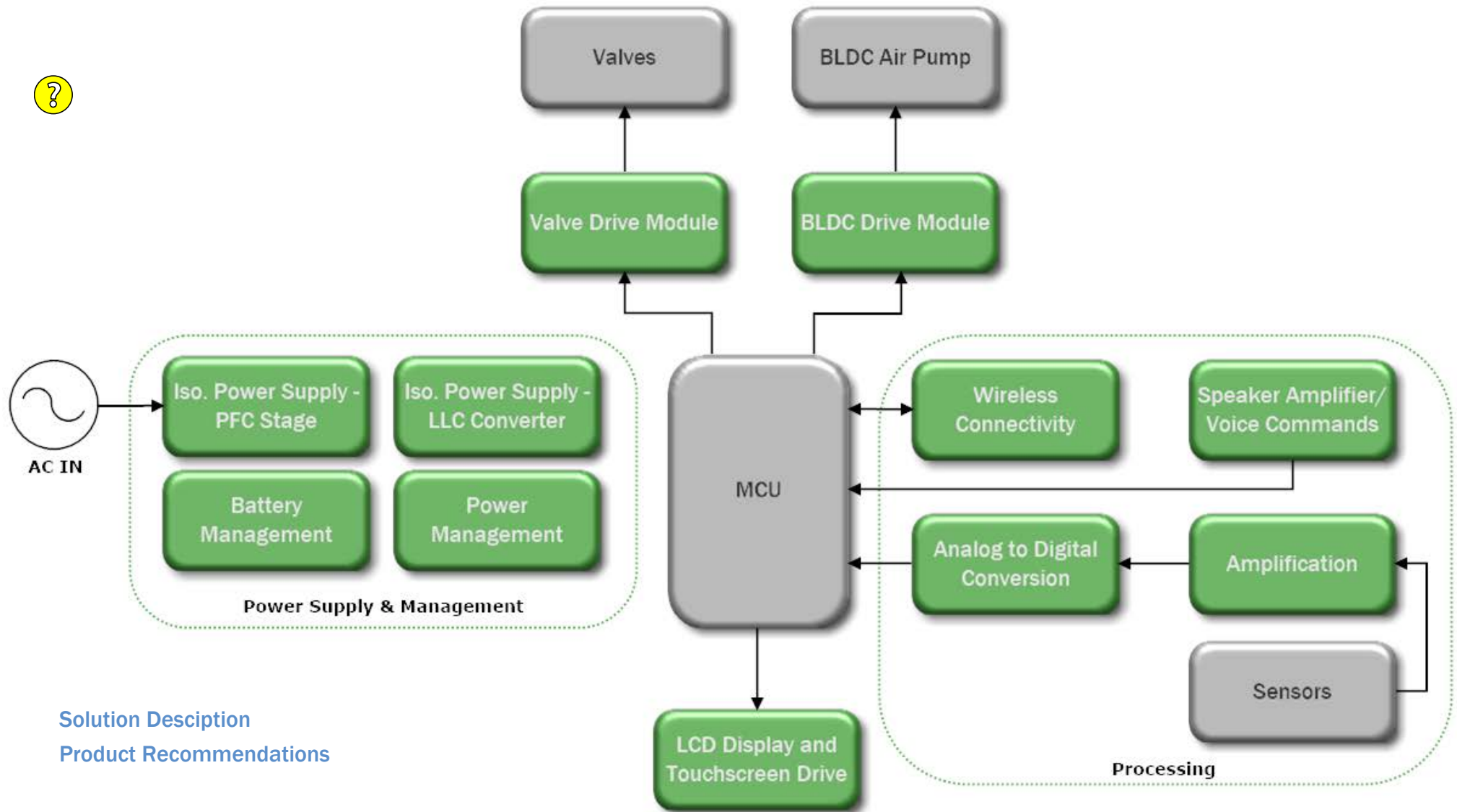
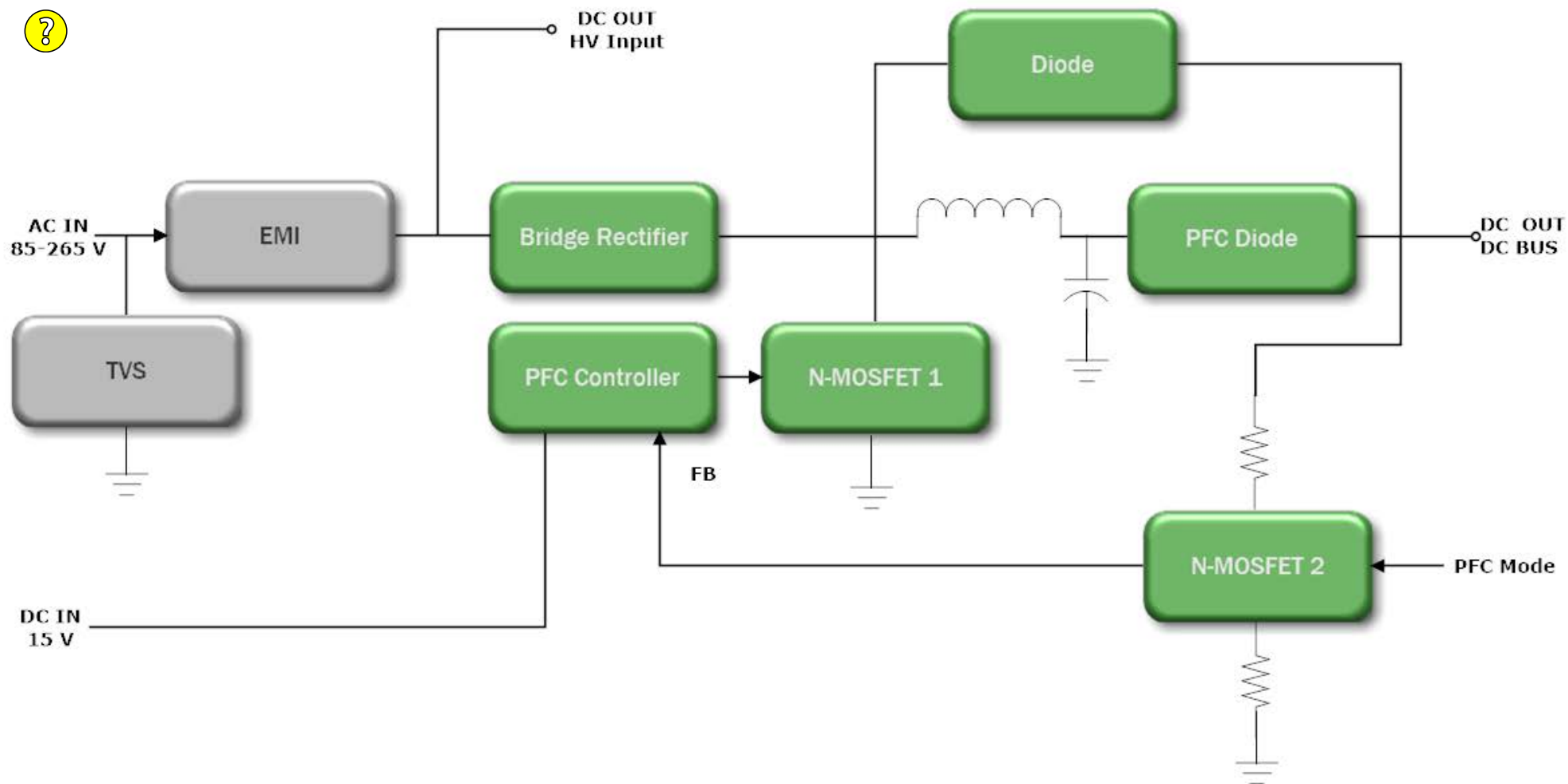


# Medical Ventilator Core Solution

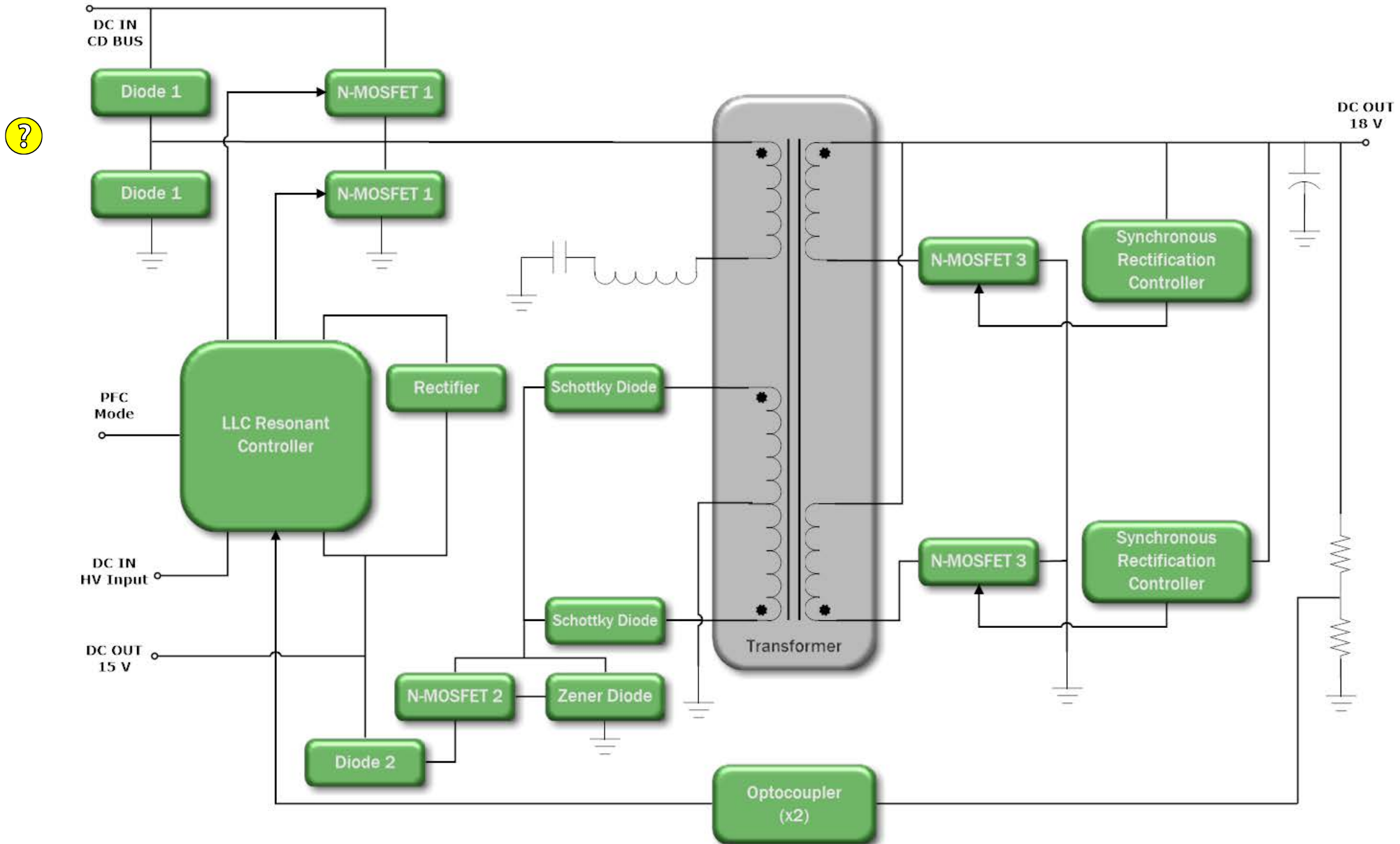


## Isolated Power Supply Unit - PFC Stage



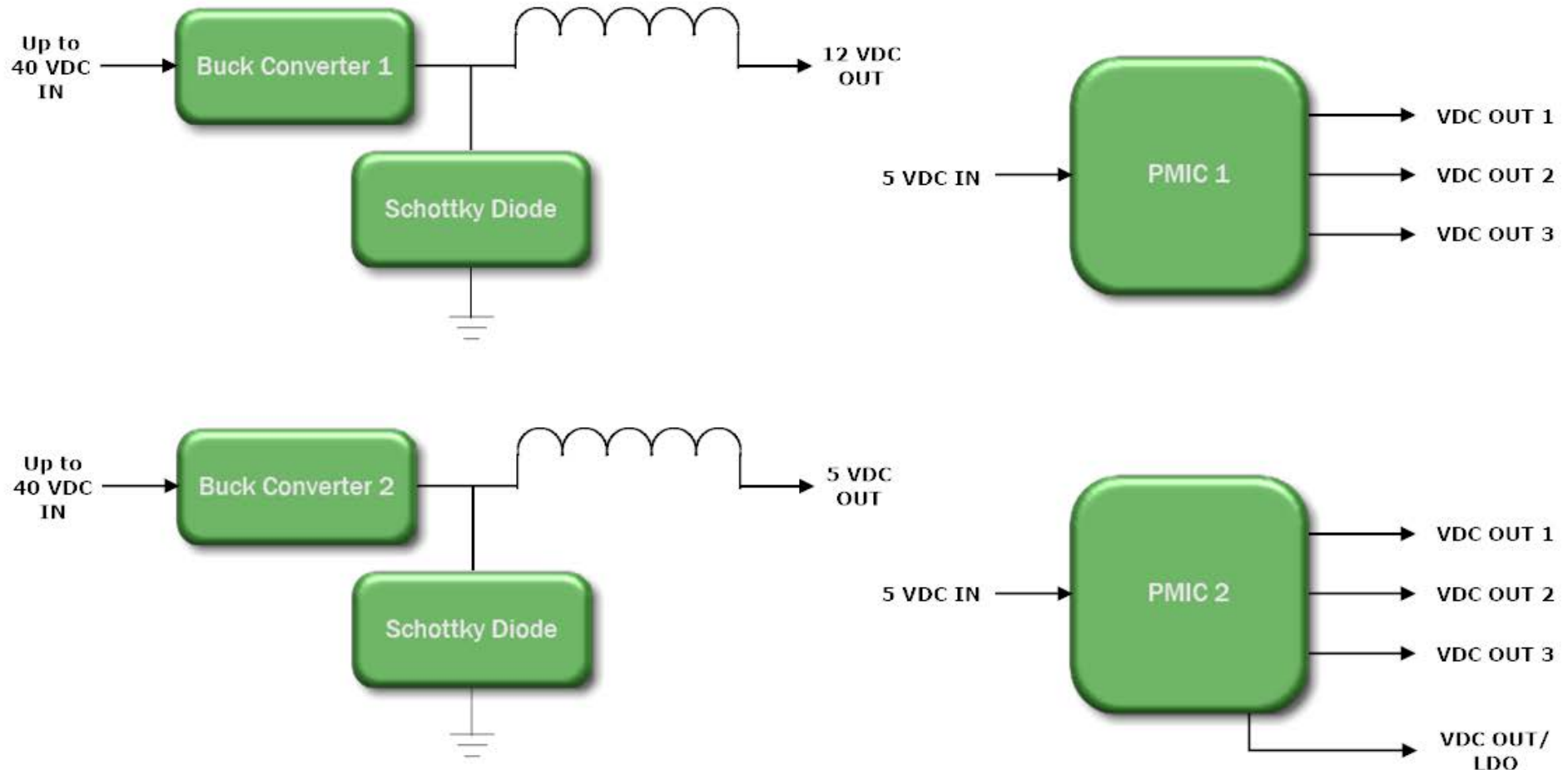
[Return to top diagram](#)

## Isolated Power Supply Unit - Resonant Half-Bridge LLC Converter Stage



[Return to top diagram](#)

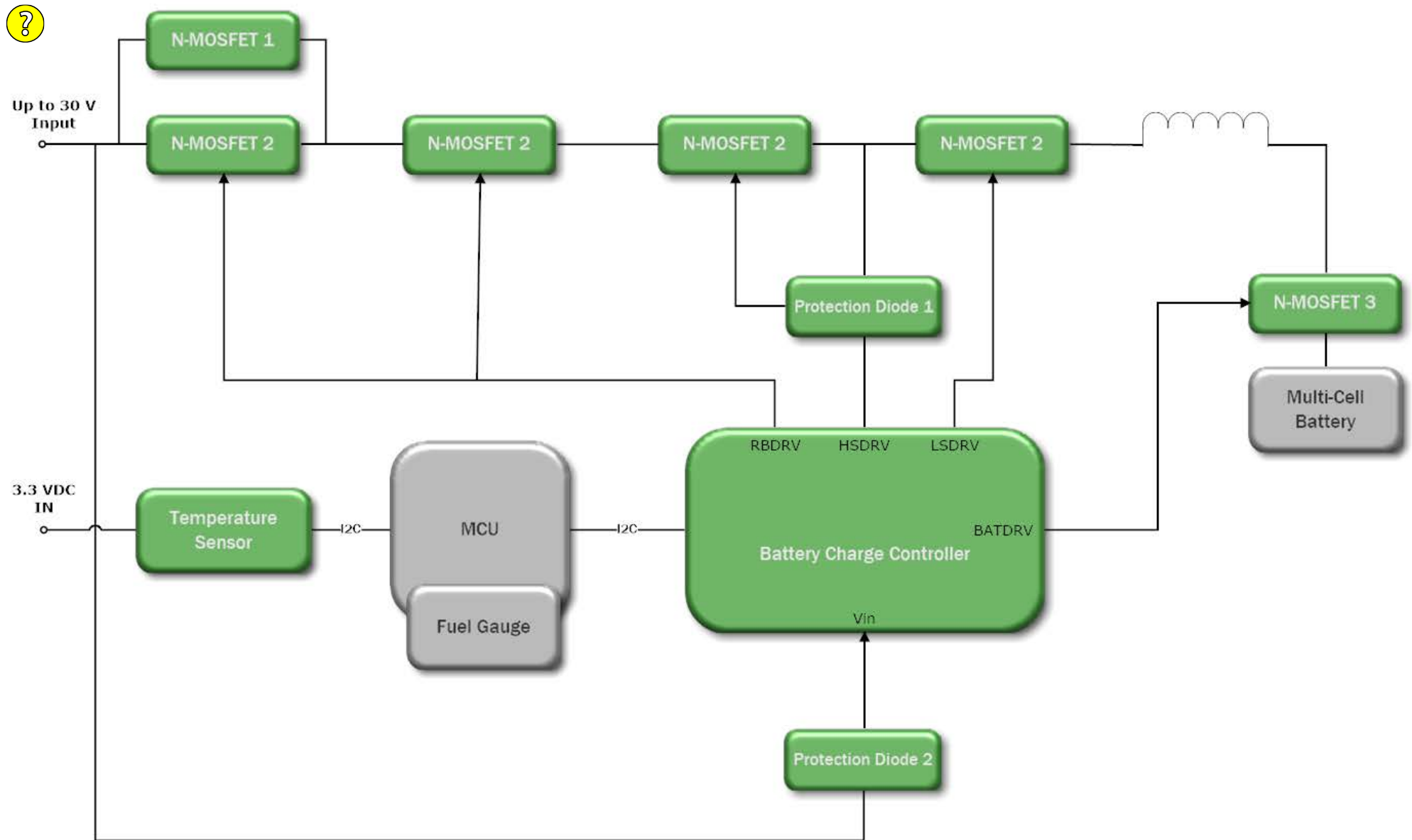
# Power Management



[Return to top diagram](#)

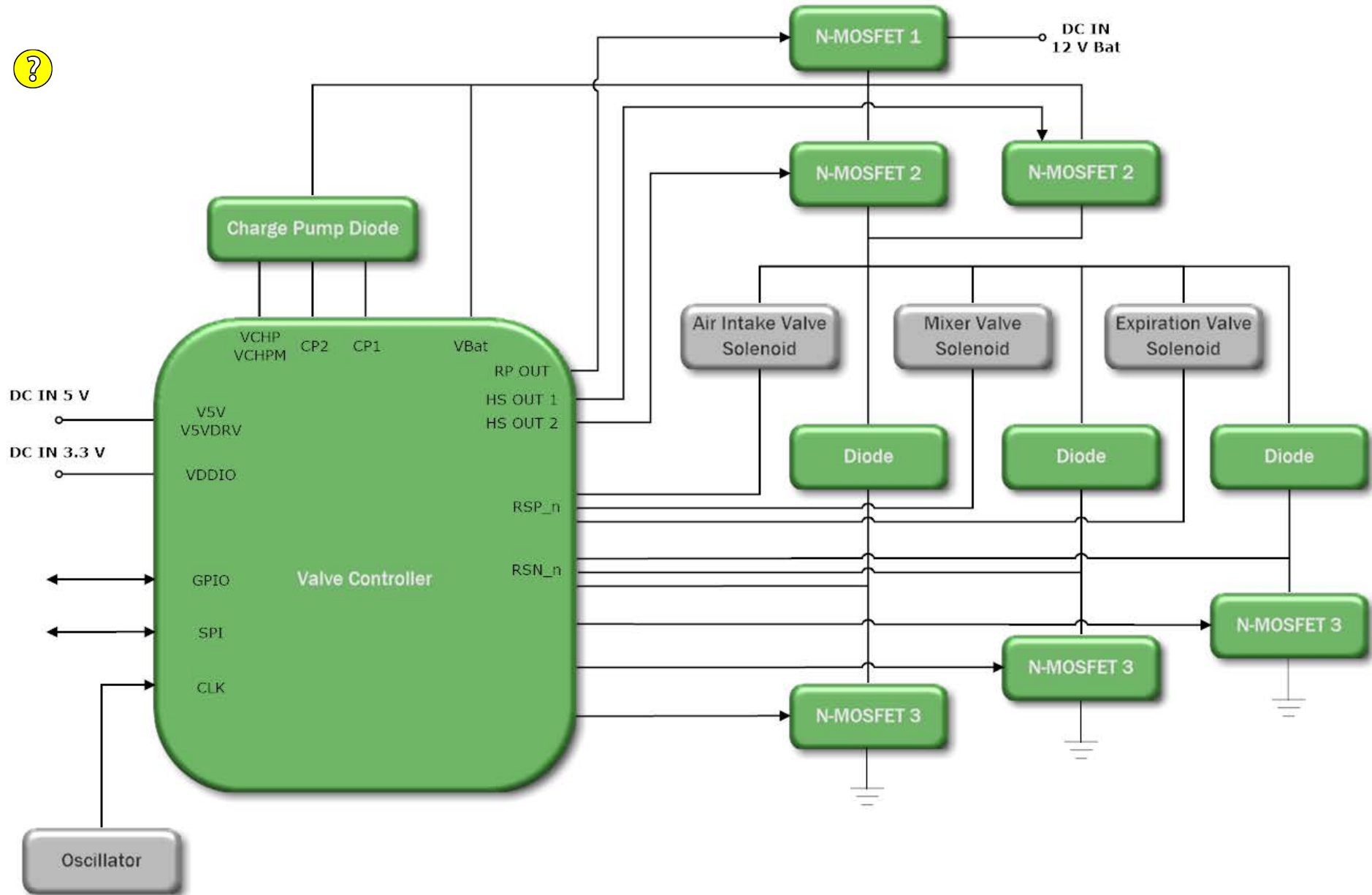


# Battery Management



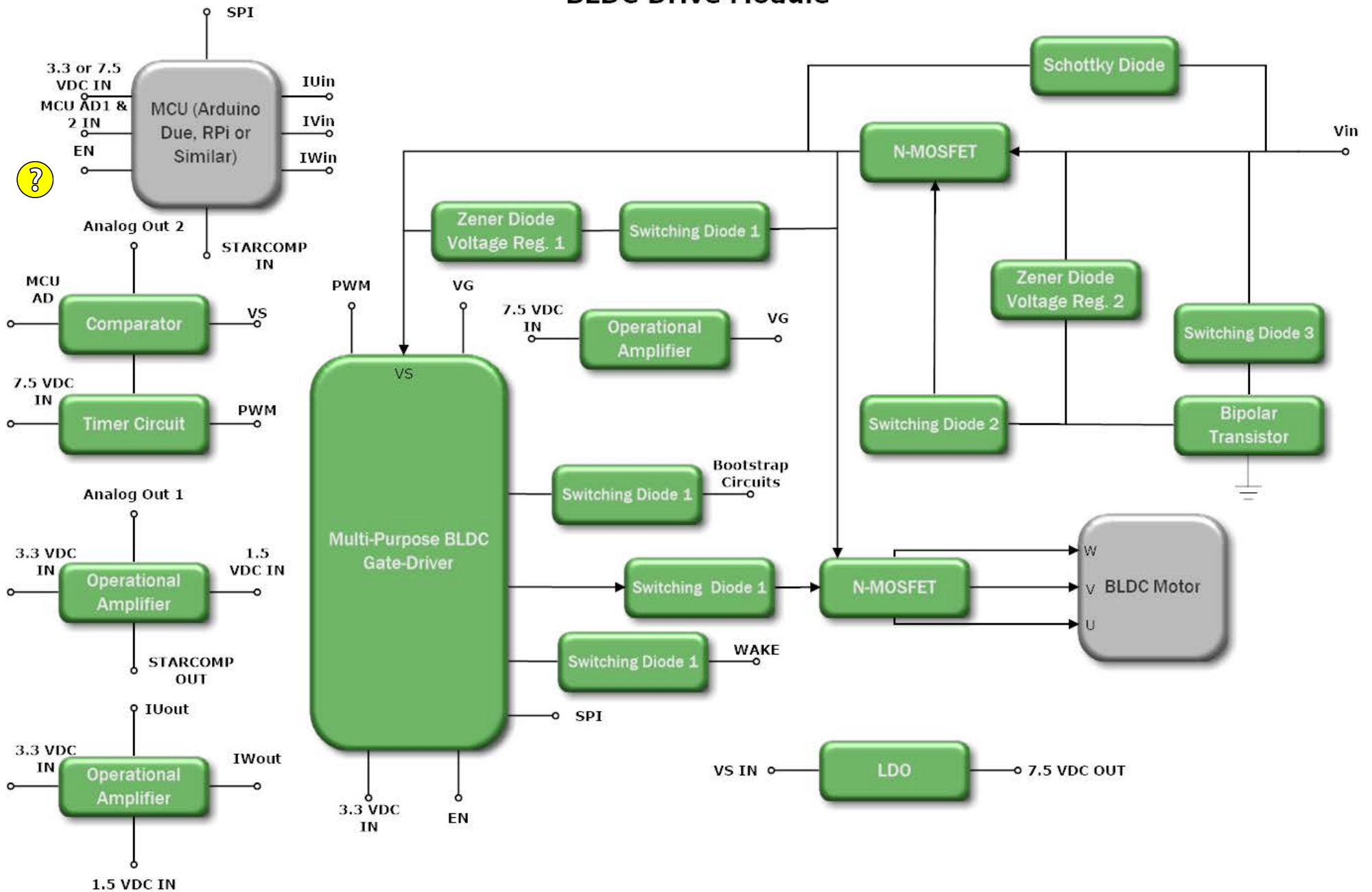
[Return to top diagram](#)

## Value Drive Module



[Return to top diagram](#)

# BLDC Drive Module

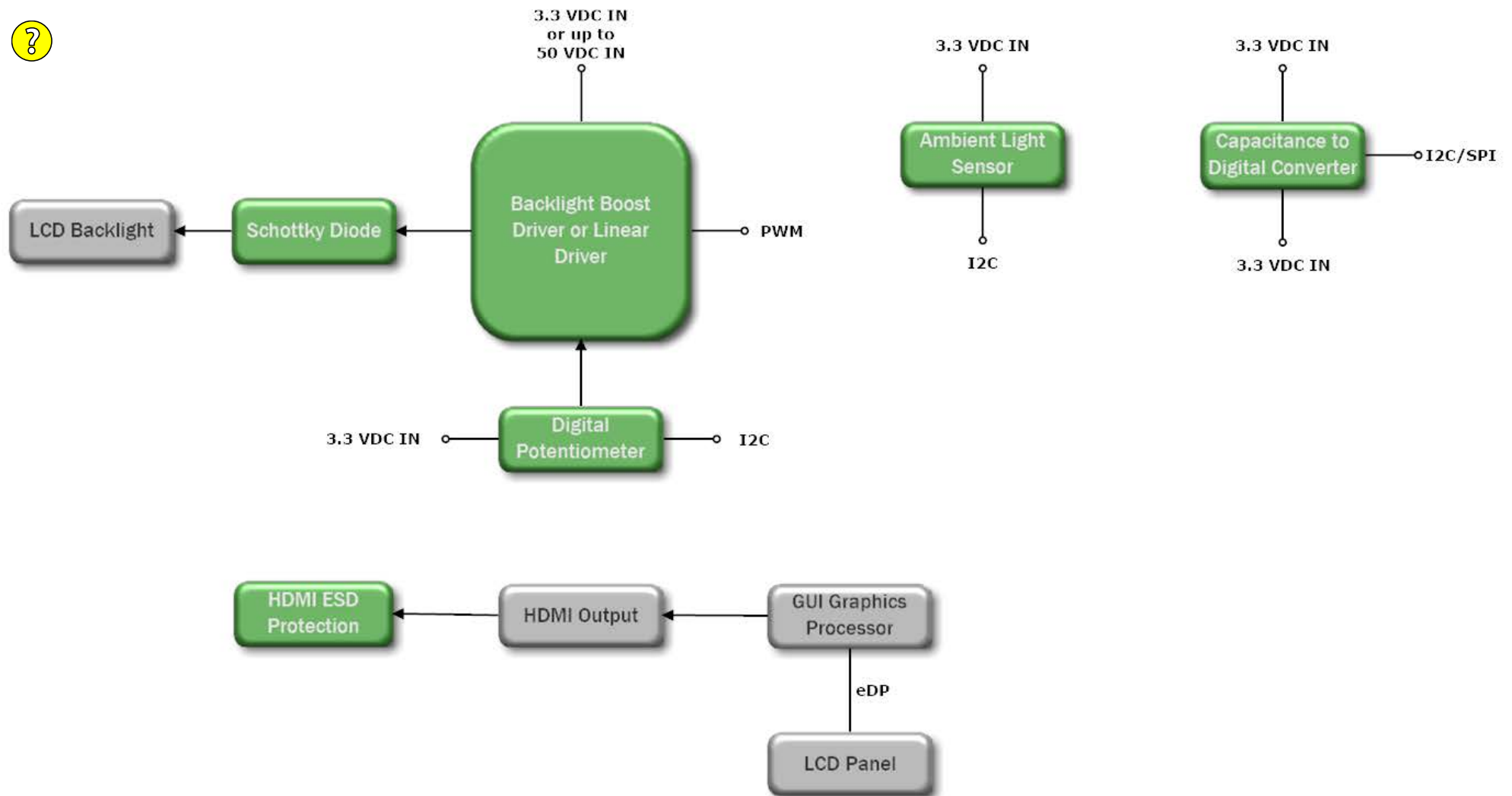


[Return to top diagram](#)





# LCD Display & Touchscreen Drive Module

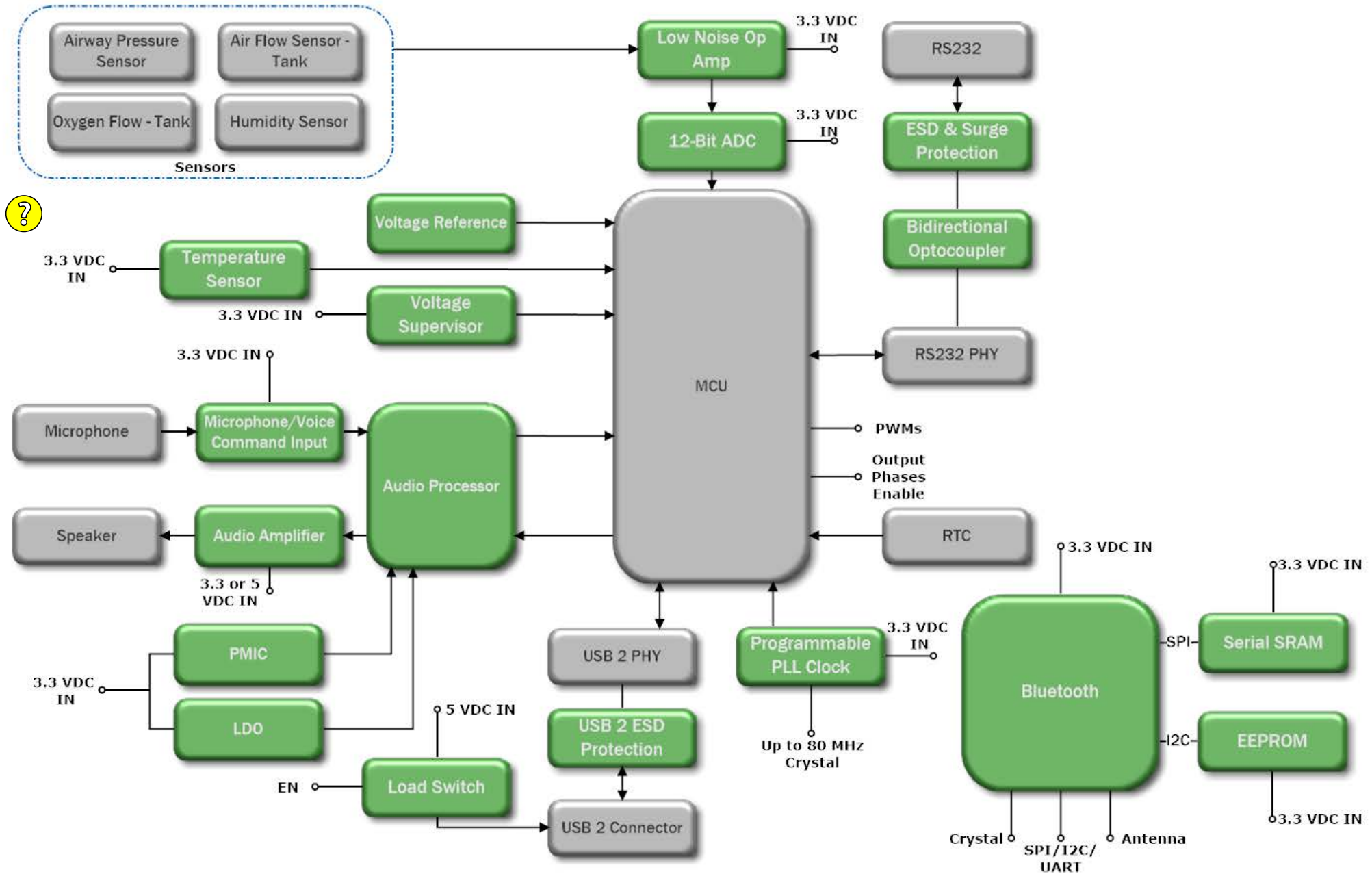


[Return to top diagram](#)





## MCU and Processing



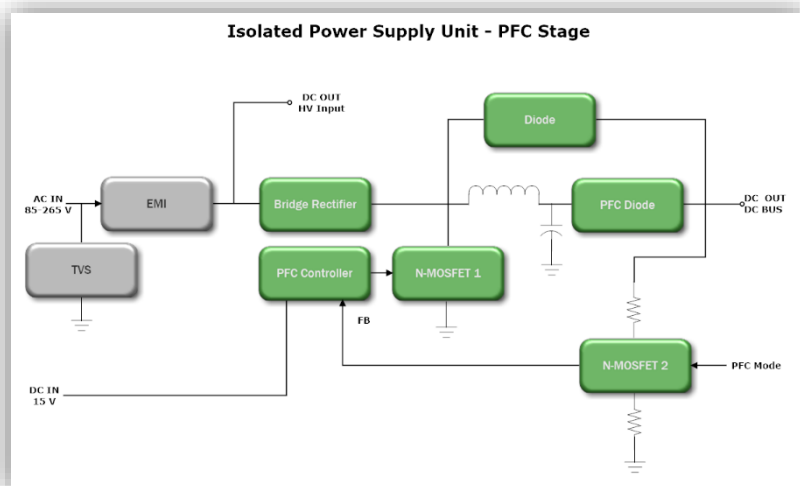
[Return to top diagram](#)

## Medical Ventilator Solution Description

Due to the rapid increases in the number of COVID-19 hospitalizations, it has created an unprecedented strain on the world's inventory of ventilators. ON Semiconductor and our operations have also been deemed as essential and a [critical infrastructure](#) by the Department of Homeland Security as our company is a supplier of semiconductor components, which are a critical part of the supply chain for medical device manufacturers. Our products are used in a variety of medical devices, including ventilators, which are helping keep COVID-19 patients with severe cases breathing. Medical ventilators move air in and out of the lungs in cases where patients are not physically able to breathe on their own and applications or use cases can be quite broad. Often the machine forces humidified and warmed air with supplemental oxygen into the lungs. Equipment can be found in intensive care units, emergency rooms, ambulatory and in the home.

In response to COVID-19, ON Semiconductor has developed a relevant addition to our Block Diagram of the Month series – Medical Ventilator. This diagram looks at the various systems used in medical ventilators and provides a targeted list of relevant ON Semiconductor devices and provides an overall understanding of the solution.

### Isolated Power Supply Unit – PFC Stage



A grid voltage is rectified by a bridge rectifier **GBU8K** (800 V, 8 A, 200 A overload peak).

PFC Controller **NCP1654** controls the PFC Boost stage of the isolated power supply unit. It controls the power N-Mosfet **FCPF250N65S3R0L** (650 V, 12 A, 250 mΩ). Diode **MSR860G** (600 V, 8 A) is also used in PFC boost.

Auxiliary power for NCP1654 is supplied from the dedicated output of the NCP1399 (LLC stage).

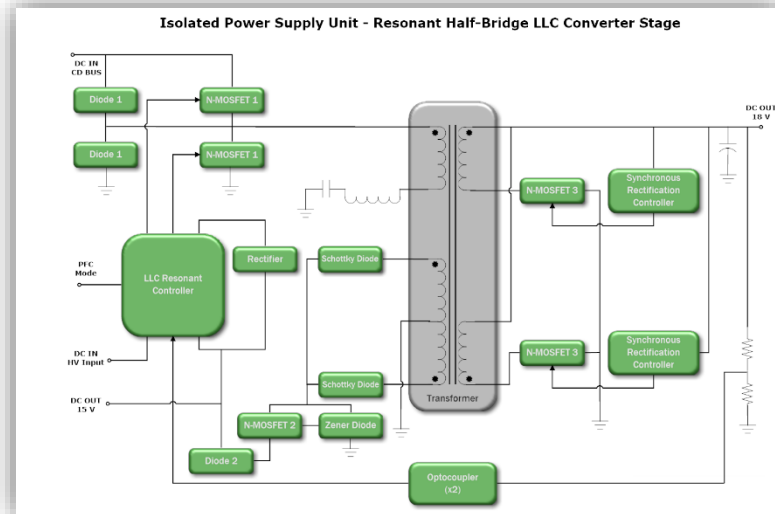
[Return to top diagram](#)

### Isolated Power Supply Unit – Resonant Half-Bridge LLC Converter Stage

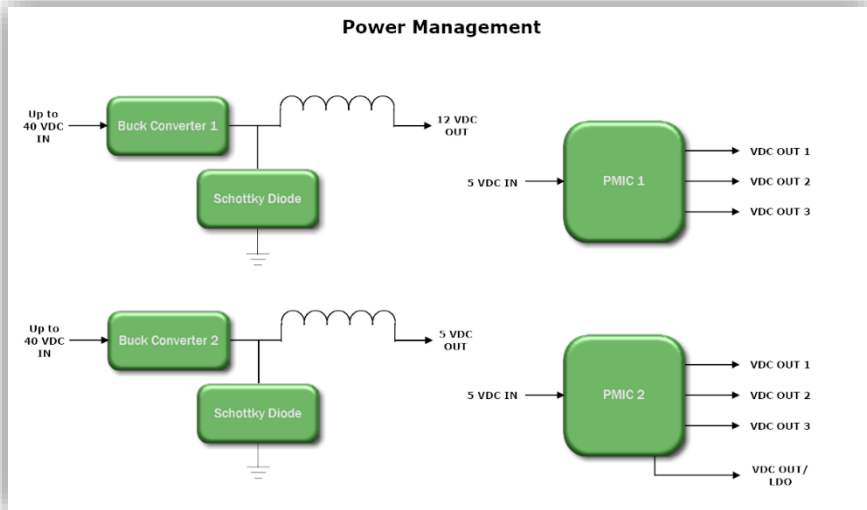
Output from the PFC stage is converted to 18V by resonant half-bridge LLC converter. The main controller **NCP1399** drives high-side and low-side N-MOSFETs **FCD260N65S3** (650 V, 12 A, 260 mΩ). It features a dedicated output to drive the PFC controller. This feature, together with dedicated skip mode technique, further improves light load efficiency. The **NCP1399** provides a suite of protection features allowing safe operation in any application. This includes overload protection, over-current protection to prevent hard switching cycles, brown-out detection, open optocoupler detection, automatic dead-time adjust, over-voltage (OVP) and over-temperature (OTP) protections.

Synchronous rectification controller **NCP4306** is used for rectification on the secondary site of the half-bridge converter; it drives N-MOSFET **FQP55N10** (100 C, 55 A, 26 mΩ, TO-220) or **NTMFS6H848NL** (80 V, 59 A, 8.8 mΩ, SO-8FL / DFN-5 package).

Feedback to the **NCP1399** from the secondary site to the half-bridge controller is done via two optocouplers, **FOD8717** or **FODM1008**.



## Power Management

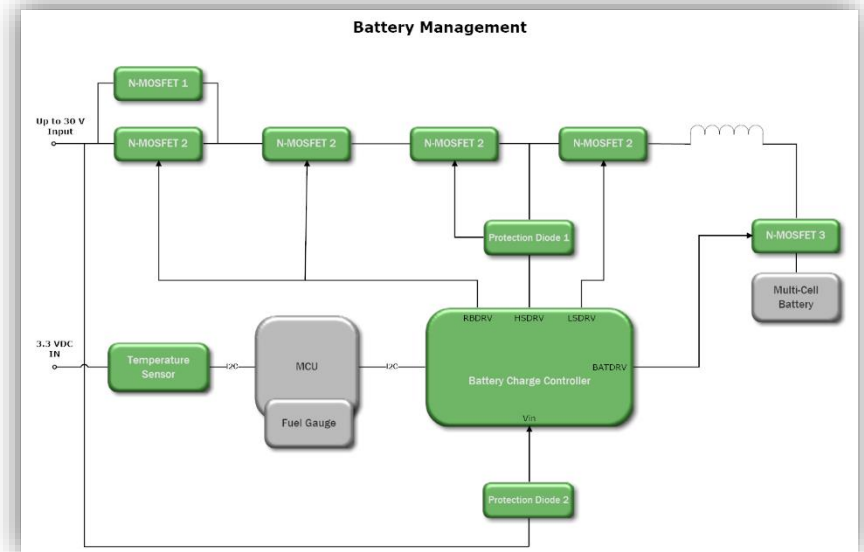


As a power management solution, two **LM2576** buck converters are used to lower the input voltage from a LLC stage. They are followed by two power management integrated circuits. The **NCV97310** is three output regulator consisting of a low-I<sub>q</sub> battery-connected 3 A 2 MHz non-synchronous switcher and two low-voltage 1.5 A 2 MHz synchronous switchers; all using integrated power transistors. The high-voltage switcher is capable of converting a 4.1 V to 18 V battery input into a 5 V or 3.3 V output at a constant 2 MHz switching frequency, delivering up to three A currents. The **NCP6922C** device integrates two high efficiency 800 mA step-down DC to DC converters with dynamic voltage scaling (DVS) and two low dropout (LDO) voltage regulators in 4x4 mm 20 pins WQFN package.

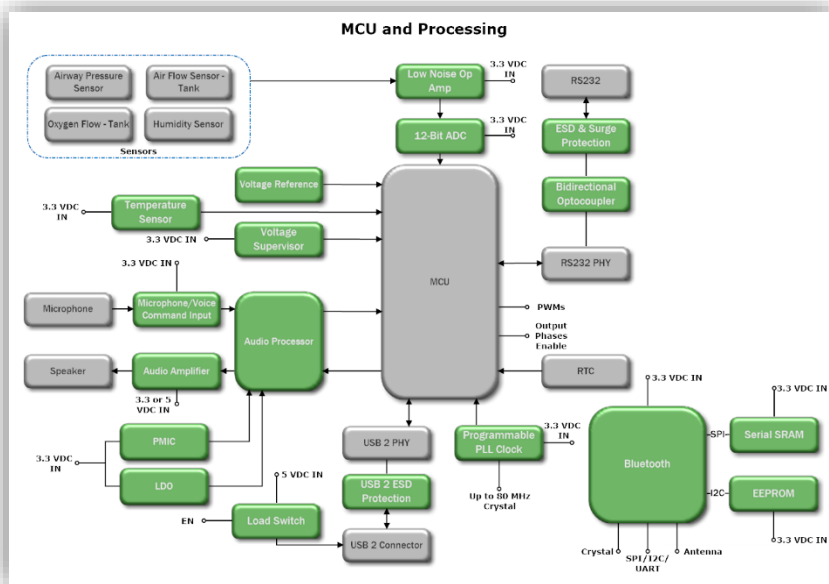
[Return to top diagram](#)

## Battery Management

A switching battery charger block is designed for 2–3–4 battery cell applications. The **NCP1871** device is built around a full NMOS DC to DC controller that brings down the high voltage charger adapter voltage to a regulated system supply that is in the same range as the battery pack voltage. This limits the variation on the system supply voltage and improves the efficiency of the core converters. The device includes a voltage drop monitor, charger adapter validation and blocking, as well as an intelligent battery connection control. The adapter current, charge current and system current are closely monitored, and an image is provided to the host processor. The NCP1871 is fully programmable through an I2C or System Management Bus interface.



## MCU and Processing



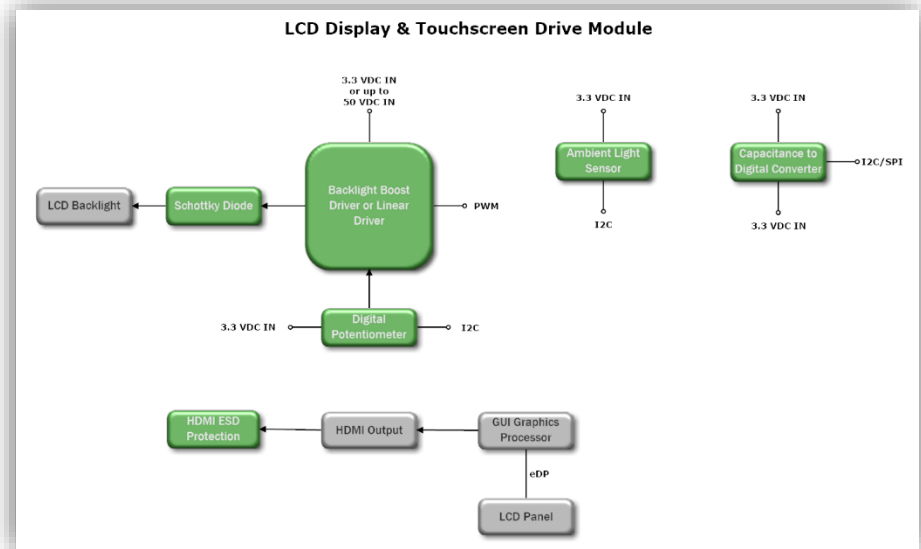
To the MCU management solution, we can offer standard logic parts – programmable clock **FS7140** for clock distribution. Additionally, our voltage supervisor **NCP308** is used for monitoring the input voltage level to the CPUs (supporting the manual – external reset). Also, we can offer parts needed for voice command input on our **FAN3852** microphone to digital preamplifier and for feedback from the device we can offer audio amplifier **NCP2820**. The **LC823455** is a mature audio processor, with a dual ARM cortex M3 plus a 32-bit DSP. The LC823455 is proven to be a proficient voice user interface (VUI) using the sensory algorithm (license required, including trigger phrase and up to 75 commands). The LC823455 also supports up to 4 mic inputs and both analog and digital audio outputs.

To process the input from sensors, we are proposing our low noise operational amplifiers and analog to digital converter **NCD98010**. To control optional USB devices connected to the device, load switch **FPF1048** and **ESD8472** protection were offered. As for the connectivity, a medical variant of our **RSL10** Bluetooth system on chip and bidirectional optocoupler **FOD8012A** were offered.

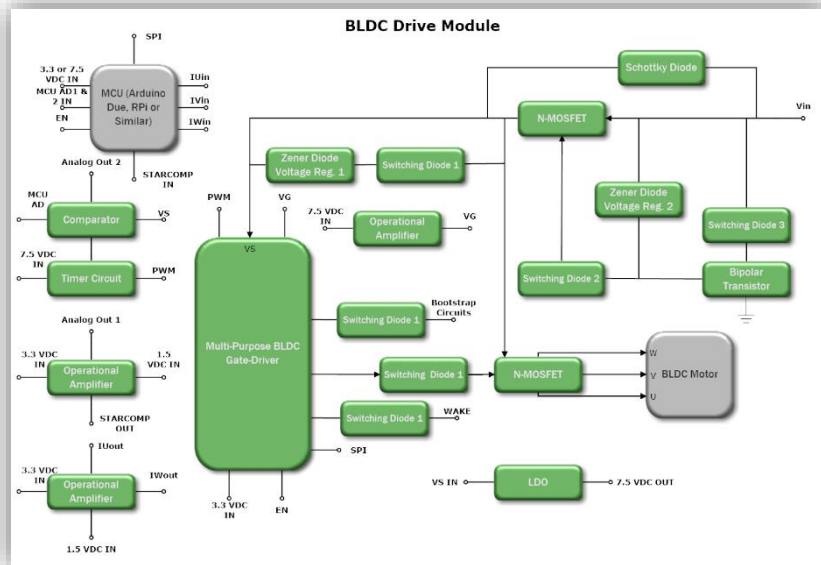
[Return to top diagram](#)

## LCD Display and Touchscreen Module

For LCD implementation, our suggested devices are mainly for the backlighting drive and capacitive touch LED driver **CAT32**. If the customer would like to drive the backlight without flickering **NSI50150** linear driver in combination with the digital potentiometer to set the backlight intensity, ambient light sensor **LV0104CS** for outer light sensitivity measurement and touch to digital converter **LC717A10AR** to process the touch input. If the end application would require display output, our HDMI **ESD7104** protection can be used to protect the data lines.



## BLDC Drive Module



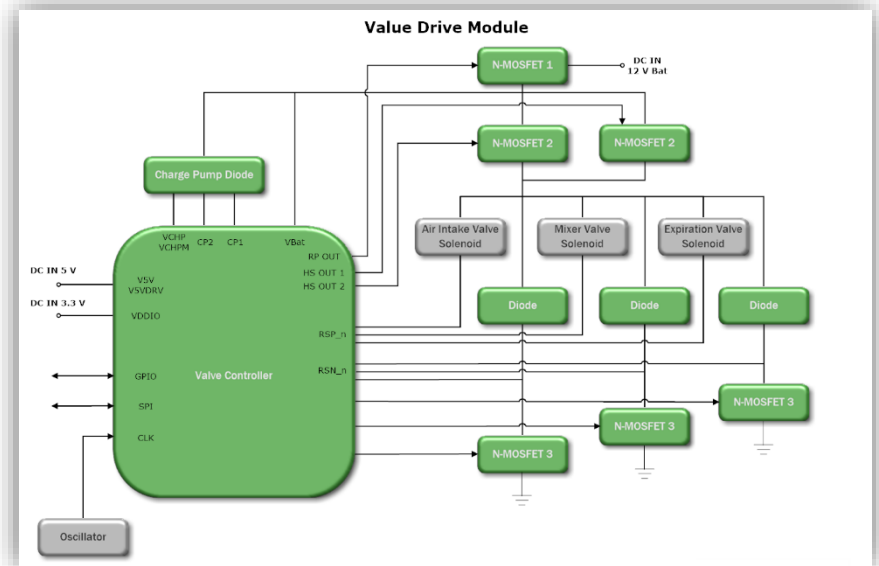
As a driver for the main component of the air pump, BLDC compressor, we can offer the **LV8968** BLDC gate driver with support for programming via SPI interface, PWM inputs, six gate drivers provide 400 mA gate current to external power bridges allowing use of low-resistance power FETs, as well as logic level FETs. All FETs are protected against overcurrent, short-circuit, over-temperature and gate under-voltage. A multitude of protection and monitoring features make this device suitable for ISO26262 applications. Three independent low-side source pins allow multiple shunt measurements.

The device also includes a programmable linear regulator, a fast current-sense amplifier and a window watchdog for microcontroller support. The SPI interface allows for real time parameter setup and diagnostics. Critical system parameters can be programmed into non-volatile OTP memory. Various optional periphery is offered to support motor control implementations from simple sensor-less BEMF commutation, to complex field oriented algorithms. The solution can be used in cooperation with an Arduino DUE board.

[Return to top diagram](#)

## Valve Module

Valve are controlled by Hex Solenoid Current Controller with N-FET predrivers **NCV7120**. Each pre-driver channel contains a programmable PWM current controller with dithering modulation. It is able to control six low side N-MOSFET **NTMFD5C680NL** (3x, 60V, 26A, 28mΩ) for solenoids. For safety and protection, the chip is equipped with three high side pre-drivers. Inside is implemented charge pump which allows to drive high-side N-MOSFET **NTMFS5C442NL** (40V, 130A, 2mΩ) as reverse polarity protection. Three external diodes **HN2D02FUTW1T1G** are used for this purpose. Two MOSFETs **NTMFS5C468NL** (40V, 37A, 10.3mΩ) are used as Failsafe. NCV7120 communicates with main MCU via SPI. Three diodes **MURS210T3G** are used for recirculation.



ON Semiconductor offers technologies and solutions that are used, in collaboration with our customer and partners, to improve lives through innovative semiconductor solutions. We're glad that our products are contributing to life-saving medical technology during this time and work to continue to make a difference across all industries with our semiconductor components.

[Return to top diagram](#)



Suggested Block	Qty.	WPN	WPN Description	OT?
<b>Isolated Power Supply Unit - PFC Stage</b>				
Bridge Rectifier	1	<a href="#">GBU8K</a>	8 A Bridge Rectifier	N
PFC Controller	1	<a href="#">NCP1654BD133R2G</a>	Power Factor Correction Controller for Compact and Robust, Continuous Conduction Mode Pre-Converters	Y
N-MOSFET 1	1	<a href="#">FCPF250N65S3ROL</a>	Power MOSFET, N-Channel, SUPERFET® III, Easy Drive, 650 V, 12 A, 250 mΩ, TO-220F	Y
PFC Diode	1	<a href="#">MSR860G</a>	Power Rectifier, Soft Recovery, Switch-mode, 8 A, 600 V	N
Diode	1	<a href="#">MUR4100EG</a>	Power Rectifier, Ultra-Fast Recovery, Switch-mode, 4 A, 1000 V	N
N-MOSFET 2	1	<a href="#">FQT1N60CTF-WS</a>	Power MOSFET, N-Channel, QFET®, 600 V, 0.2 A, 11.5 Ω, SOT-223	N
<b>Isolated Power Supply Unit - Resonant Half-Bridge LLC Converter Stage</b>				
LLC Resonant Controller	1	<a href="#">NCP1399AADR2G</a>	Current Mode Resonant Controller (Integrated High Voltage Drivers, High Performance)	Y
Optocoupler	1	<a href="#">FOD8173S</a>	4-Pin DIP Phototransistor Optocouplers	N
Optocoupler	Alternative	<a href="#">FODM1008</a>	Single Channel, DC Sensing Input, Phototransistor Optocoupler In Stretched Body SOP 4-Pin	N
Synchronous Rectification Controller	2	<a href="#">NCP4306DAHZZAASNT1G</a>	Secondary Side Synchronous Rectification Driver for High Efficiency SMPS Topologies	Y
Diode 1	2	<a href="#">1N4937G</a>	600 V, 1.0 A Fast Recovery Rectifier	N
Diode 2	1	<a href="#">MMDL914T1G</a>	100 V 200 mA High Speed Switching Diode	N
Rectifier	1	<a href="#">MURA160T3G</a>	Power Rectifier, Ultra-Fast Recovery, 1 A, 600 V	N
Schottky Diode	2	<a href="#">MBR2H200SFT1G</a>	Schottky Power Rectifier, Surface Mount, 2.0 A, 200 V	N
N-MOSFET 1	2	<a href="#">FCD260N65S3</a>	Power MOSFET, N-Channel, SUPERFET® III, Easy Drive, 650 V, 12 A, 260 mΩ, DPAK	Y
N-MOSFET 1	Alternative	<a href="#">FCP360N65S3R0</a>	Power MOSFET, N-Channel, SUPERFET® III, Easy Drive, 650 V, 10 A, 360 mΩ, TO-220	Y
N-MOSFET 2	1	<a href="#">BSS138</a>	N-Channel Logic Level Enhancement Mode Field Effect Transistor, 50V, 220mA	N
N-MOSFET 3	2	<a href="#">FQP55N10</a>	Power MOSFET, N-Channel, QFET®, 100 V, 55 A, 26 mΩ, TO-220	N
N-MOSFET 3	Alternative	<a href="#">NTMFS6H848NLT1G</a>	Power MOSFET, Single N-Channel, 80V, 59A, 8.8 mOhm	Y
Zener Diode	1	<a href="#">MMSZ15T1G</a>	500 mW 15 V ±5% Zener Diode Voltage Regulator	N
<b>Power Management</b>				
Buck Converter 1	1	<a href="#">LM2576D2TR4-012G</a>	Buck Regulator, Switching, 3.0 A, 15 V, 3.0 A, 12 V, 52 kHz	N
Buck Converter 2	1	<a href="#">LM2576D2T-005G</a>	Buck Regulator, Switching, 3.0 A, 15 V, 3.0 A, 5.0 V, 52 kHz	N
PMIC 1	1	<a href="#">NCV97310MW33AR2G</a>	Multi-output Power Management Unit (PMU) with 3 Buck Regulators, NCV97310A 3.3V version	N
PMIC 2	1	<a href="#">NCP6922CDMTTXG</a>	LDO Regulator, Dual, 4-Channel PMIC, Dual DC-DC Converters	Y
Schottky Diode	2	<a href="#">FSV340FP</a>	Surface Mount Schottky Barrier Rectifier	N
<b>Battery Management</b>				
Battery Charge Controller	1	<a href="#">NCP1871MNTXG</a>	Battery Charge Controller, Switching, NVDC, 2/3/4 Cell, with SMBus Interface	N
N-MOSFET 1	1	<a href="#">2N7002LT1G</a>	N-Channel Small Signal MOSFET 60V 115mA 7.5 Ω	N
N-MOSFET 2	4	<a href="#">NTTFS4C10NTWG</a>	Power MOSFET 30V 44A 7.4 mOhm Single N-Channel u8FL	N
N-MOSFET 3	1	<a href="#">FDN028N20</a>	N-Channel PowerTrench® MOSFET 20V, 6.1A, 28mΩ	Y
Protection Diode 1	1	<a href="#">MBRM120ET1G</a>	Schottky Power Rectifier, Surface Mount, 1.0 A, 20 V	N
Protection Diode 2	1	<a href="#">MBRA340T3G</a>	Schottky Power Rectifier, Surface Mount, 3.0 A, 40 V	N
Temperature Sensor	1	<a href="#">NCT72DMNR2G</a>	±1°C Temperature Monitor with Series Resistance Cancellation	N
<b>Valve Drive Module</b>				
Valve Controller	1	<a href="#">NCV7120FP0R2G</a>	Hex Solenoid Current Controller with N-FET Predrivers	N
N-MOSFET 1	1	<a href="#">NTMFS5C442NL</a>	Single N-Channel Power MOSFET 40V, 130A, 2.5mΩ	Y
N-MOSFET 2	2	<a href="#">NTMFS5C468NL</a>	Single N-Channel Power MOSFET 40V, 37A, 10.3mΩ	Y
N-MOSFET 3	3	<a href="#">NTMFD5C680NL</a>	Dual N-Channel Power MOSFET 60V, 26A, 28mΩ	Y
Diode	3	<a href="#">MURS210T3G</a>	Power Rectifier, Ultra-Fast Recovery, 2 A, 100 V	N
Charge Pump Diode	3	<a href="#">HN2D02FUTW1T1G</a>	Ultra High Speed Switching Diode	N

[Return to top diagram](#)

Public Information

ON Semiconductor®





Suggested Block	Qty.	WPN	WPN Description	OT?
<b>BDLC Drive Module</b>				
Multi-Purpose BLDC Gate Driver	1	<a href="#">LV8968BBUWR2G</a>	Multi-purpose BLDC Pre-driver, For Automotive	Y
N-MOSFET	7	<a href="#">FDP8447L</a>	N-Channel PowerTrench® MOSFET 40V, 50A, 8.7mΩ	N
Timer Circuit	1	<a href="#">MC1455DR2G</a>	Timer Circuit	N
Zener Diode Voltage Regulator 1	1	<a href="#">MM3Z39VT1G</a>	300 mW 39 V ±5% Zener Diode Voltage Regulator	N
LDO	1	<a href="#">LM317MBSTT3G</a>	Linear Voltage Regulator, 500 mA, High PSRR, Adjustable, Positive	N
Schottky Diode	1	<a href="#">MBR540MFST1G</a>	Schottky Power Rectifier, Switch-mode, 5.0 A, 40 V	N
Zener Diode Voltage Regulator 2	1	<a href="#">BZX84B18LT1G</a>	Zener Diode Voltage Regulator, 250 mW, 18 V, ±2% Tight Tolerance	N
Switching Diode 1	12	<a href="#">MMDL6050T1G</a>	70 V Switching Diode	N
Operational Amplifier	3	<a href="#">MC33202VDR2G</a>	Operational Amplifier, Rail to Rail I/O, High Output Drive	N
Switching Diode 2	2	<a href="#">BAV74LT1G</a>	50 V Dual Common Cathode Switching Diode	N
Comparator	1	<a href="#">LM2903DR2G</a>	Comparator, Dual, Low Offset Voltage	N
Bipolar Transistor	1	<a href="#">BC846ALT1G</a>	NPN Bipolar Transistor	N
Switching Diode 3	1	<a href="#">MMSD914T1G</a>	Switching Diode, High Speed, 100 V	N
<b>LCD Display &amp; Touchscreen Drive</b>				
Backlight Boost Driver	1	<a href="#">CAT32TDI-GT3</a>	White LED Driver	N
Linear Driver	Alternative	<a href="#">NSI50150ADT4G</a>	LED Driver, Adjustable Constant Current Regulator, 50 V, 150 - 350 mA	Y
Ambient Light Sensor	1	<a href="#">LV0104CS-TLM-H</a>	Ambient Light Sensor, I2C Interface	N
Capacitance to Digital Converter	1	<a href="#">LC717A10AR-NH</a>	Capacitance-Digital-Converter for Electrostatic Capacitive Touch Sensors	Y
Schottky Diode	1	<a href="#">MBR0530T1G</a>	Schottky Power Rectifier, Surface Mount, 0.5 A, 30 V	N
Digital Potentiometer	1	<a href="#">CAT5138SDI-10GT3</a>	Digital Potentiometer (POT), 128-Taps, I2C Interface	N
HDMI ESD Protection	1	<a href="#">ESD7104MUTAG</a>	ESD Protection, Low Capacitance, High Speed Data	Y
<b>MCU and Processing</b>				
Bluetooth	1	<a href="#">NCH-RSL10-101Q48-ABG</a>	Radio SoC, Bluetooth® 5 Certified, SDK 3.2	Y
Serial SRAM	1	<a href="#">N01S830BAT22IT</a>	Serial SRAM Memory, 1 Mb, Ultra-Low-Power, 2.5 to 5.5 V, TSSOP-8 (Industrial) 3000 Units/ Tape & Reel	Y
EEPROM	1	<a href="#">N84C163WD28TG</a>	EEPROM Serial 16-Kb CPU Supervisor	N
Load Switch	1	<a href="#">FPF1048BUCX</a>	IntelliMAX™ 3A-Capable, Slew-Rate-Controlled Load Switch with True Reverse Current Blocking	Y
Low Noise Operational Amplifier	4	<a href="#">NE5534ADR2G</a>	Operational Amplifier, Low Noise, Single	N
Low Noise Operational Amplifier	Alternative	<a href="#">NCS2003SN2T1G</a>	Operational Amplifier, High Slew Rate, Low Voltage, Rail-to-Rail Output	Y
Low Noise Operational Amplifier	Alternative	<a href="#">NCS333ASQ3T2G</a>	Low Power, Zero-Drift Operational Amplifier with 10 µV Offset	Y
12-Bit ADC Converter	4	<a href="#">NCD98010XMXTAG</a>	12-Bit Low Power SAR ADC Unsigned Output	Y
ESD and Surge Protection	1	<a href="#">SMDA15CDR2G</a>	ESD / Surge Protector	N
Bidirectional Optocoupler	1	<a href="#">FOD8012A</a>	High CMR, Bi-Directional, Logic Gate Optocoupler	Y
Programmable PLL Clock	1	<a href="#">FS7140-02G-XTP</a>	I2C Programmable 1-PLL Clock	Y
USB 2 ESD Protection	2	<a href="#">ESD8472MUT5G</a>	Ultra-Low Capacitance RF ESD Protection	Y
Audio Amplifier	1	<a href="#">NCP2820FCT1G</a>	Audio Power Amplifier, Class D, 2.65 W, Filterless, Mono	N
Audio Processor	1	<a href="#">LC823455</a>	Low Power & High-Resolution Audio Processing System LSI for Portable Sound Solutions. Dual ARM Cortex-M3 (170MHz), plus 32bit LPDSP, >1k Total MIPS, 4MB SRAM (shared by CPU's/DSP), 12bit ADC, with 54 ch GPIO.	Y
PMIC	1	<a href="#">NCP6925</a>	Power Management IC (PMIC), 7 Channels, with 2 DC-DC Converters and 5 LDOs. PMIC accepts 2.5V to 5.5V input. Outputs: 5 LDO's (Vout: 0.8V to 3.5V, 300mA), and two 3MHz bucks (Vout: 0.6V to 3.3V, 1A)	Y
LDO	1	<a href="#">NCP705</a>	LDO Regulator, 500 mA, Ultra-Low Iq, High PSRR, Ultra-Low Noise. VIN 2.5V to 5.5V, VOUT 0.8V to 3.5V, 500mA, PSRR 71dB @ 1kHz, Noise 12uV from 100Hz to 100kHz.	Y
Temperature Sensor	1	<a href="#">N34TS108C6ECT5G</a>	Low-Voltage Digital Temperature Sensor, Low-Voltage Digital Temperature Sensor	N
Voltage Supervisor	1	<a href="#">NCP308MT300TBG</a>	Voltage Supervisor, Ultra Low Quiescent Current, Programmable Delay Time, Low Quiescent Current, Delay Time Programmable Supervisory Circuit	N
Microphone/Voice Command Input	1	<a href="#">LA74309FA-BH</a>	Microphone Amplifier	N
Microphone/Voice Command Input	1	<a href="#">FAN3852UC16X</a>	Microphone Pre-Amplifier with Digital Output	Y
Voltage Reference	1	<a href="#">KA431SLMF2TF</a>	Adjustable/2.5 V, 0.5% Tolerance Shunt Regulator	N

[Return to top diagram](#)

