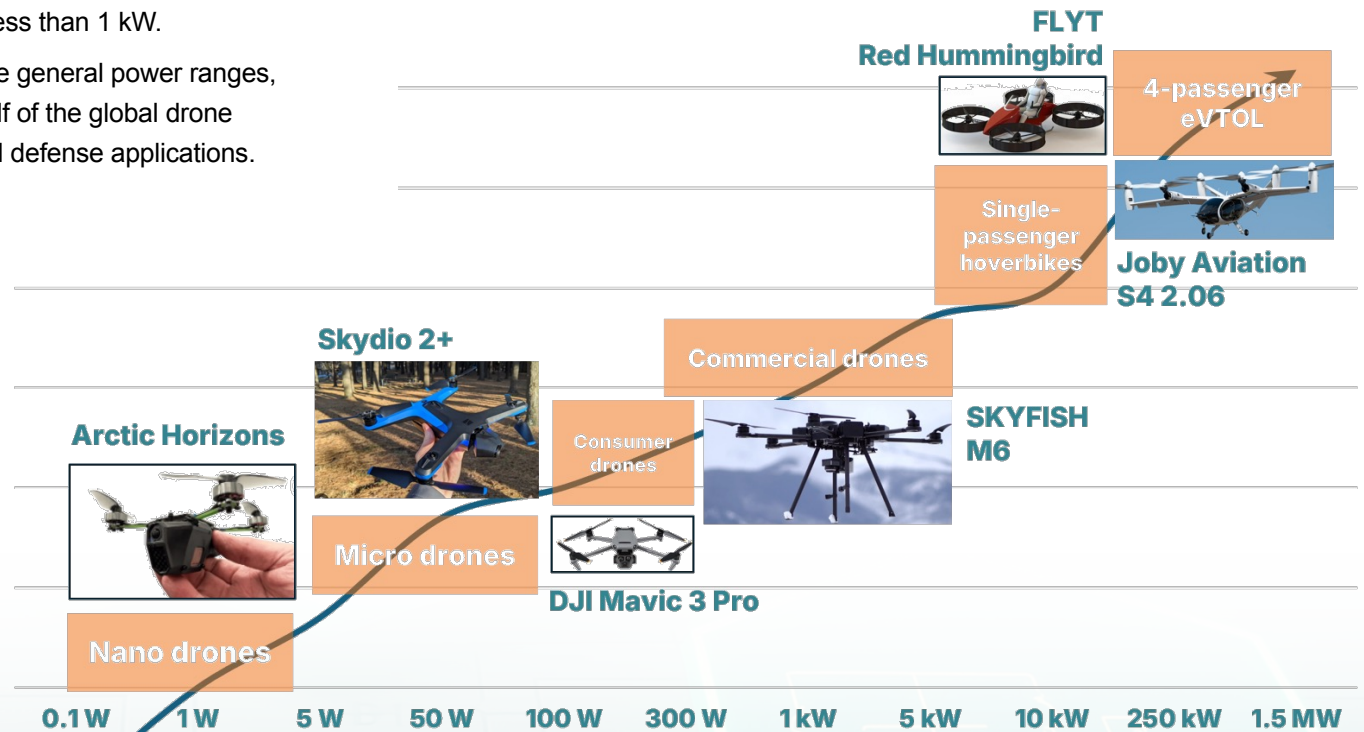


# Drone Classes by Power Consumption Scale

For the vast majority of very small and consumer-grade drones, the total electrical system power consumption is at or below the level of a moderately bright incandescent light bulb. Only when we start adding load-bearing characteristics to the picture do we start thinking in terms of kilowatts, and then megawatts when we add human passengers to its cargo. This tutorial covers power systems for drones whose combined system power draw should be less than 1 kW.

In this chart, each of the orange rectangles represents the general power ranges, in watts, of commercial drones produced today. About half of the global drone market is comprised of purchasing activity for military and defense applications.

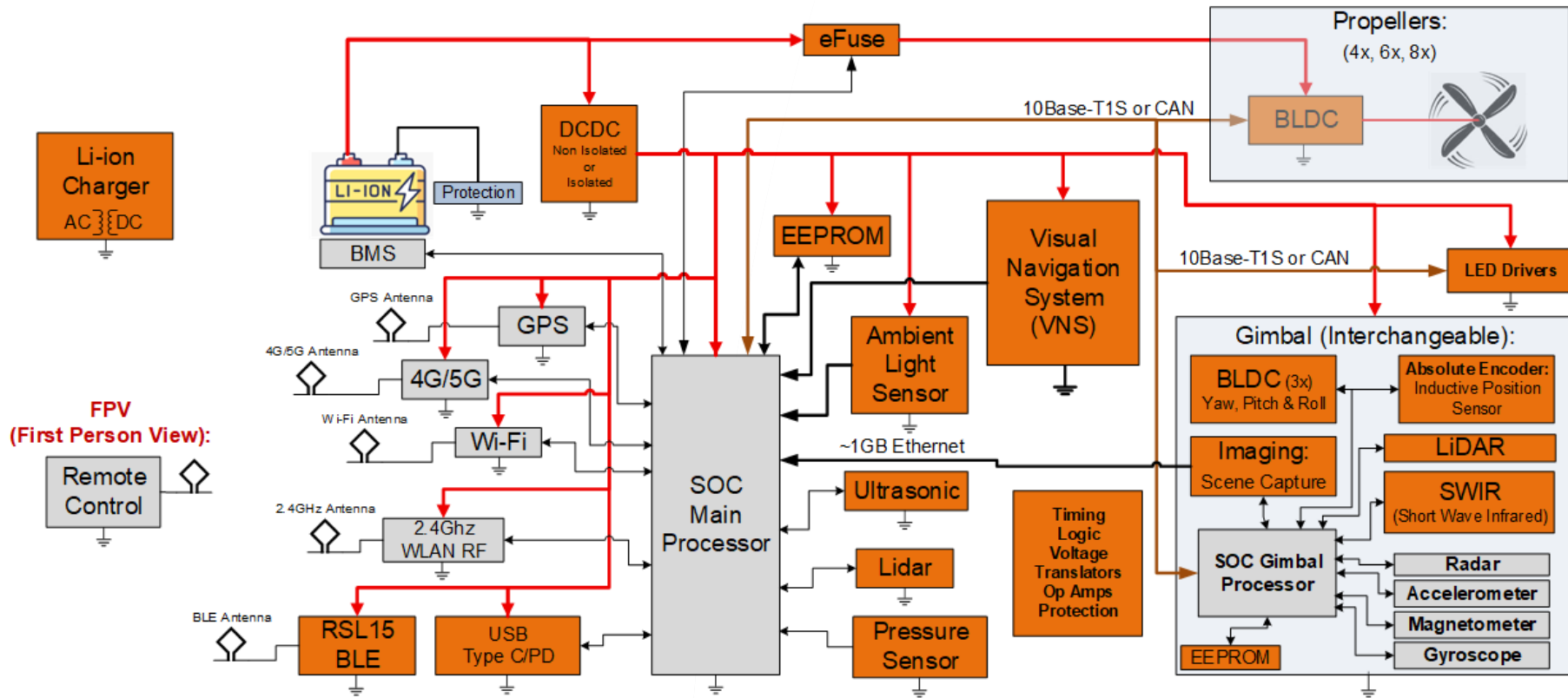
However, especially in terms of smaller-scale devices, defense services are procuring off-the-shelf drones from commercial suppliers, with minimal or even no specialization applied. In many cases, what's already commercially available is perfectly well-suited for defense purposes.



## A Drone's Generic Block Diagram

At the top of a drone's typical block diagram is a power rail that connects directly, by way of an electronic fuse, to the BLDC motors. There will be one BLDC per propeller, and while four is the common number of propellers, many designs utilize eight or more.

To optimize drone flight time, you should design your power system to accommodate as much of the battery-supplied energy as possible. Flight is the critical function of a drone. For this reason, every other function powered by the same batteries (often lithium polymer electrolyte) should be very highly efficient.

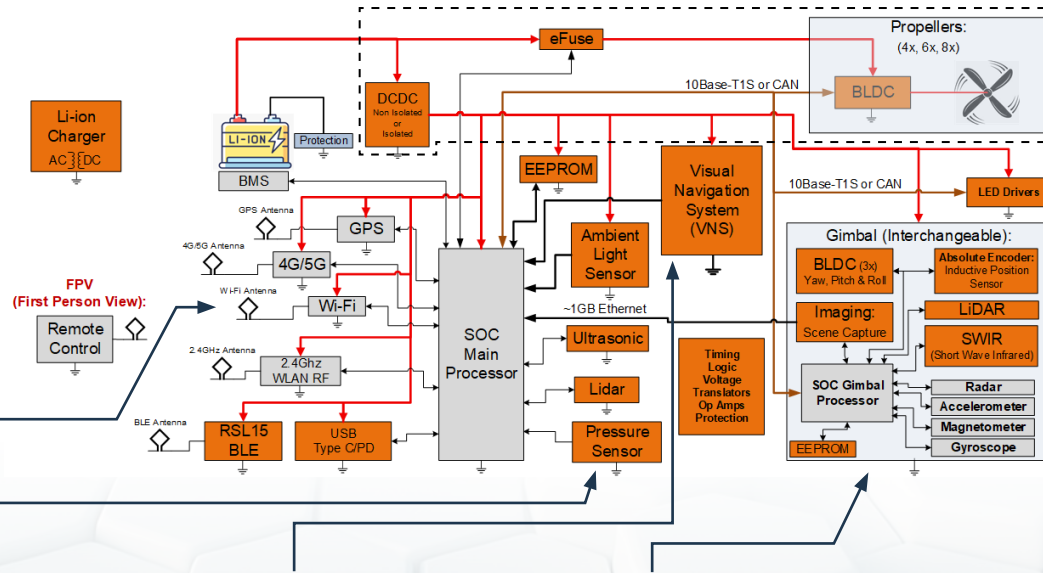


# Interpreting a Drone's Generic Block Diagram

## Subsystems

The drone power system's DCDC converter will serve as the root of the power tree for its electronics and subsystems. The main subsystem is the processor system-on-a-chip. Recently, the processor handles more AI-level, semi-autonomous functionality, enabling the drone to avoid power lines and trees without remote pilot intervention. These functions, naturally, require more on-chip memory, thus raising power requirements.

## Other subsystems include:



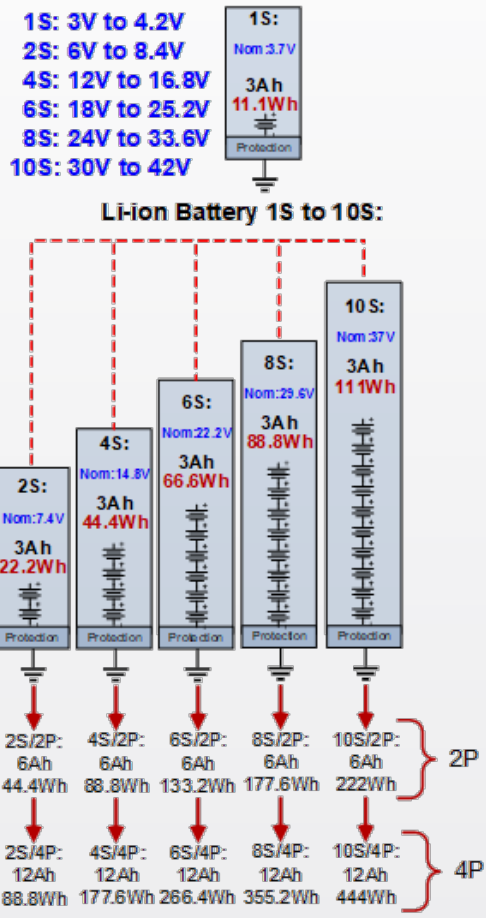
**Wireless communication** using processors similar or identical to what you'd find in smartphones

**Electronic speed controller** — The power and control stage between the battery or DC bus and the BLDC, converting DC power into controlled, multiphase motor (MDM) drive signals, regulating motor speed and torque in response to commands from the MCU

**Sensory functions** such as ambient light sensors, ultrasonic systems, LiDAR, and pressure sensors

**Visual navigation systems** which utilize their own exclusive array of image sensors

**Gimbal systems** that may include image sensors for photography and scene capture, LiDAR and short-wave infrared (SWIR) for range finding, and may also include a separate BLDC for powering radar, accelerometer, magnetometer, and gyroscope



## Connecting Li-Ion Batteries In-Series and Parallel

Lithium polymer electrolyte is the preferred battery type for drones. Although they are among the most expensive, they provide the highest amount of energy storage per volume. For in-series packaging, a single Li-ion power source provides between 3V and 4.2V, with a 10S package (ten batteries in series) provide 30V to 42V. Normally, a power tree for powering a drone would use a fixed-voltage input. However, anything that's Li-ion powered will provide different voltage outputs between 0% and 50% state-of-charge, between 50% and 85%, and between 85% and 100%.

As you place Li-ion battery packs in series, output voltage will increase while capacity remains the same. By contrast, when you place them in parallel, capacity will increase while output voltage remains steady. For example, in the lower right corner of this battery placement chart, four series of 10-battery packs placed in parallel (10S/4P), where each pack delivers a nominal output voltage of 3.7V, would deliver in total 12 amp-hours (Ah) and 444 watt-hours (Wh).

You should always think of voltage outputs as moving targets. For this reason, you should choose a DCDC converter that gives the battery pack enough voltage headroom for the system to tolerate wide voltage swings, while keeping the rest of the powertrain downstream running efficiently.

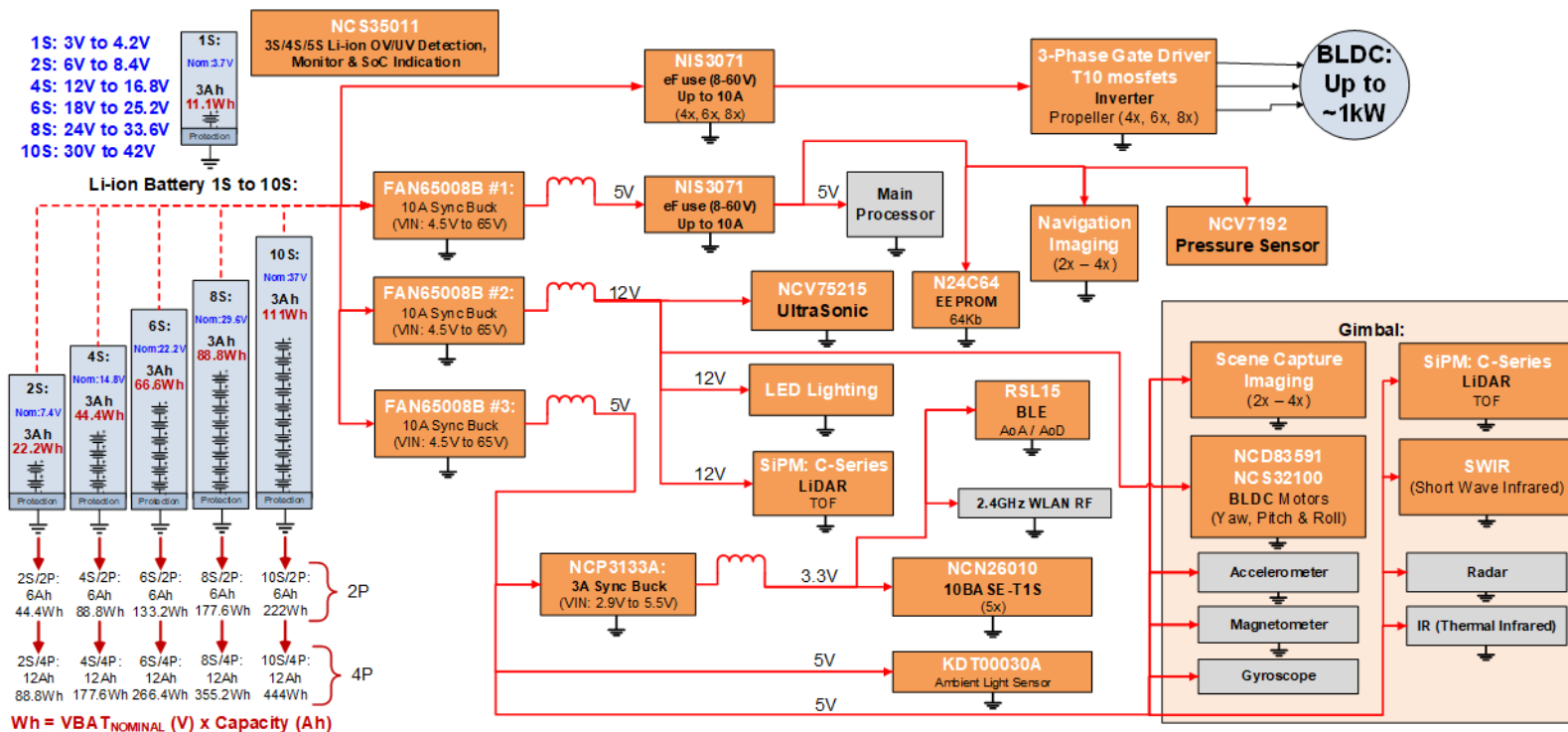
# Components of a Drone's Power Tree

The first DCDC converters in this drone power tree are a trio of onsemi **FAN65008B** 10A synchronous buck converters. These components have a very wide input voltage range  $V_{IN}$  of 4.5V to 65V.

The first buck converter of this trio bucks voltage down to 5V to drive the main processor by way of an **NIS3071** eFuse.

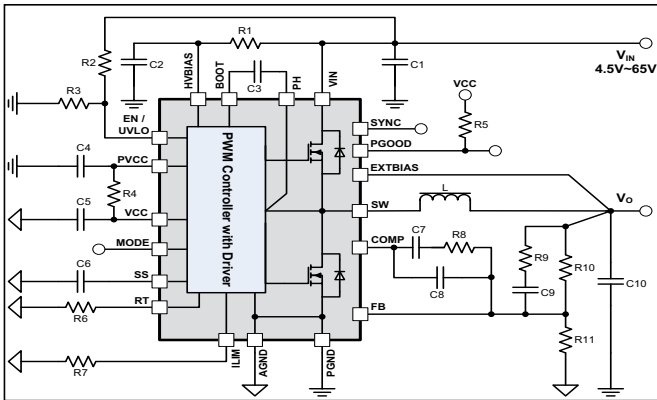
The second drives a 12V rail to drive the **NCV75215** ultrasonic sensor, a silicon photomultiplier (SiPM) for LiDAR, and an LED lighting array. That same rail then powers the BLDC motors in the gimbal for yaw, pitch, and roll.

The third power leg is a 5V rail that powers the **NCN26010** 10BASE-T1S network controller, the **KDT00030A** ambient light sensor, and other subsystems that run on 3.3V input voltage, stepped down using an **NCP3133A** synchronous buck converter.



## onsemi FAN6500xx Synchronous Buck Converter

onsemi produces three devices in the FAN6500xx synchronous buck converter family, for 6A (FAN65004C), 8A (FAN65005A/B), and 10A (FAN65008B) applications. These parts are designed to be used as high-voltage point-of-load DCDC converter modules, for use in telecommunications, networking, and industrial equipment. All use the PQFN 6x6 mm, 35-lead form factor. High-side/low-side switches are integrated. Frequency is programmable by way of an external resistor, from 100 kHz to 1 MHz.



**Input Voltage Range:** 4.5V to 65V

### Output Current & Voltage

- Continuous current: 6A to 10A
- Output voltage: 0.6V to 55V

### Buck Regulator

- Constant frequency voltage-mode controller
- DCM with pulse skipping for light load efficiency
- Programmable frequency 100kHz – 1MHz
- Frequency synchronization – master or slave

### Additional Features

- Precision reference voltage, VREF,  $\pm 1\%$  over temperature
- High-voltage LDO for single-supply operation
- Selectable VO LDO for  $VO \geq 5V$  to reduce system power loss
- Adjustable soft-start timing
- Low shutdown current
- External compensation for wide operating range
- Support pre-bias startup
- Enable with precision reference for accurate adjustable input voltage UVLO
- Power good indication
- Integrated high performance MOSFETs

### Protection

- VIN UVLO (adjustable), VO UV&OV
- Over load and short-circuit
- Thermal shutdown

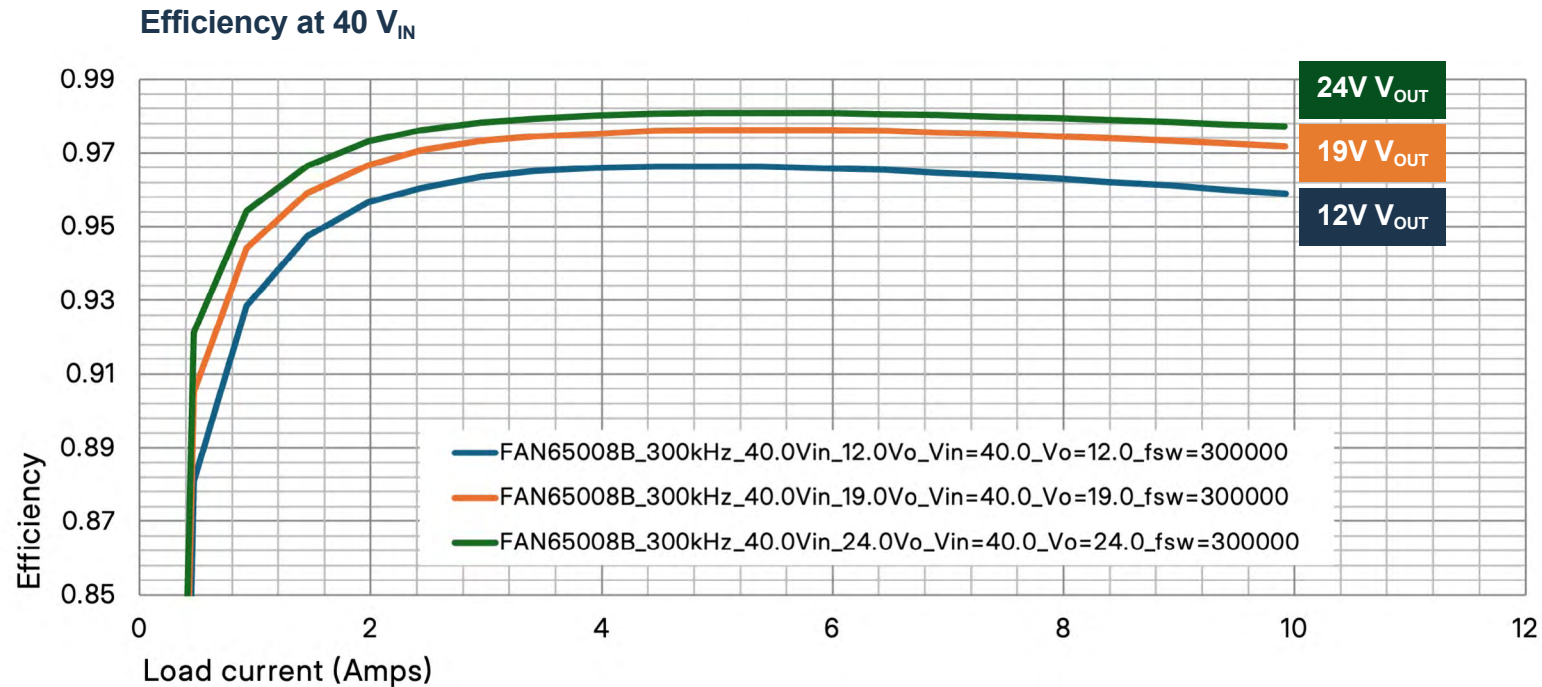
### Package

- PQFN 6x6mm 35L

# onsemi FAN65008B Synchronous Buck Converter

## Charting efficiency

This chart measures the efficiency levels of an onsemi **FAN65008B** 10A power converter at three output voltage  $V_{OUT}$  levels. With 40V  $V_{IN}$  and 12V  $V_{OUT}$ , efficiency is just under 97% at 6A of current. At 19V and 24V  $V_{OUT}$ , efficiency levels are well above 97%. You can draw a straight-correlation between power efficiency and flight time using higher-efficiency synchronous bucks such as onsemi **FAN6500xx** throughout your system.



## onsemi NIS(V)3071 eFuse

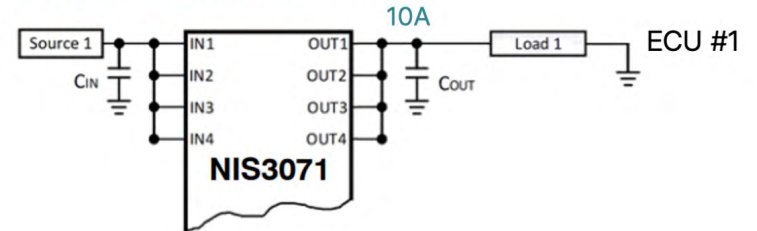
### Scalability

It's very important to have plenty of power protection throughout your drone power system design. onsemi's **NIS3071** (as well as its automotive-qualified counterpart **NIV3071**) provides excellent performance, flexibility, and scalability. It has an input voltage  $V_{IN}$  range of 8V to 60V, along with four 2.5A channels, each capable of handling 150W loads. You can group these channels together to form one virtual 10A channel handling a 600W load, or two virtual 5A channels handling 300W loads. Each channel utilizes its own exclusive enable pin, and includes a fault pin output that delivers status information by way of a truth table.

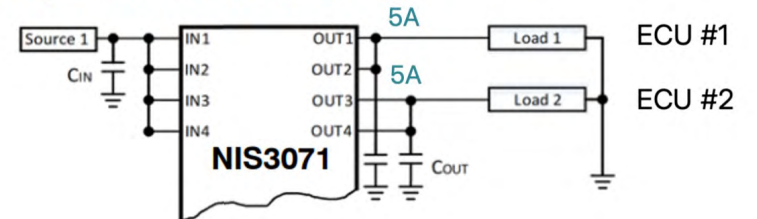
### Features:

- Input voltage range 8V to 60V
- 4 independent channels with 2.5 A current capability each
- Power device thermally protected for each channel
- No external current shunt required
- Active-high digital enable pin
- Open-drain common fault pin
- Adjustable overcurrent limit for all channels
- Adjustable turn-on time control

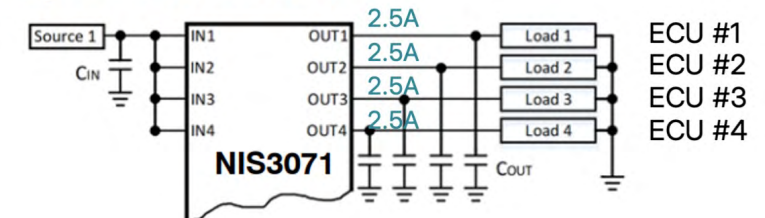
### Up to 1× 600W load



### Up to 2× 300W loads



### Up to 4× 150W loads



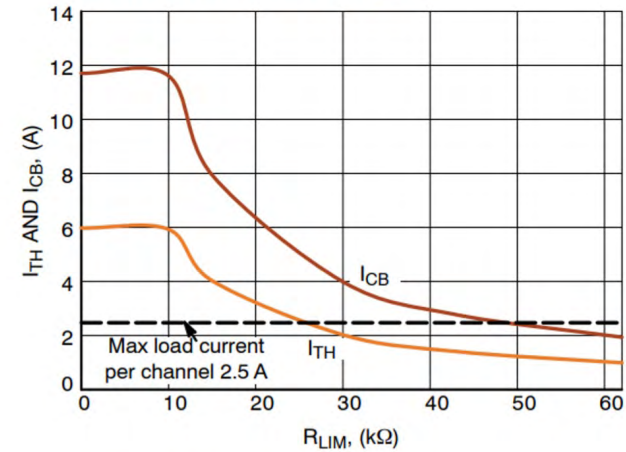
# onsemi NIS(V)3071 eFuse

## Flexibility

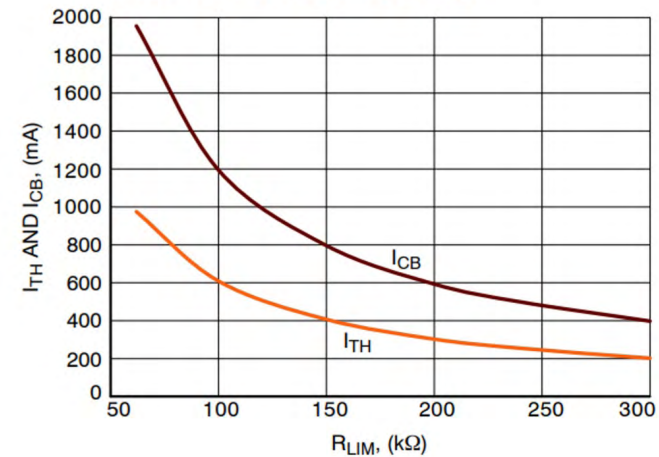
onsemi **NIS3071** and **NIV3071** eFuses both feature overcurrent protection. Here, the overcurrent protection circuit monitors the load current, allowing the load to draw current as long as its level remains within the allowable overcurrent range. The minimum value of that range  $I_{TH}$  is set by the current limiting resistor  $R_{LIM}$ . The maximum range value  $I_{CB}$  will be two times  $I_{TH}$ . As long as the load for a specific channel draws current not exceeding  $I_{CB}$ , the FET will be on; if the current exceeds  $I_{CB}$ , then the FET is turned off. Optionally, you can use the built-in overcurrent trip timer that can shut off the FET after a specified time interval, once the current level has risen beyond the set  $I_{TH}$ .

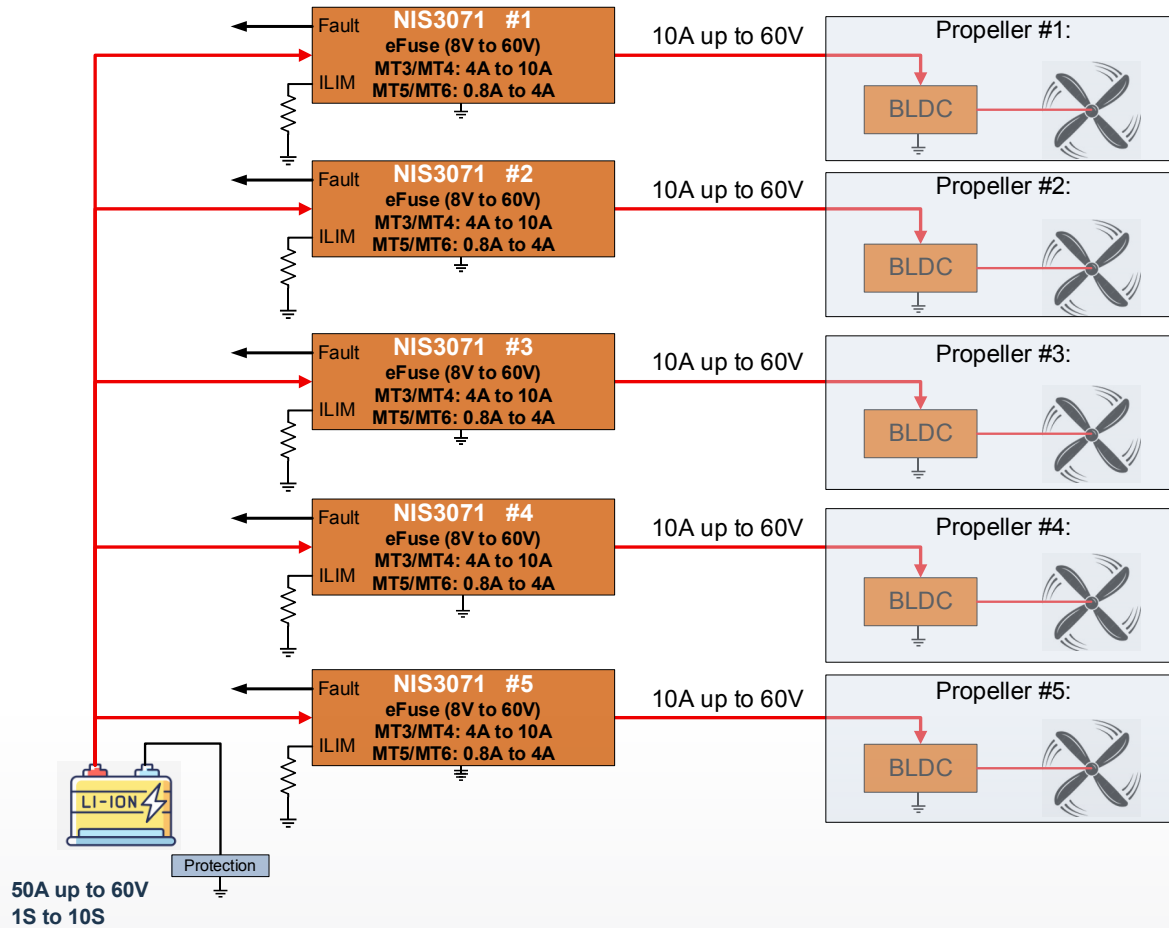
Using the built-in  $I_{LIM}$  current input limiter with an external resistor, you can change the value of the current limiting for each channel. The top chart shows the current limiting range for low-current fuses **NIV3071MTW3TWG** and **NIV3071MTW4TWG**, with  $I_{LIM}$  in the range of 1A to 2.5A, for values of  $R_{LIM}$  from 0 k $\Omega$  to 60 k $\Omega$ . The bottom chart shows the current limiting range for higher-current fuses **NIV3071MTW5TWG** and **NIV3071MTW6TWG**, with  $I_{LIM}$  in the range of 200 mA to 1A, for values of  $R_{LIM}$  from 60 k $\Omega$  to 300 k $\Omega$ .

**ILIM: 1A to 2.5A range**



**ILIM: 200mA to 1A range**

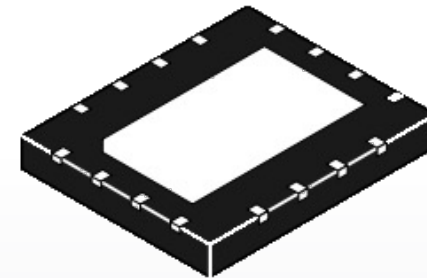




## onsemi NIS(V)3071 eFuse

### Brushless DC motor protection

This part of the drone block diagram shows an array of propellers, each powered by a BLDC motor, tied in parallel to the Li-ion battery pack. In series with each propeller is an **NIS3071** eFuse. In the case of a short circuit event in one propeller, where there's lots of current going through, the rest of the drone may be protected from any adverse effect. **NIS3071**'s wide input voltage  $V_{IN}$  range of 8V to 60V makes it well-suited for 10S battery pack configurations.



**onsemi NIS(V)3071**  
WQFN16 6x5  
CASE 510CM

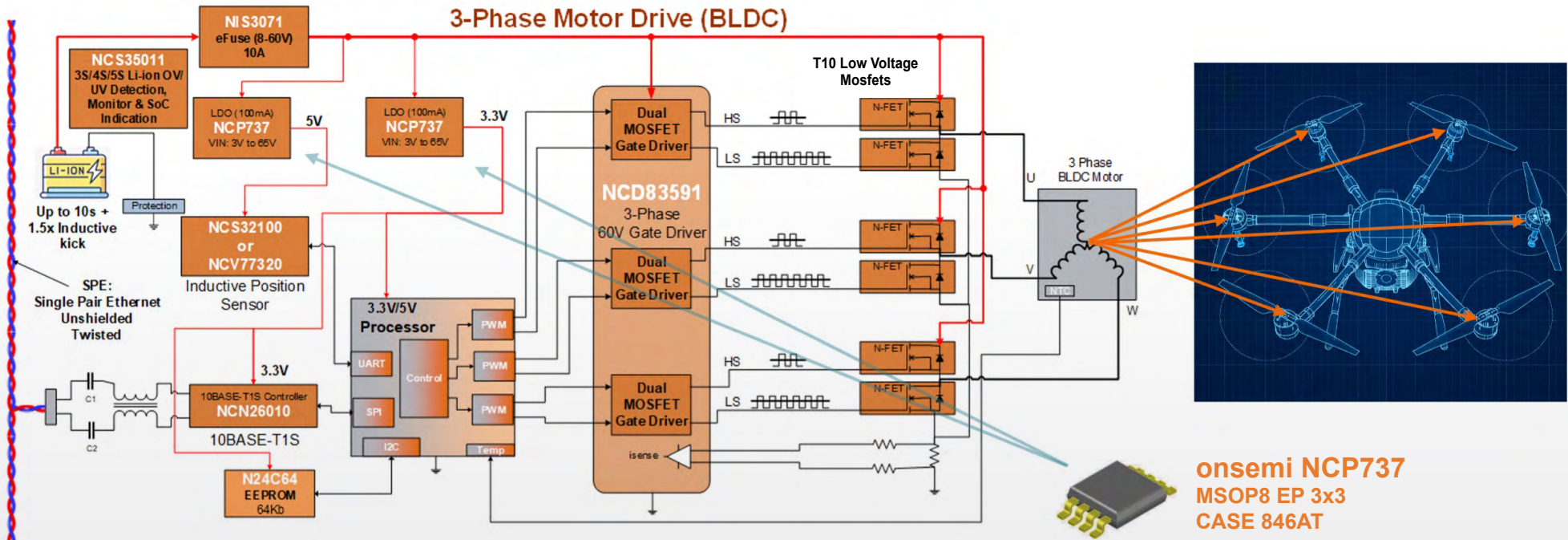
1 channel: 80mΩ (typical)  
4 channel parallel: 20mΩ (typical)

# Power Tree for a Propeller's Brushless DC Motor (BLDC)

Each of a drone's three-phase BLDC motors uses **U**, **V**, and **W** windings for spinning the rotor, each of which leads to a high-side and low-side pair of 40V **T10M** N-channel MOSFET switches, with very low on-resistance  $R_{DS(on)}$ . Collectively, this "six-pack" of high- and low-side switches are driven by onsemi's **NCD83591** three-phase gate driver, rated up to 60V. The gate driver is tied to the battery pack by way of an **NIS3071** eFuse in-series.

In the diagram below, there is an MCU providing pulse width modulation (PWM) for the NCD83591 three-phase gate driver; an MCU connected to sensors, LiDAR, and wireless connectivity; and an MCU driving the BLDC motor to spin the propeller. For the BLDC, the modulation pattern may be trapezoidal, sinusoidal, or field-oriented control (FOC).

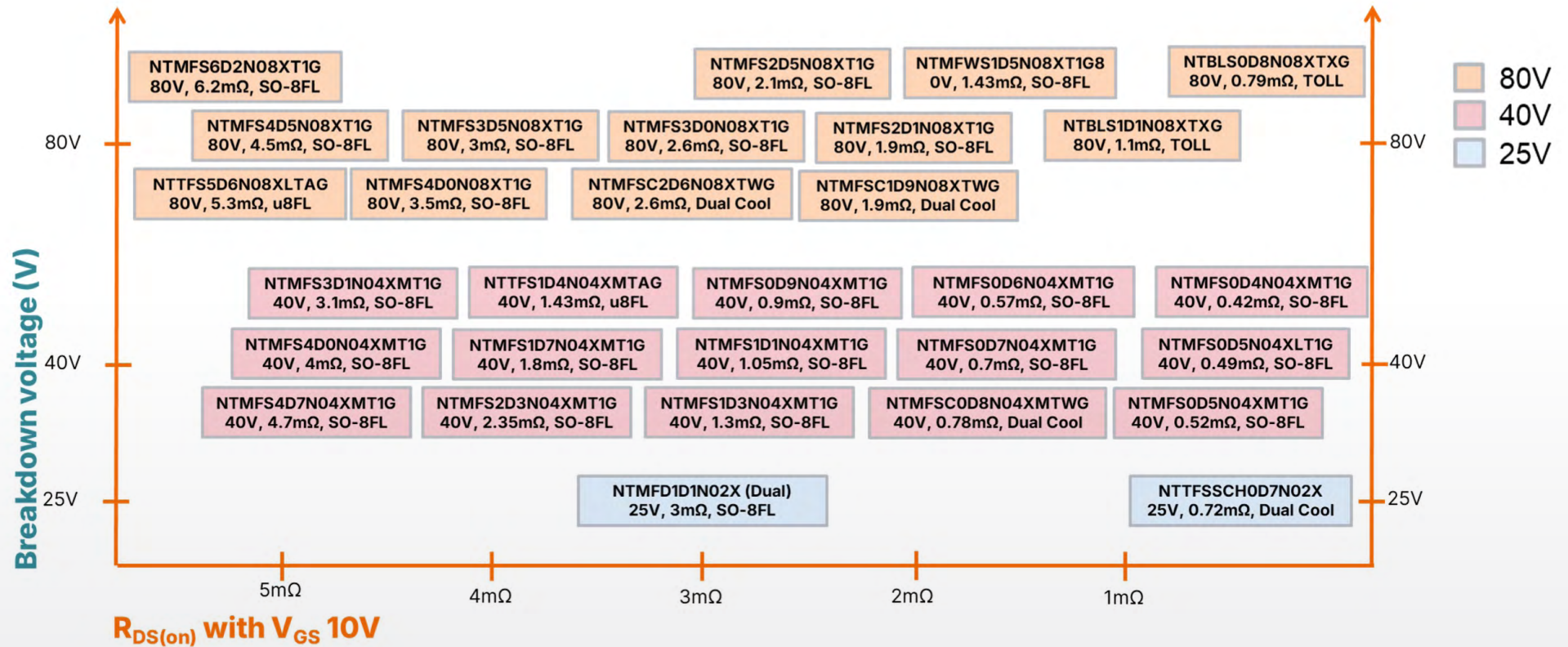
Protecting the processor is a pair of **NCP737** high-voltage tolerant LDO linear regulators, capable of withstanding continuous DC or transient input voltages up to 65V, with ultra-low quiescent current below 5  $\mu$ A.



## Range of T10 Low-Voltage MOSFETs for BLDC

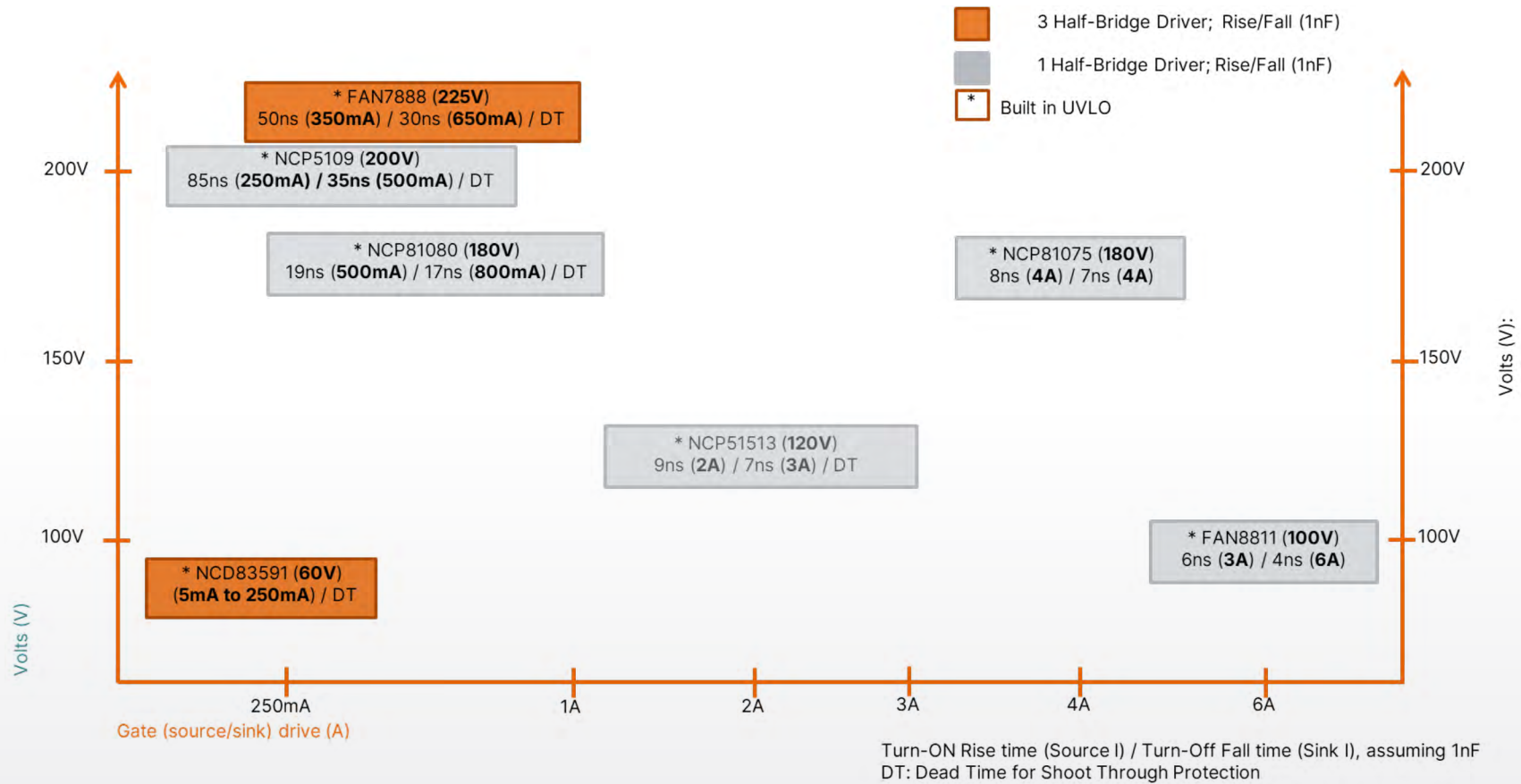
onsemi is a global leader in the market for low-voltage MOSFETs. This chart depicts the full range of onsemi T10 low-voltage MOSFETs, representing their comparative on-resistance ranges  $R_{DS(on)}$  at gate-to-source voltage  $V_{GS}$  at 10V along the X-axis, and breakdown voltage rating (at which the part “breaks down” and switches from being insulating to being conductive) along the Y-axis. Note

there are plenty of MOSFET options with lower than 1 mΩ of  $R_{DS(on)}$  at breakdown voltages of 80V, 40V, and 25V. For a drone’s BLDC, the lower the  $R_{DS(on)}$ , the lower the conduction losses, and in turn the greater the efficiency, which ultimately extends flight time.



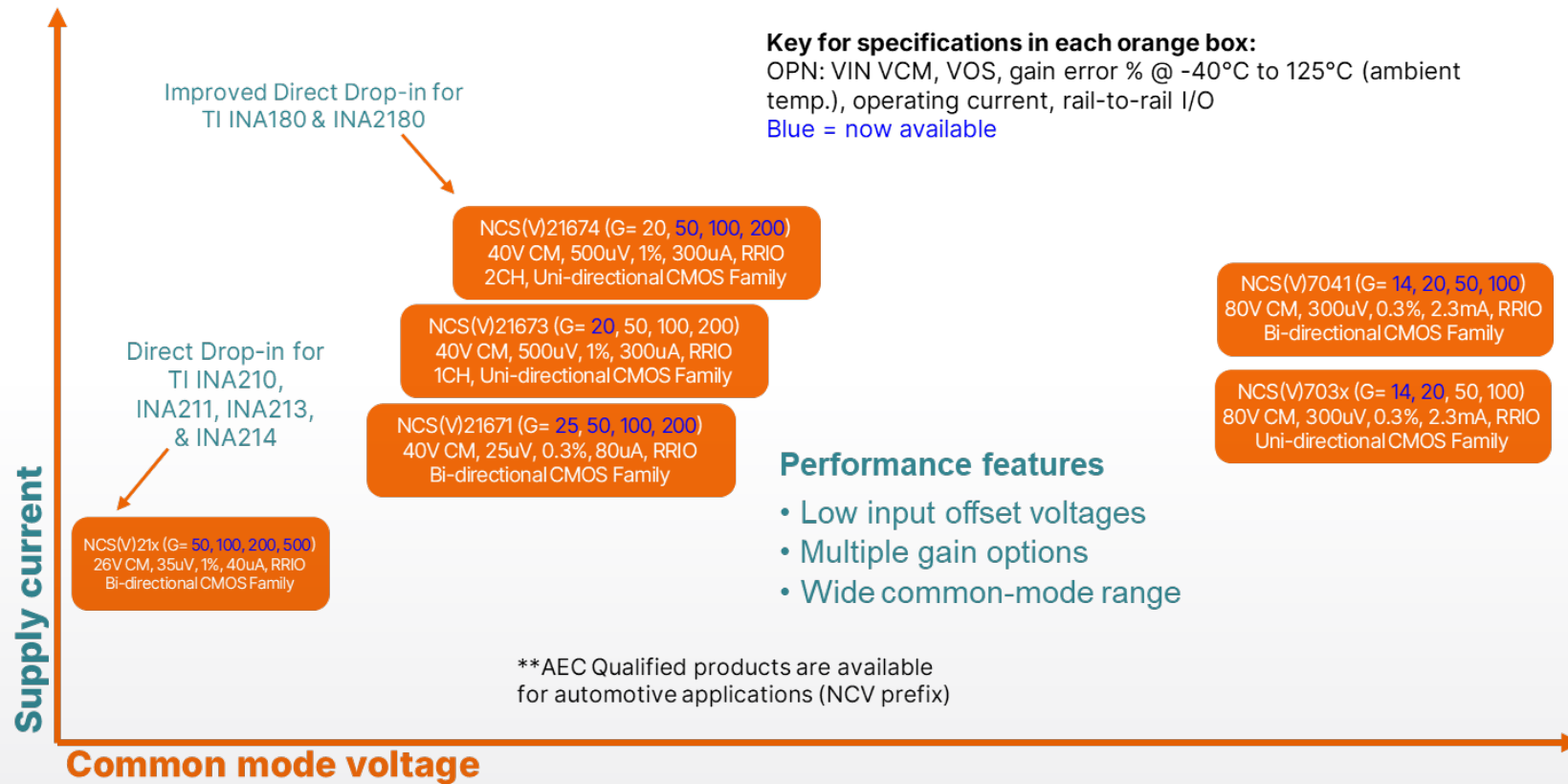
## onsemi BLDC Low-Voltage Gate Driver Portfolio

This chart represents the full portfolio of onsemi low-voltage gate drivers for drones' BLDC motors. The orange blocks represent three-phase parts, while the grey blocks represent half-bridge parts (three of which would be required for a BLDC instead of one three-phase). All of these parts feature UVLO.



# onsemi Current Sense Amplifier Portfolio

This chart represents onsemi’s portfolio of current sense amplifiers with integrated resistors, which may be used to measure phase current for the BLDC. Here, the x-axis represents common mode voltage range. On the far left you’ll find onsemi **NCS21x / NCV21x** rated for 26V common mode voltage. The three parts in the middle are rated for 40V, and the two on the far right for 80V.



## A Drone's Two Separate Vision Systems

### Visual Navigation System

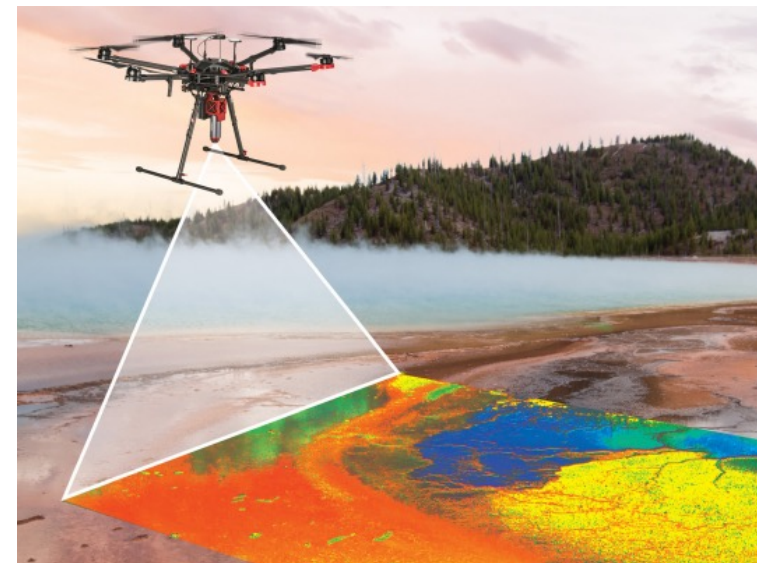
The visual navigation system (VNS) of a drone includes the cameras responsible for autonomous motion control features such as collision avoidance, basic navigation, and Simultaneous Location and Mapping (SLAM). To enable SLAM, a VNS would employ multiple cameras and other sensors including GPS, aided by algorithmic processing.



VNS

### Gimbal imaging

The image sensors attached to a drone's gimbal are generally used for photography, scene data capture, object inspection, and/or object tracking. The first-person view (FPV) from the drone is typically supplied by this system and may be utilized by a pilot, so even though this may be key to navigation, the FPV camera is separate from image sensors used for autonomous navigation. Thermal, telephoto, and high-resolution cameras, as well as LiDAR and SWIR sensors may also be mounted here. These sensors' mounts leverage 9-axis precision, using a gyroscope, accelerometer, magnetometer, absolute encoder (deducing rotors' position and rotational velocity without having to monitor rotation itself), to eliminate vibration and shaking. Three more BLDCs are contained within the gimbal for yaw, pitch, and roll.



## onsemi Hyperlux Image Sensor Portfolio

This table lists the image sensors in onsemi's **Hyperlux** portfolio that are applicable to drones' gimbal imaging systems and navigation systems. Note that entries here are grouped by function: FPV cameras, VNS sensors, infrared (IR) sensors, and depth sensors. A *global shutter*, which exposes all regions of an image to the photodiode at once, eliminates the illusion of moving objects appearing to have distorted or translucent shapes. Other categories of note include the following:

**Dynamic range** refers to the sensor's capability to reproduce an image in low-light conditions.

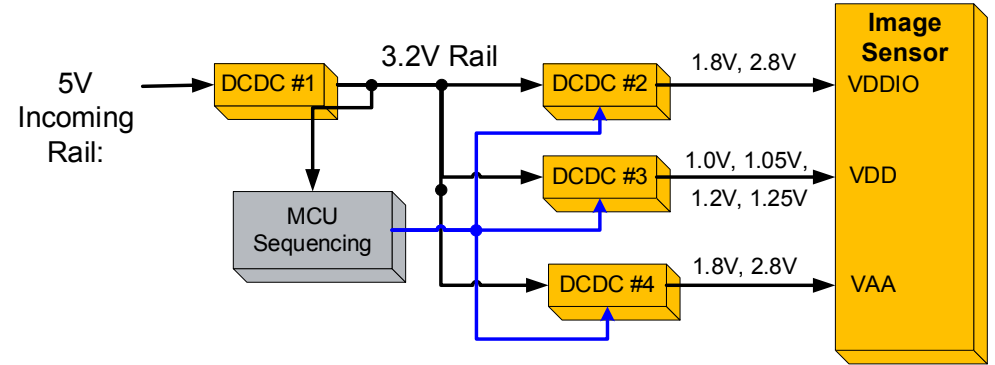
**SmartROI** (region-of-interest) enables the sensor to perceive the entire scene in front of it, plus a particular region of the scene zoomed up-close, simultaneously.

**Context switching** enables a sensor to reset itself immediately whenever it is focused on far distances, and a near object comes into its field of view.

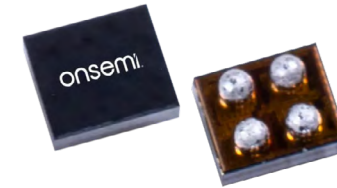
Camera	onsemi devices	Pixel size	Shutter type	Max FPS	Max dynamic range	Scaler	SmartROI	Context	Subsampling modes
FPV	20MP – AR2020 12MP – coming soon	1.4 2.0	Rolling	60	~96dB LI-HDR 120dB eHDR	Yes	Yes	up to 7	Yes
	8MP – AR0823	2.1	Rolling	60	110dB (1-exp) 150dB (3-exp)	No	No	up to 7	Yes
	8MP – AR0822	2.0	Rolling	60	120dB eHDR	No	No	up to 7	Yes
VNS	1MP – AR0144 1MP – AR0145	3.0 2.8	Global	60 120	72dB 65dB	No	No	up to 4	Yes
	2MP – AR0234 2MP – AR0235	3.0 2.8	Global	120	72dB 65dB	No	No	up to 4	Yes
	2MP – AR0246 3MP – AR0341 8MP – AR0821, AR0822 8MP – AR0823	2.0 2.1 2.1, 2.0 2.1	Rolling	60	120dB (with ALTM) 110dB (1-exp), 150dB (3-exp) Upto 140+dB 110dB (1-exp), 150dB (3-exp)	No	No	up to 7	Yes
	VGA, 1MP, 2MP – SWIR Cameras 4MP, 6MP – SWIR Sensors; Acuros4, Acuros6	15.0 7.0	Global	100	68dB 70dB	No	No	No	Yes
Depth	1.3MP – AF0130, AF0131 (iToF)	3.5	Global	60	67dB	No	No	up to 64	Yes

## Components of an Image Sensor's Power Tree

The table below lists onsemi **Hyperlux** parts appropriate for use in drone applications. At right, the power tree contains four reserved boxes (in yellow) for DCDC power converters, needed to step down power from a 5V incoming rail to the three different, lower voltage rails used by the image sensor (**VDDIO**, **VDD**, and **VAA**). The table lists the optimum onsemi LDO power regulators for each of the four DCDC slots in the power tree, for each drone-appropriate image sensor in the Hyperlux portfolio.

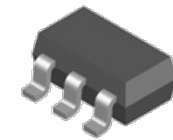


Item #	Image sensor	Family	Pixels	DCDC 1	DCDC 2	DCDC 3	DCDC 4
1	ARX383	Hyperlux SG	0.3MP	NCP163	NCP114	T30LxPSR165	n/a
2	AR0145	Hyperlux SG	1MP	NCP161	NCP114	T30LxPSR165	NCP163
3	AR0235	Hyperlux SG	2MP	NCP161	NCP114	T30LxPSR165	NCP163
4	AR2020	Hyperlux LP	20MP	NCP189	NCP114	NCP189	NCP163
5	AR0830	Hyperlux LP	8MP	NCP161	NCP114	NCP189	NCP163
6	AR0544	Hyperlux LP	5MP	NCP161	NCP114	T30LxPSR165	NCP163
7	AR0822	Hyperlux LH	8MP	NCP189	NCP114	NCP189	NCP163
8	AR0246	Hyperlux LH	2MP	NCP161	NCP114	T30LxPSR165	NCP163
9	AF0130	Hyperlux ID	1.2MP	NCP163	NCP3135	T30LxPSR165	n/a
10	AR0341	Hyperlux	3MP	FAN53745	NCP114	NCP189	NCP163
11	AR0823	Hyperlux	8.3MP	FAN53745	NCP114	NCP189	NCP163



**onsemi**  
**T30LMPSR165 LDO**  
**T30LAPSR165 LDO**

40% faster transient response



**onsemi**  
**NCP163 LDO**

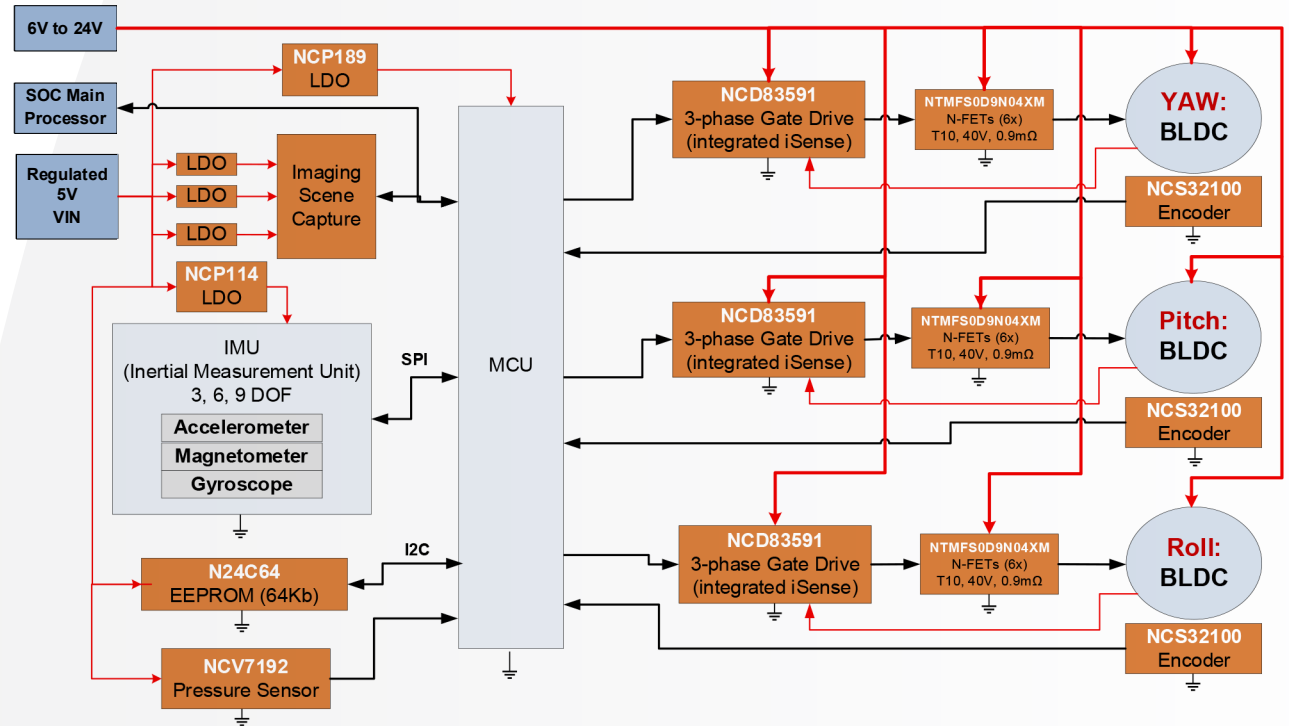
92 dB PSRR @ 1 kHz 6.5 μV noise

## Block Diagram for a Drone's Gimbal Component

A gimbal is an almost boutique piece of equipment that hangs from the bottom of the drone. It provides high stability for image capture in very harsh environments. For this reason, the gimbal features separate BLDC motors for yaw, pitch, and roll. These motors are often highly specialized to minimize vibration.

The microcontroller unit (MCU) of a modern drone gimbal is responsible for coordinating stabilization and motor-control functions. It receives inputs and commands from sensors, and responds by driving the gimbal motors through the use of control algorithms including, where implemented, *field-oriented control*. FOC manages the motor's output current (stator current) so that the perpendicular and parallel forces generated by the magnetic coils, relative to the pole axis of the rotor, are handled as separate loops. Perpendicular (quadrature) forces that do generate rotational torque (Q-torque) are maximized, while parallel forces that do not generate torque (D-torque) are minimized.

Typically housed within a drone's gimbal is its inertial measurement unit (IMU), which includes the accelerometer, magnetometer, and gyroscope. Also included is an EEPROM memory unit (onsemi recommends **N24C64**) and a pressure sensor (**NCV7192**).

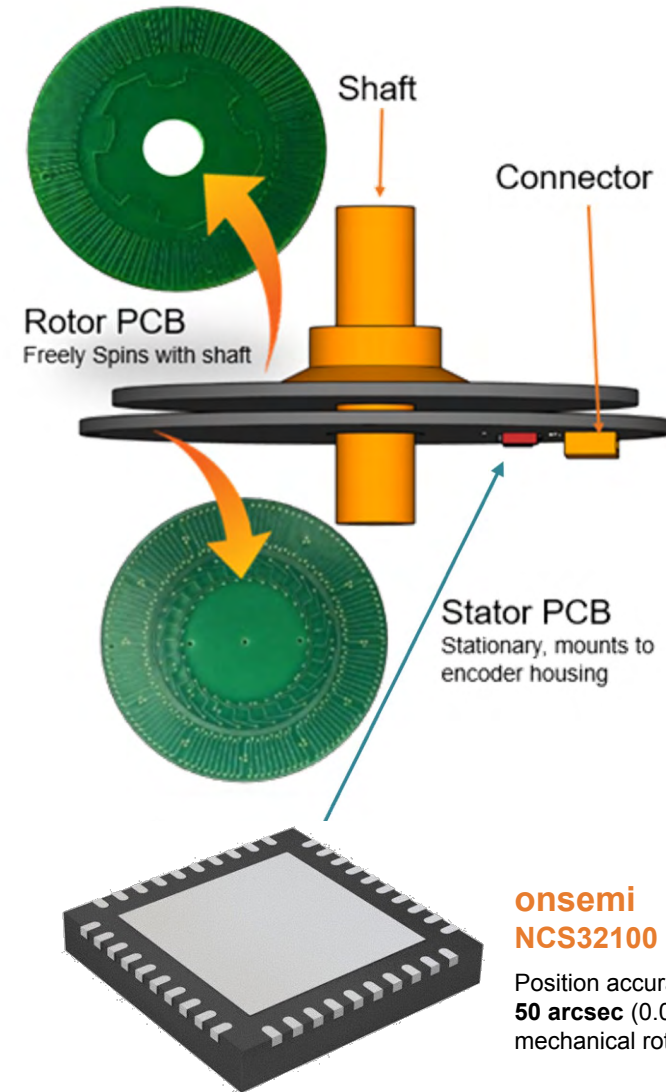


## onsemi NCS32100 Absolute Encoder

A gimbal's motors also benefit from a highly accurate *absolute encoder* which serves as a position sensor. onsemi's **NCS32100** offers many unique advantages over traditional position sensor components including insensitivity to potential contaminants, a much simpler mechanism, and lower cost.

Inductive encoders are superior to optical or magnetic encoders for the following reasons:

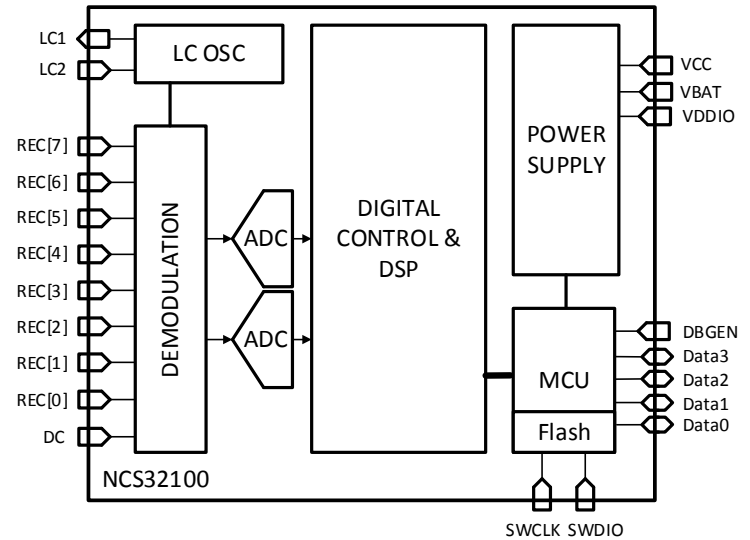
- ▶ An inductive encoder has a very low sensitivity to vibration, as well as high resistance to contaminants such as dust, water, oil, and metal particles.
- ▶ It has a low component count, omitting the use of expensive rare-earth metals for magnets.
- ▶ It is very robust, with high repeatability and high resistance to temperature extremes.
- ▶ It is very lightweight, especially compared to a traditional Hall effect sensor, by virtue of the lightweight materials used in both the rotor PCB (attached to the rotor shaft) and the stator PCB (which is stationary), both of which measure the position of the rotor. Reducing drone weight extends flight time.



## Inductive Positioning Products from onsemi

For a drone gimbal, engineers need the most accurate positioning sensor available without incurring excess weight. Of the three types of position sensors that encode the position of a rotor — magnetic, incremental, and inductive — it is the inductive variety that gives the rotor’s exact position as it spins. A magnetic encoder, by comparison, would magnetically infer the position, rendering an estimate.

onsemi produces two types of inductive position sensors. The **NCS32100** utilizes an MCU, offering position accuracy of ±50 arcsecs, or 13.8 millidegrees (m°) of mechanical rotation. By comparison, onsemi’s **NCV77320** is a state machine-based inductive position sensor (without an MCU) which has a greater ambient temperature operating range, while supporting both linear and rotary positioning.



Note: Internal power distribution lines from Power Supply block and bypass pin are not shown.

Product	Market	Rotor + stator PCB	Sensor type	Typical applications	Number of coils	Typical full scale	Typical full-scale accuracy	Accuracy 3600 full-scale	Ambient operating range	Rotor speed max	Package
<b>NCS32100 (MCU)</b>	Industrial	yes	Rotary	BLDC Rotor	8 RX / 1TX	360° Only	+,- 0.004%	+ , - 50 arcsec	-40 °C to 85 °C	**45,000 rpm	40QFN
<b>NCV77320 (State machine)</b>	Automotive ASIL B (D)	yes	Rotary & Linear	Pedal, Valve, BLDC Rotor	3 RX / 1TX	30°, 60°, 90°, 360°	+,- 0.15%	1943 arcsec	-40 °C to 150 °C	10,800 rpm	TSSOP16

\*\* Reduced accuracy > 6,000 rpm.

**1 arcmin** = 10 / 60, or 0.01660 mechanical rotation angle

**1 arcsec** = 10 / 3600 , or 0.000270 mechanical rotation

**50 arcsec** = 0.0138 degrees mechanical rotation (3600 full-scale)

**1943 arcsec** = 0.539 degrees mechanical rotation (3600 full-scale)

# Automotive LED Drivers for Use in Drones

onsemi is a global leader in automotive-rated LED drivers. It's because they meet the varied, diverse requirements of automobile manufacturers, including for tail and signal lighting, that there's a wide variety of LED drivers suited for drone applications.

<b>SPI multi-channel</b>	Boost + dual buck		<b>NCV78763</b>	1.6A / 60V PWM 2 independent LED-strings	Integrated HS dimming OCP, OVP, OTP, diag. QFN32, SSOP36 (leadless)	<b>VIN: 4V to 40V</b>
	Dual buck		<b>NCV78723</b>	1.6A / 60V Asynchronous dual buck 2 independent LED-strings	Integrated HS <b>Integrated R for I-sensing</b> Dimming	OCP, OVP, OTP, diag. QFN24 <b>VIN: 6V to 67V</b>
			<b>NCV78825</b>	3A / 60V Synchronous dual buck 2 independent LED-strings	Integrated HS <b>Integrated R for I-sensing</b> Dimming	OCP, OVP, OTP, Diag. SSOP36 (leadless) <b>VIN: 6V to 67V</b>
	Multiphase boost		<b>NCV78702</b>	1.6A / 60V 2-phase Diag. w/ SPI	Programmable Input Current Limitation OCP, OVP, OTP, QFN24,	TSSOP20 (leadless) <b>VIN: 5V to 30V</b>
			<b>NCV78703</b>	1.6A / 60V 3-phase Diag. w/ SPI	Programmable Input Current Limitation OCP, OVP, OTP, QFN24	Up to 6-phase w/ 2 parallel NCV78703s <b>VIN: 5V to 30V</b>
	Matrix beam controllers		<b>NCV78247</b>	1A / 60V 12 Pixel Switch: 1x or 2x or 3x or 4x	Dimming PWM + Phase Shift OCP, OVP, OTP,	Diag. SSOP36 EP (leadless). <b>VIN: 4.5V to 40V</b>
UART (CAN) + M+LVDS			<b>NCV78343</b>	1.4A / 60V 12 Pixel Switch: 1x or 2x Dimming PWM + Phase Shift	OCP, OVP, OTP, Diag. SSOP36 EP (leadless).	<b>VIN: 4.5V to 40V</b>
<b>Non-SPI single-channel</b>			<b>NCV78514</b>	1.5A / 60V 1-channel H-bridge (buck-boost)	18-20 LEDs in series up to 60V/20W, 200mA to 1.5A current	<b>VIN: 5V to 20V</b>
			UART (CAN) + M+LVDS	<b>NCV78343</b>	1.4A / 60V 12 Pixel Switch: 1x or 2x Dimming PWM + Phase Shift	OCP, OVP, OTP, Diag. SSOP36 EP (leadless). <b>VIN: 4.5V to 40V</b>
<b>Single-channel</b>	Pre-driver		<b>NCV7691</b>	Current Controller for automotive LED lamps	PWM, diagnostics	
			<b>NCV7692</b>	Current Controller for automotive LED lamps	PWM, diagnostics Open Load Detection-optimized for >5V	SOIC8 (leadless)
	CCR		<b>NSI45xxx</b>	10 – 160 mA 45 V Constant Current Regulator		
<b>Multi-channel</b>	Regulated current source	Tail / stop interface	<b>NCV7683</b>	8-channel 100 mA per channel TAIL / STOP	Programmable latch-off Ballast drive Sequencing	Diagnostics SSOP24 (leadless)
		I <sup>2</sup> C interface	<b>NCV7685</b>	12-channel 60 mA per channel I <sup>2</sup> C protocol	OTP setting Stand-alone mode + I <sup>2</sup> C (MCU) Mode Fault detection	Independent PWM/dimming per LED channel/string Adaptive Rear Lighting System SSOP24 leadless
	On / off		<b>NCV7693</b>	3-channel switch Independent PWM control	Open/short LED string diagnostic Fault detection	External resistors define max. current TSSOP-14

## onsemi's LED Drivers

### NCV7685

For multi-channel applications requiring a regulated current source, onsemi's **NCV7685** in the SSOP24 package consists of twelve linear programmable constant current sources with common reference. It can be used with MCU applications using the I2C bus, or in stand-alone applications enabling a choice between two static configurations. Supports 12 common current programmable sources of up to 60 mA each, and has independent PWM duty cycling control for each channel, allowing for programmable, per-channel independent dimming. It also supports Open LED String Diagnostics, enabling the notification of a companion MCU if there's a fault or a break in the line.



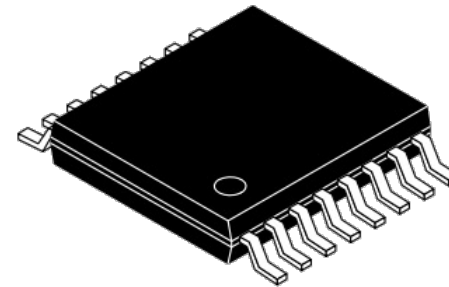
### onsemi NCV7685

SSOP24 package

- ▶ 12 common current programmable sources up to 60 mA each
- ▶ Independent PWM duty cycle control for each channel via PC
- ▶ Common PWM duty cycle control via I2C.
- ▶ On-chip 150, 300, 600 and 1200 Hz PWM
- ▶ Open LED string diagnostics
- ▶ Low-dropout operation for pre-regulator applications

### NCV78514

For driving up to 20 LEDs in series, of up to 60V or 20W, onsemi's **NCV78514** in the TSSOP-16 package is a unique, single-channel LED driver. Its four-phase, H-bridge topology automatically adapts the output voltage whenever the input voltage stays in the range from 5V to 20V. If it's not receiving enough input, it automatically boosts; if it has too much input, it bucks down. It also features a programmable 200 mA to 1.5 A range using an external resistor.



### onsemi NCV78514

TSSOP16-EP package

# 10BASE-T1S Controllers

Under the drone's hood, the flight control system and the main processor will be communicating directly with cameras using high-bandwidth, wired SerDes or gigabit Ethernet connections. Meanwhile, lower-bandwidth communications will be taking place between the VNS and the external sensors, as well as between the VNS and the propeller BLDCs. While the CAN bus remains popular with some drone architectures, 10BASE-T1S Ethernet delivers data rates as much as three times faster over the same paired wires.

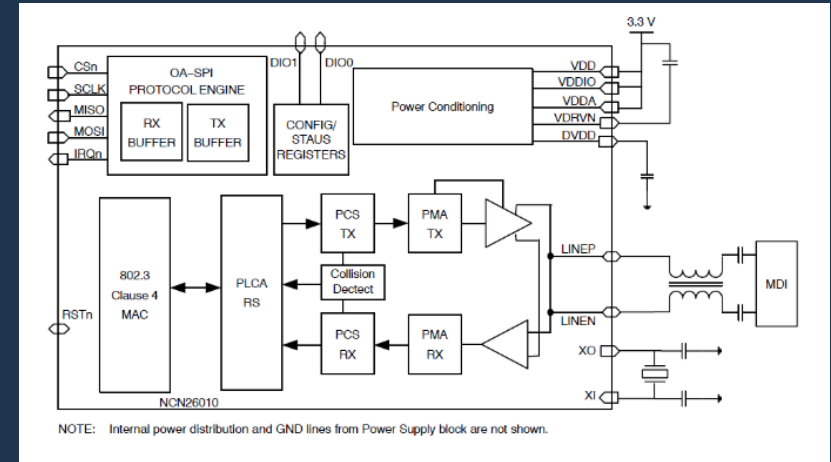
## NCN26010

onsemi's **NCN26010** 10BASE-T1S industrial Ethernet controller fully supports the IEEE 802.3cg specification for 10 Mbps, half-duplex Ethernet over short-range, twisted-pair cable. It uses a SPI interface to the MCU, and supports physical layer collision avoidance (PLCA) protocol. This implements a round-robin, arbitrated network scheme between clusters of nodes sharing a multi-drop bus, ensuring that one node always has control over the bus even when all the other nodes may appear to have dropped out. It runs off of a 3V supply, and has integrated MAC (data link layer) and PHY (physical layer) communications management.

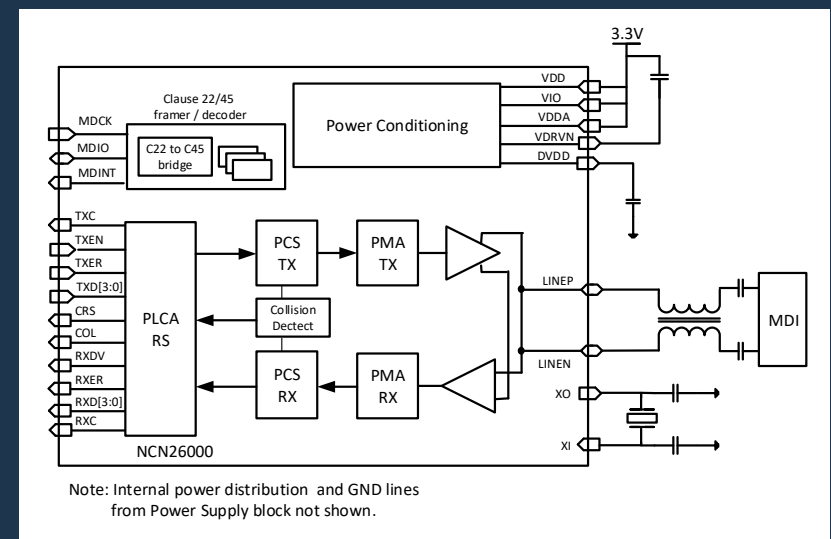
## NCN26000

For applications where the MCU already supplies MAC management functions, onsemi offers the **NCN26000** which is identical to **NCN26010** except it does not integrate MAC.

## onsemi NCN26010



## onsemi NCN26000

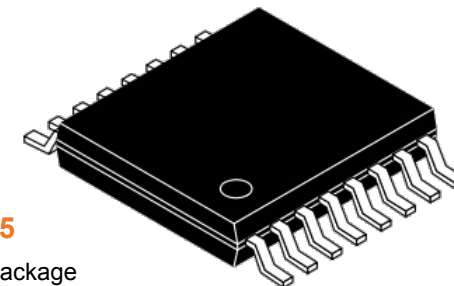
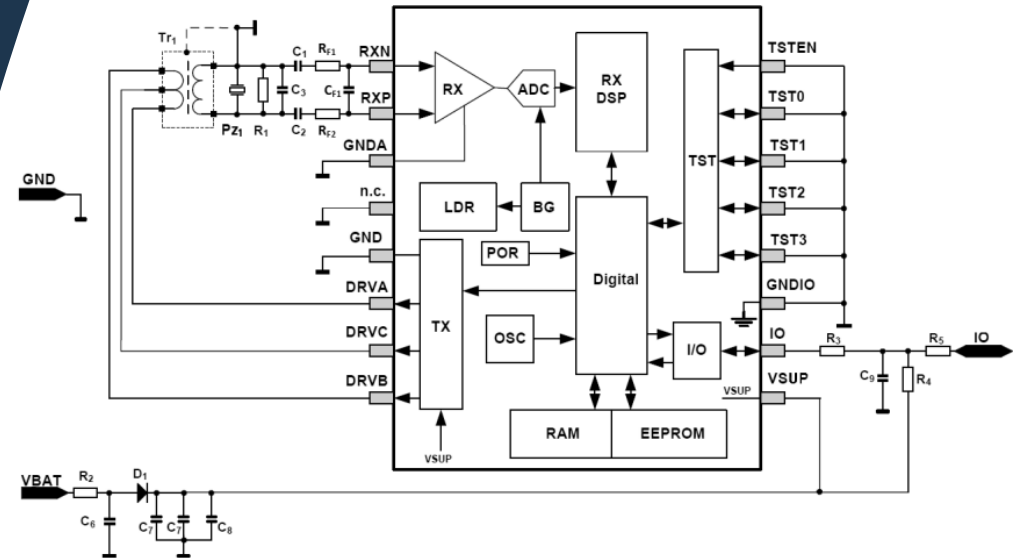


## onsemi NCV75215 Ultrasonic Sensor

The **NCV75215** ultrasonic sensor in the TSSOP-16 package supports a true time-of-flight measurement distance range of 0.25 m to 4.5 m, with a transducer sender frequency range from 35 to 90 kHz, assuming the use of a piezoelectric ultrasonic transducer with external analog parts. Under ideal conditions, with perfectly tuned and matched external circuitry, a minimum distance of 0.2 m is achievable.

**NCV75215** is an application-specific standard product (ASSP), and the application it was originally designed for is determining obstacle distance while parking a car. The component drives an ultrasonic transducer with a programmable frequency by way of a transformer. The received echo is amplified and converted to a digital signal, then filtered. The detected magnitude is compared to a time-dependent threshold stored in memory. Distance to the obstacle is calculated by measuring the interval between transmission burst and echo recognition — true time-of-flight.

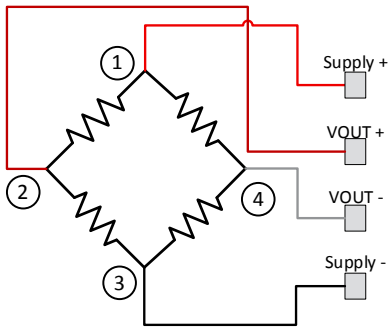
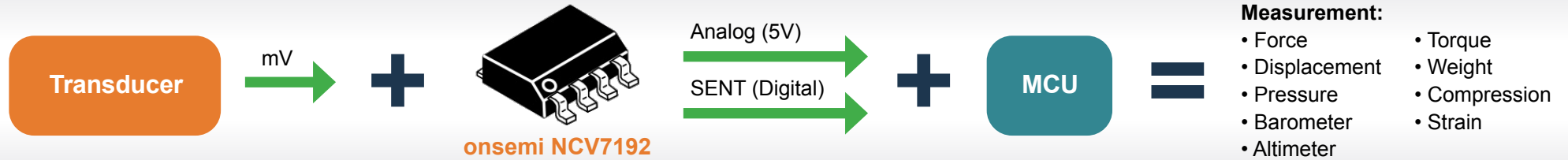
For drone applications, as the drone is landing, an ultrasonic sensor can be used to measure its approach to ground, as well as the distances between other drones in flight. This makes these sensors invaluable for swarm light show applications, but also very useful in mapping applications.



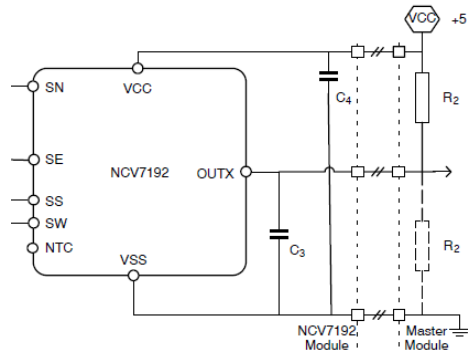
**onsemi**  
**NCV75215**

TSSOP16 package

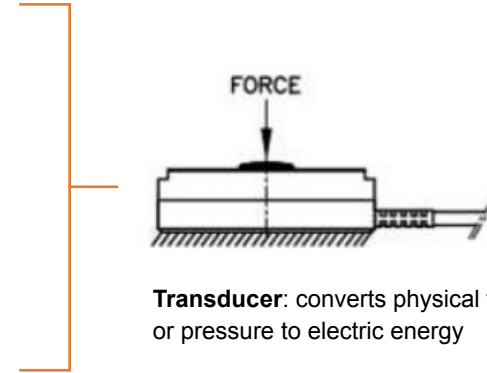
# onsemi NCV7192 Signal Conditioning Interface



**Piezoresistive Wheatstone Bridge (PWB)**



**LPF + Gain (2x) + ADC + DSP + LPF + DAC + EEPROM + NTC**

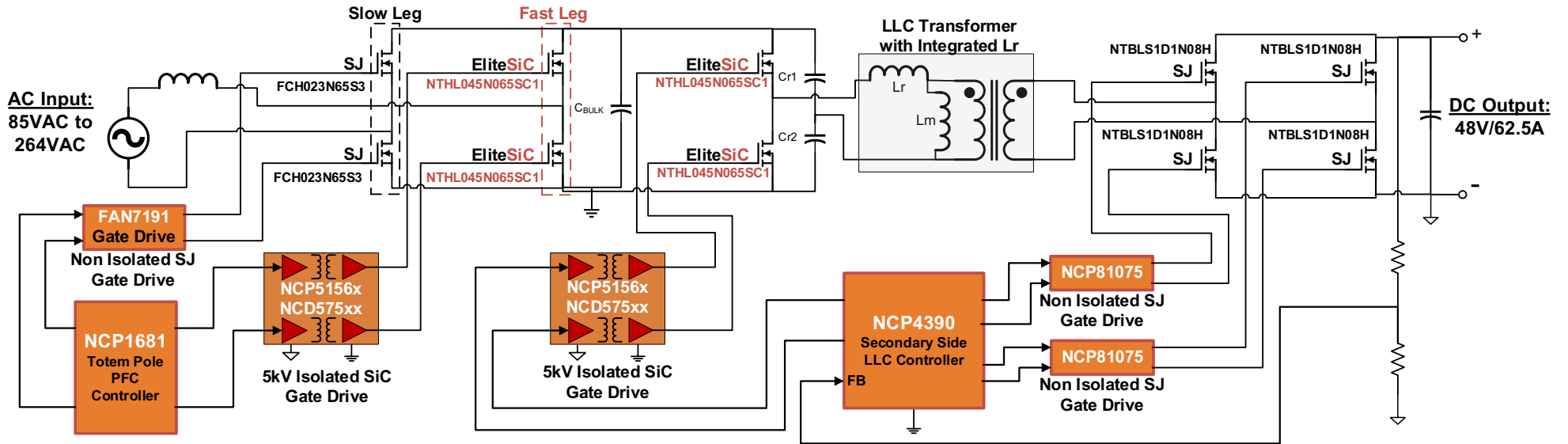


## Pressure sensing

A signal conditioning interface (SCI) such as onsemi’s NCV7192 is designed to respond to changes in pressure signals being sent by a piezoresistive Wheatstone bridge (PWB). Its differential voltage output is proportional to absolute pressure. When it senses a pressure signal, the PWB responds by shifting its resistor values, resulting in a change in differential voltage. Without pressure on the bridge, it will output 0 mV.

The SCI will take this input and respond with either an analog 5V output or a Single Edge Nibble Transmission (SENT protocol, as defined by SAE J2716) digital output stream. That response is acquired by the MCU, which will use that stream to measure force, displacement, pressure, barometric pressure, altitude, torque, weight, compression, and/or strain. For example, for a design where the gimbal mechanism plugs into the drone, the NCV7192 can use pressure sensor data to determine whether the plug is secure and locked in at the proper torque level.

# Driving Lithium-Ion Battery Charger Subsystems

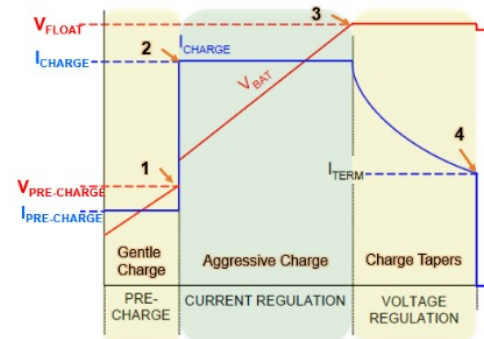


Larger drones that need to fly faster and for longer distances will require larger battery packs, for cells both in series and in parallel. Because these packs require frequent recharging, they will need higher-power AC/DC or switch-mode power supplies.

This diagram represents a charging mechanism with an AC input range of 85V to 264V. Its output is 48V with 62.5A. That DC output would be directed into the charger's constant-current/constant-voltage (CC/CV) autonomous charging profile controller, which will host a 10-cell in-series (10S) pack. The CC/CV profile is an algorithm that the charger will use to produce the charging pattern indicated by the chart at right.

CC/CV Autonomous Charging Profile (4 end points):

- 1) Pre-Charge until Vbat ~31V (1),
- 2) CC Mode @ max Icharge (2) until Vbat = V<sub>FLOAT</sub> (3)
- 3) CV mode, until charge terminated ~ C/15 (4)



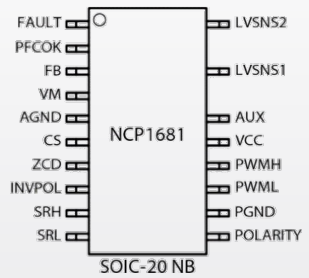
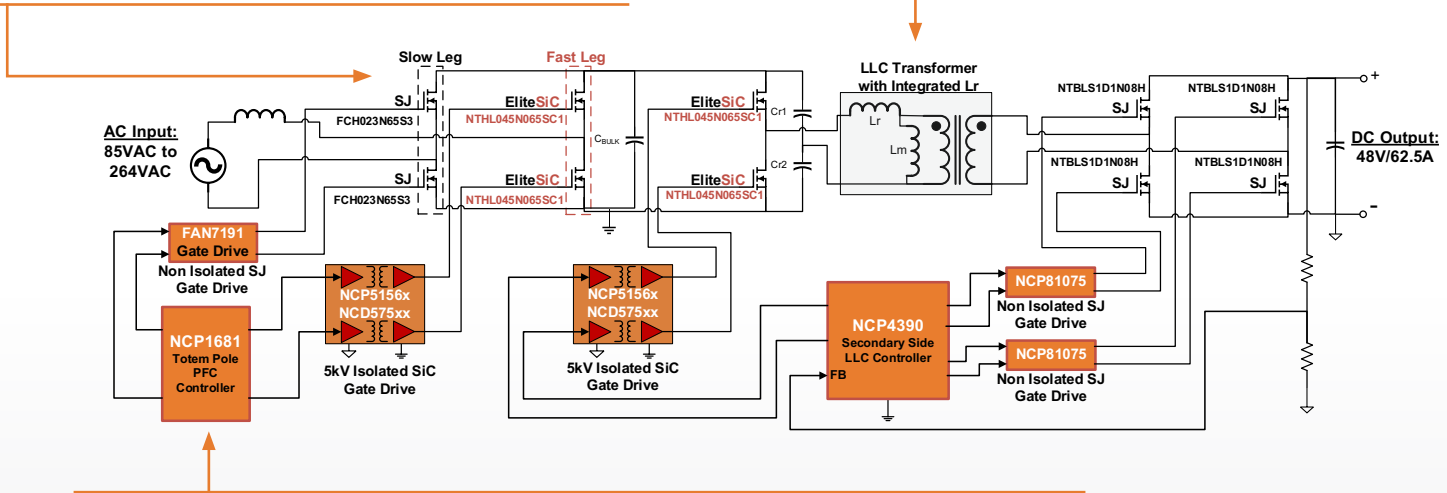
# Driving Lithium-Ion Battery Charger Subsystems

## Full-bridge primary phase fast and slow legs

The first function of power factor correction (PFC) is to align the current and voltage when the load changes. A totem pole PFC such as onsemi's **NCP1681** effectively nullifies the need for a full-bridge rectifier, making the charger more efficient and reducing its overall size with the elimination of those redundant diodes. The **NCP1681** will control the slow leg and fast leg of PFC. With the slow leg running at the line frequency of 50-60 Hz, the **FAN7191** gate driver is best suited. At the fast leg, which runs from 130 kHz down to 30 kHz depending on the load, onsemi offers its **NCP5156x** and **NCD575xx** 5 kV isolated silicon carbide gate drivers for driving the SiC switches.

## LLC transformer

At the LLC transformer stage of PFC, onsemi's **NCP4390** secondary side LLC controller manages the secondary phase of the full bridge, along with **NCP81075** non-isolated dual MOSFET silicon gate drivers. With this configuration and topology, a 3 kW power supply in a minimum form factor becomes achievable.



## NCP1681 totem pole PFC controller

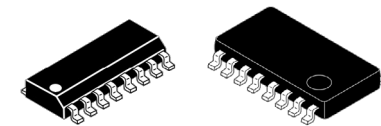
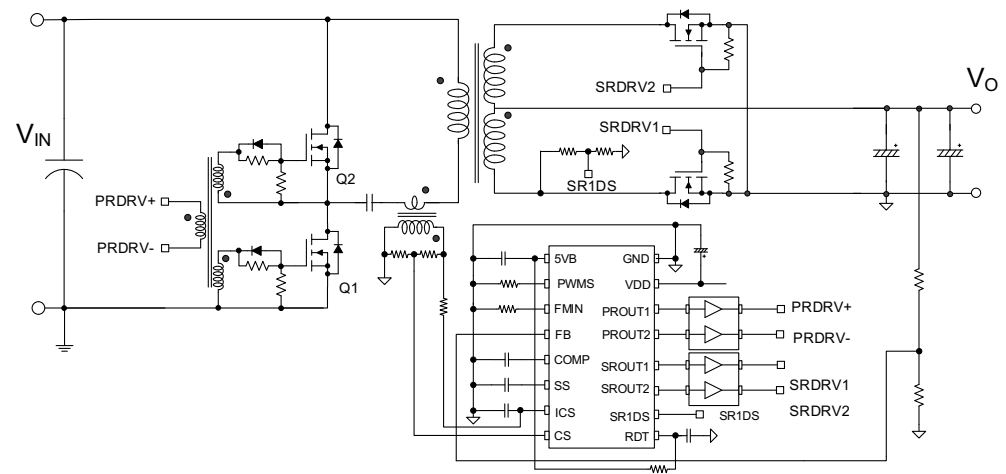
The **NCP1681** in the SOIC-20 package is a multi-mode controller designed to run autonomously in either critical conduction mode (CrM) in light and medium load conditions, or continuous conduction mode (CCM) in heavy load conditions. It is state machine-based, running without an MCU.

# onsemi NCP/V4390 Secondary-Side Resonant Converter

In the secondary side of the full-bridge of the battery charger subsystem is an onsemi **NCP4390** or **NCV4390** (automotive-rated) LLC controller. With an LLC, you can run at a faster operating frequency range — from 39 kHz up to 690 kHz. Those speeds will enable you to reduce the size of many of your larger parts, including transformers, input and output capacitors, and inductors. It's available in both wide- and narrow-body SOIC-16 packaging.

- ▶ Metal change derivative of existing FAN7688
- ▶ Secondary-side PFM controller for LLC resonant converter with synchronous rectifier control
- ▶ Charge current control for better transient response and easy feedback loop design
- ▶ Synchronous Rectification Control with dual-edge tracking
- ▶ Closed loop soft-start for monotonic buildup of the output voltage
- ▶ Wide operating frequency (39kHz ~ 690kHz)
- ▶ Green functions to improve light load efficiency
  - Symmetric PWM control at light load to limit the switching frequency while reducing switching losses
  - Programmable PWM mode entry point
  - SR Gate signal shrinking at light load condition to prevent negative resonant current
  - Disabling SR at extremely light load condition
- ▶ Protection functions with auto-restart
  - NON ZVS prevention (NZP) by compensation cutback (frequency shift)
  - Over Current Protection (OCP)
  - Output Short Protection (OSP)
  - Power limit by compensation cutback (frequency shift)
  - Overload Protection (OLP) with programmable shutdown delay time
  - Over temperature protection (OTP)
- ▶ Programmable dead times for primary side switches and SR switches
- ▶ Wide operating temperature range -40°C To 125°C

## onsemi NCP4390



	NCP/V4390	FAN7688
<b>Package</b>	SOIC-16 NB	SOP16
<b>Programmable PWM-mode entry threshold voltage <math>V_{COMP.PWM}</math></b>	1.07~2.05 or fully disabled	5~2.05
<b>Thermal Shutdown</b>	No	Yes

## Empowering the Growth of the Drone Manufacturing Industry



onsemi

The market for drones, like the market for autonomous mobile robots, is now a permanent fixture of the global economy. The most conservative estimates for its growth forecast average compound annual growth rates of greater than 10% through the year 2034. Most analysts' estimates are higher.

The global drone market has been characterized as a proving ground for fast-growing, "gazelle" startup companies. As a whole, however, this market is comprised of larger, prominent manufacturers, with longer histories and records of success extending further back than the drone era. Indeed there are younger, smaller companies in the drone industry today such as Neros, Helsing, Mach Industries, and Sunflower Labs. Yet there are also larger,

well-established players in the consumer market such as DJI, plus defense contractors such as Kratos and AeroVironment.

And then there is onsemi, the pre-eminent global leader in intelligent sensing and intelligent power systems. onsemi has world-class expertise in image sensors, SWIR, inductive position sensors, ultrasonic sensors, and pressure sensors. The company offers expertise in BLDC, as well as pioneering design leadership in 10BASE-T1S wired communications. onsemi is the acknowledged champion of silicon carbide technologies, with the intention to become just as much a leader in gallium nitride technologies. Count on onsemi to lead the way in drone systems engineering.



▶▶▶ Visit our [drones solution page](#) for more for more information and additional resources.

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