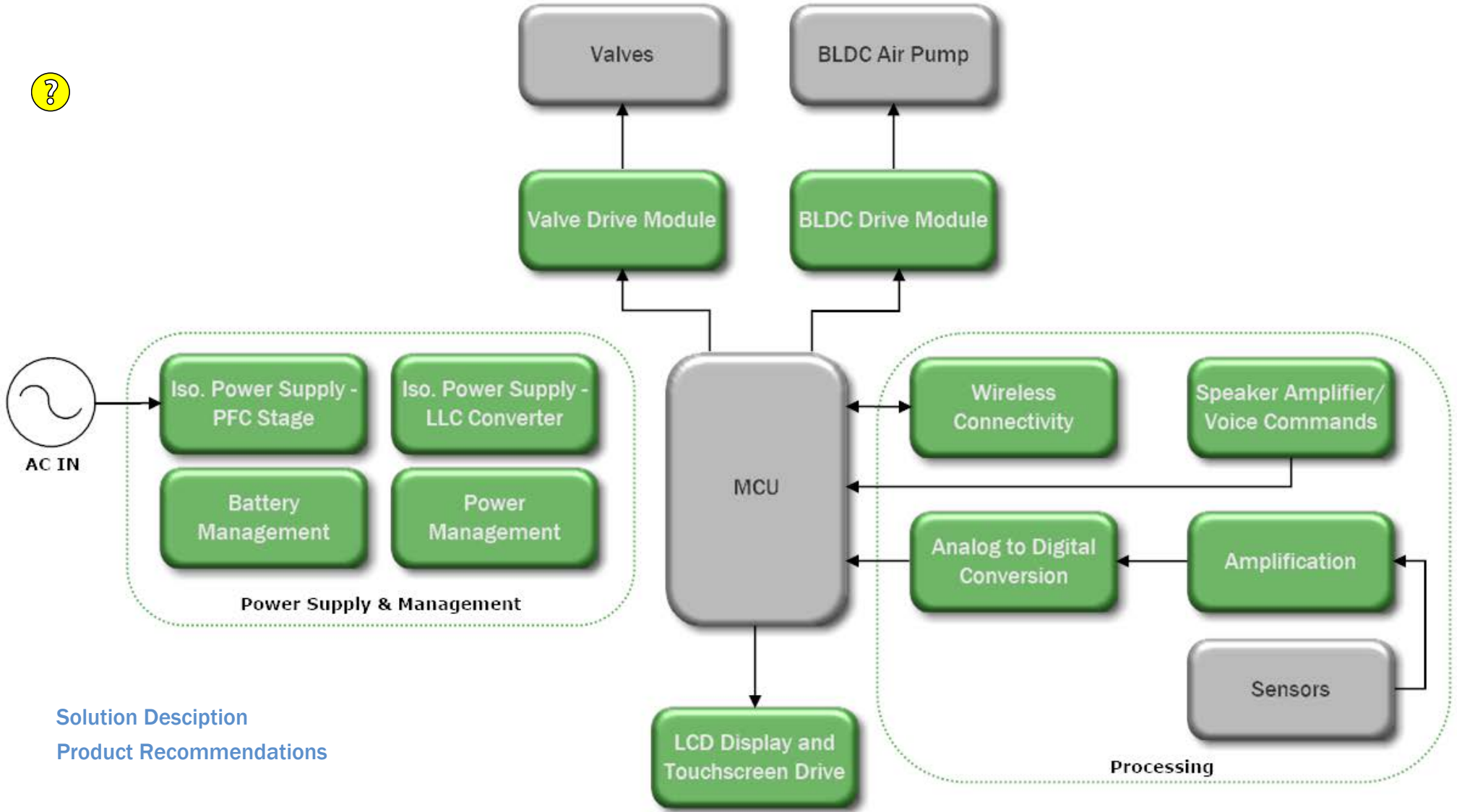


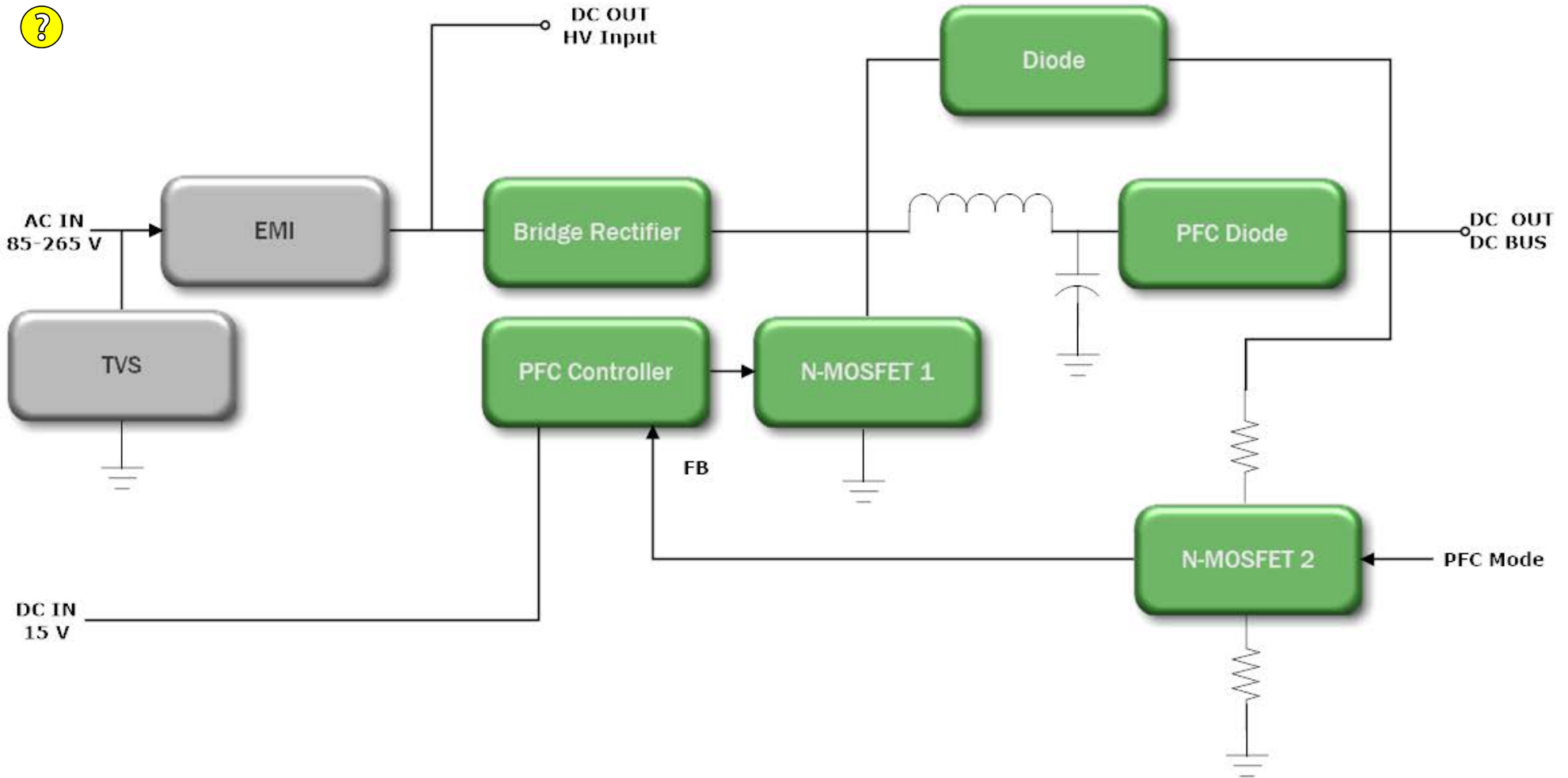
Medical Ventilator Core Solution



Solution Description
Product Recommendations



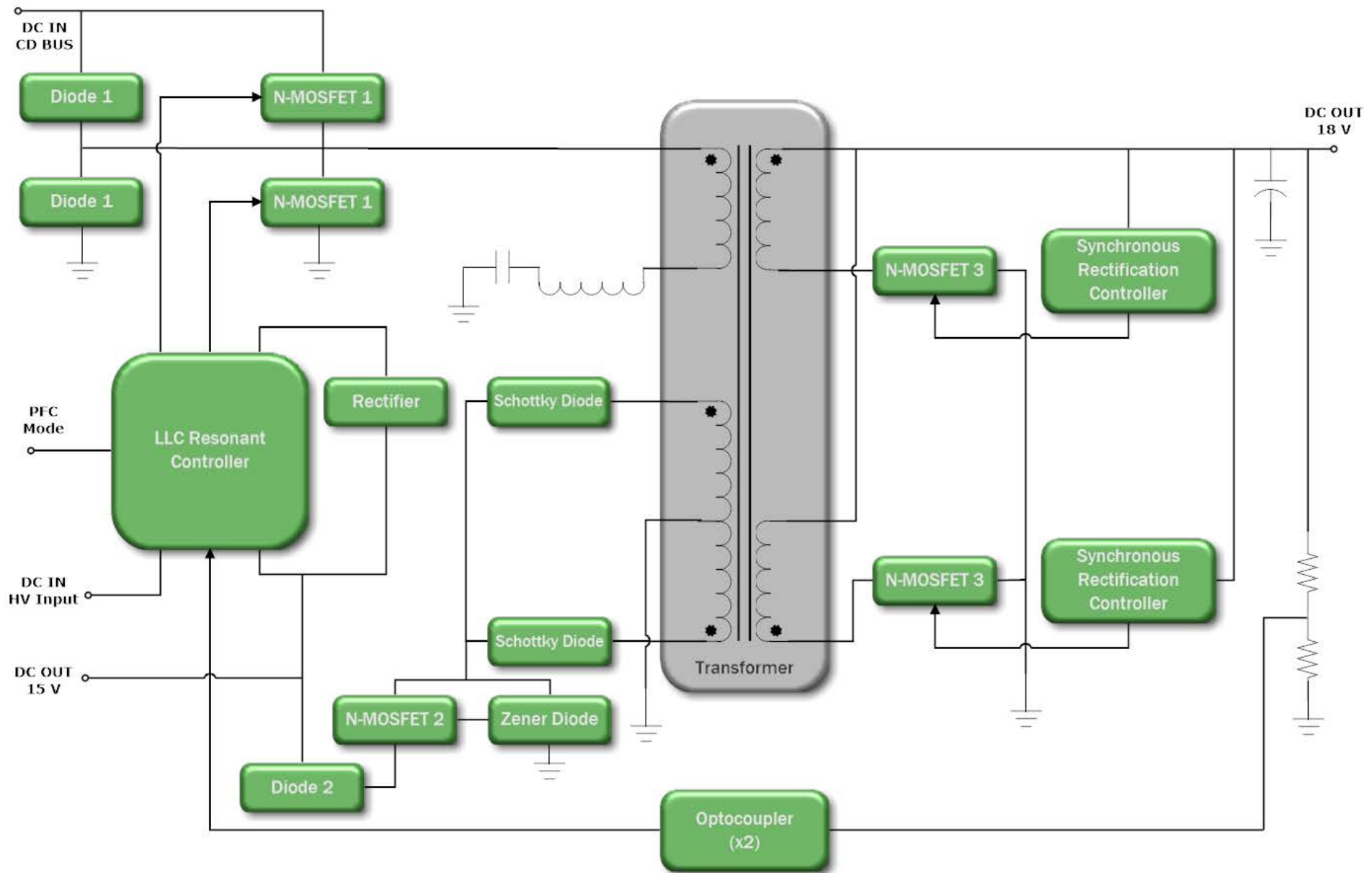
Isolated Power Supply Unit - PFC Stage



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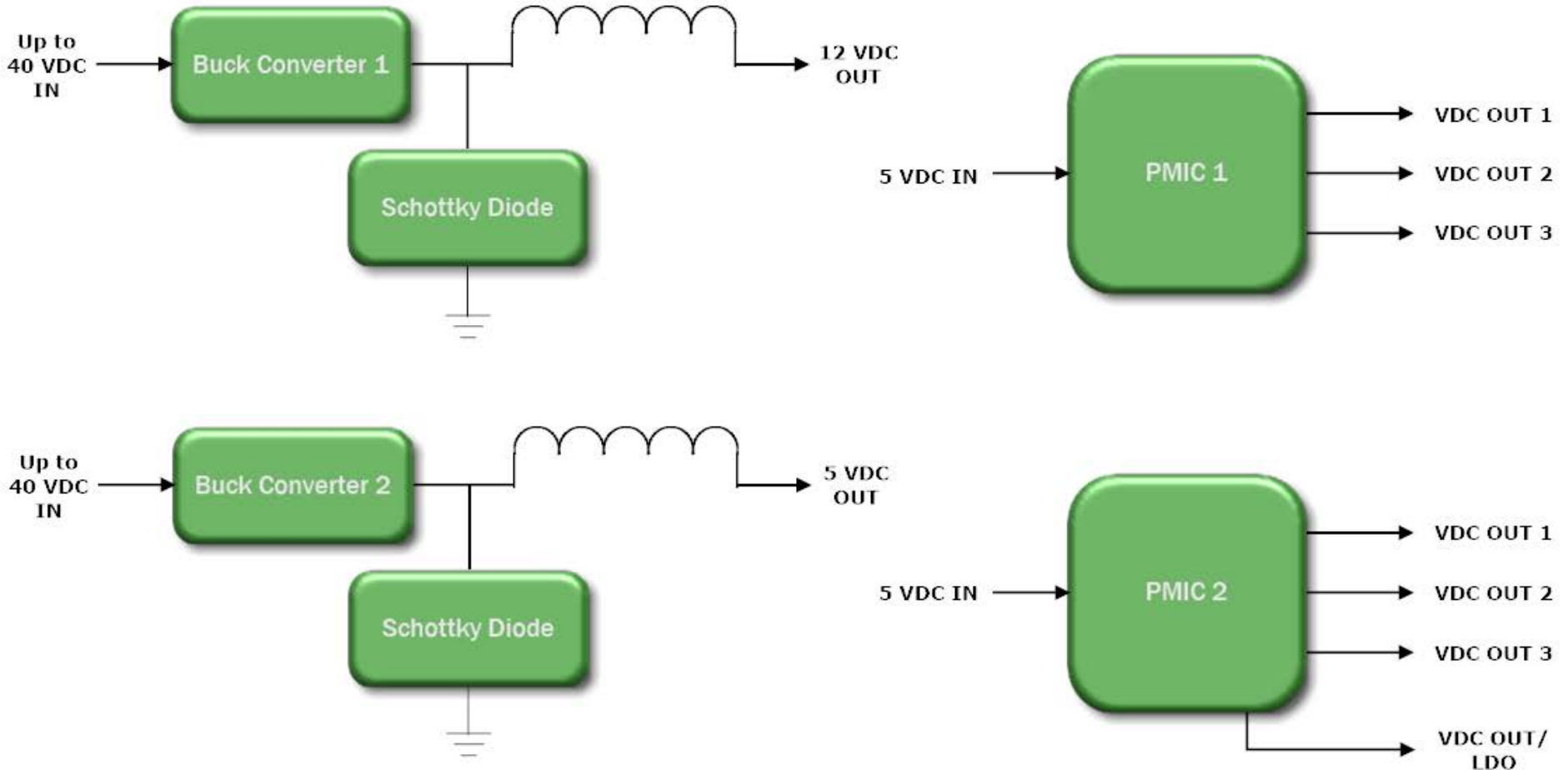
Isolated Power Supply Unit - Resonant Half-Bridge LLC Converter Stage



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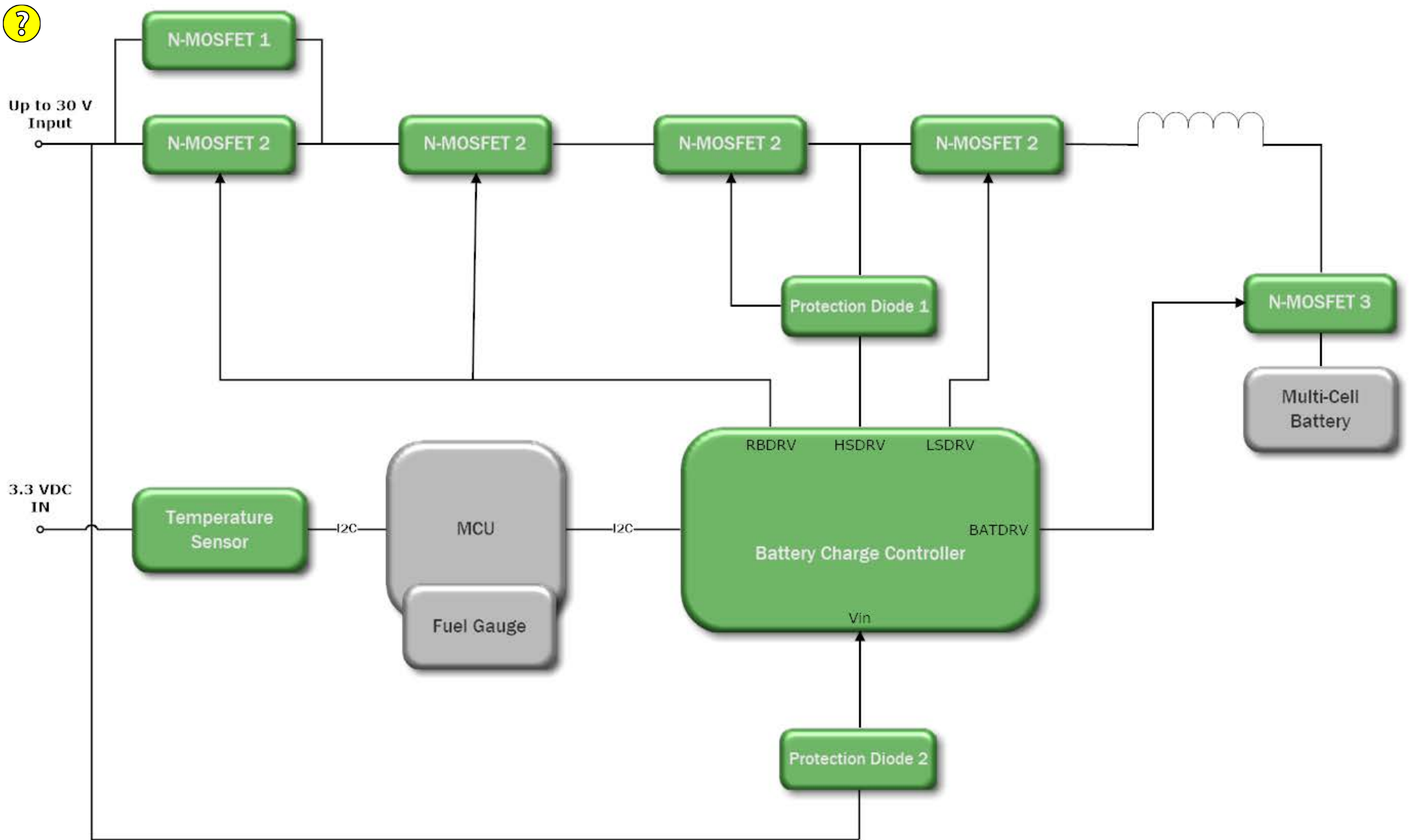
Power Management



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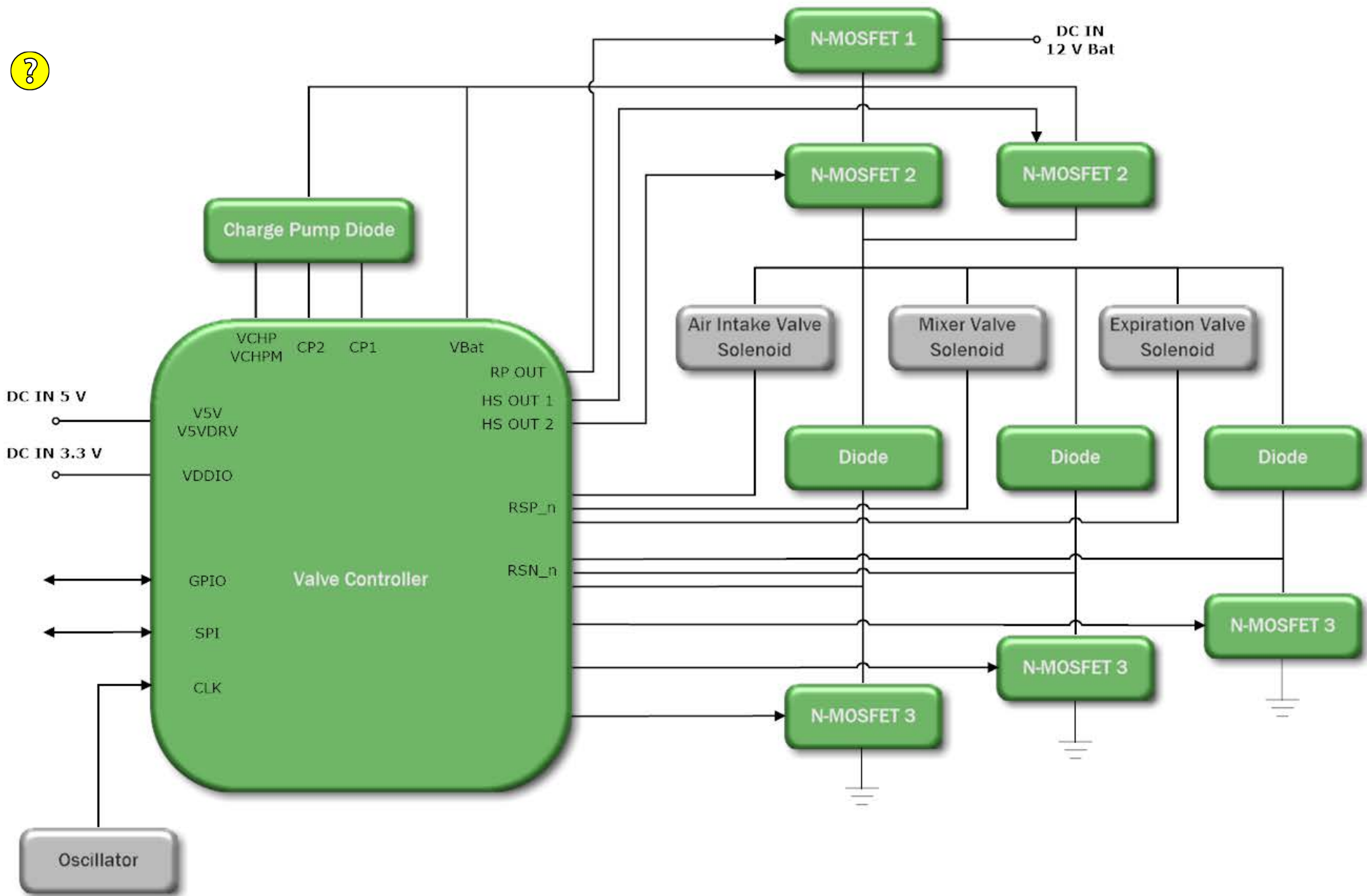
Battery Management



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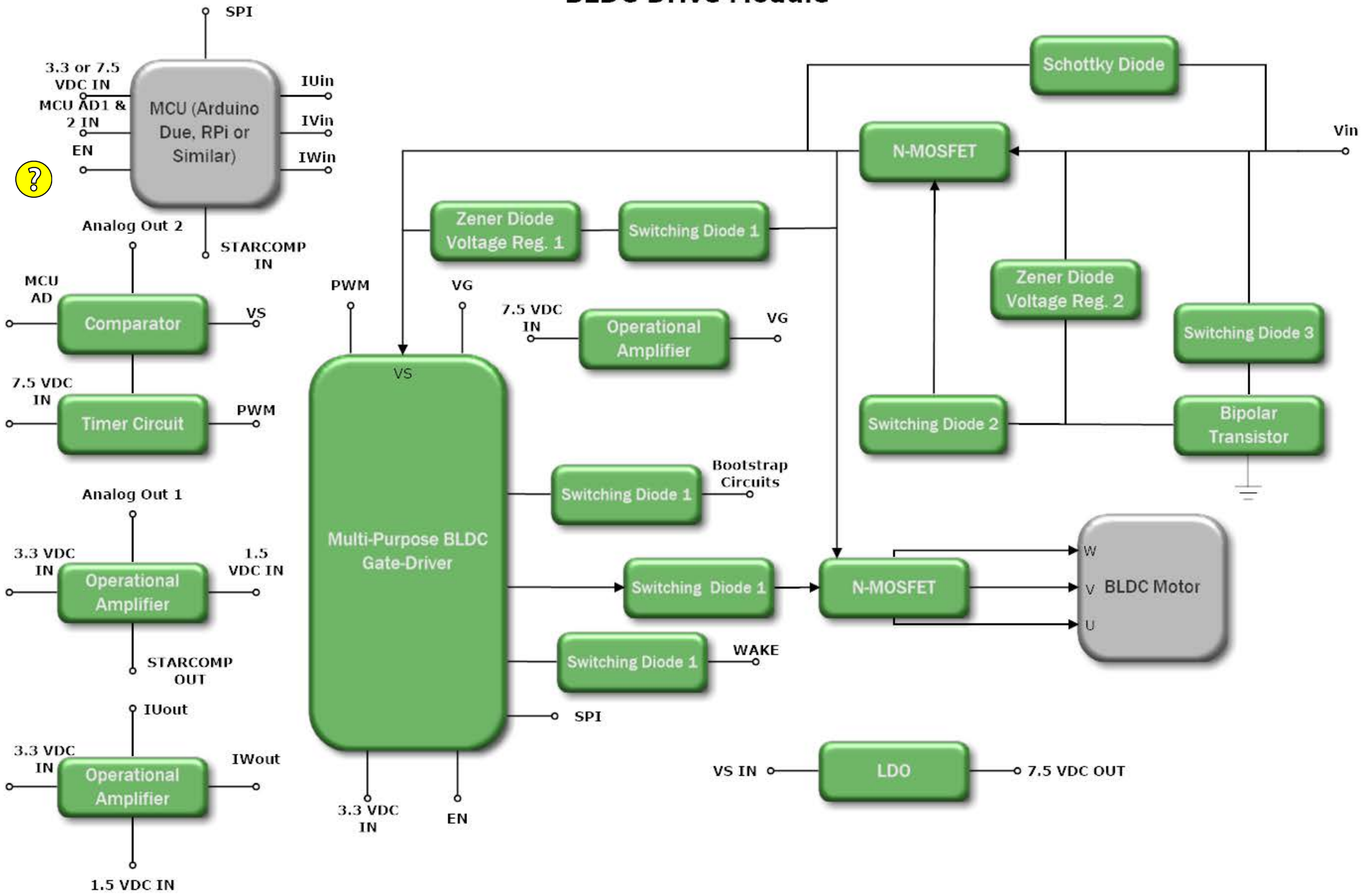
Value Drive Module



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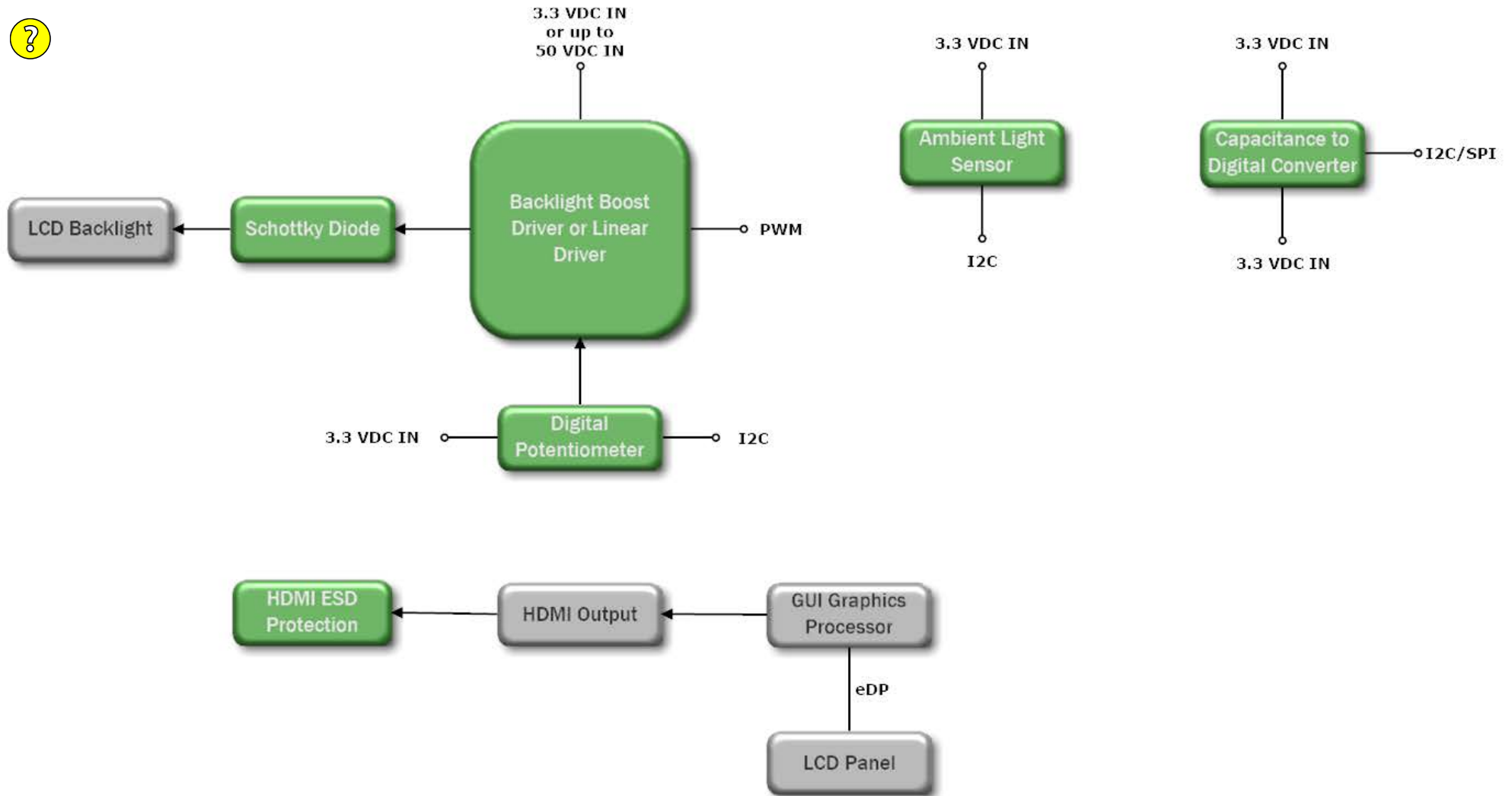
BLDC Drive Module



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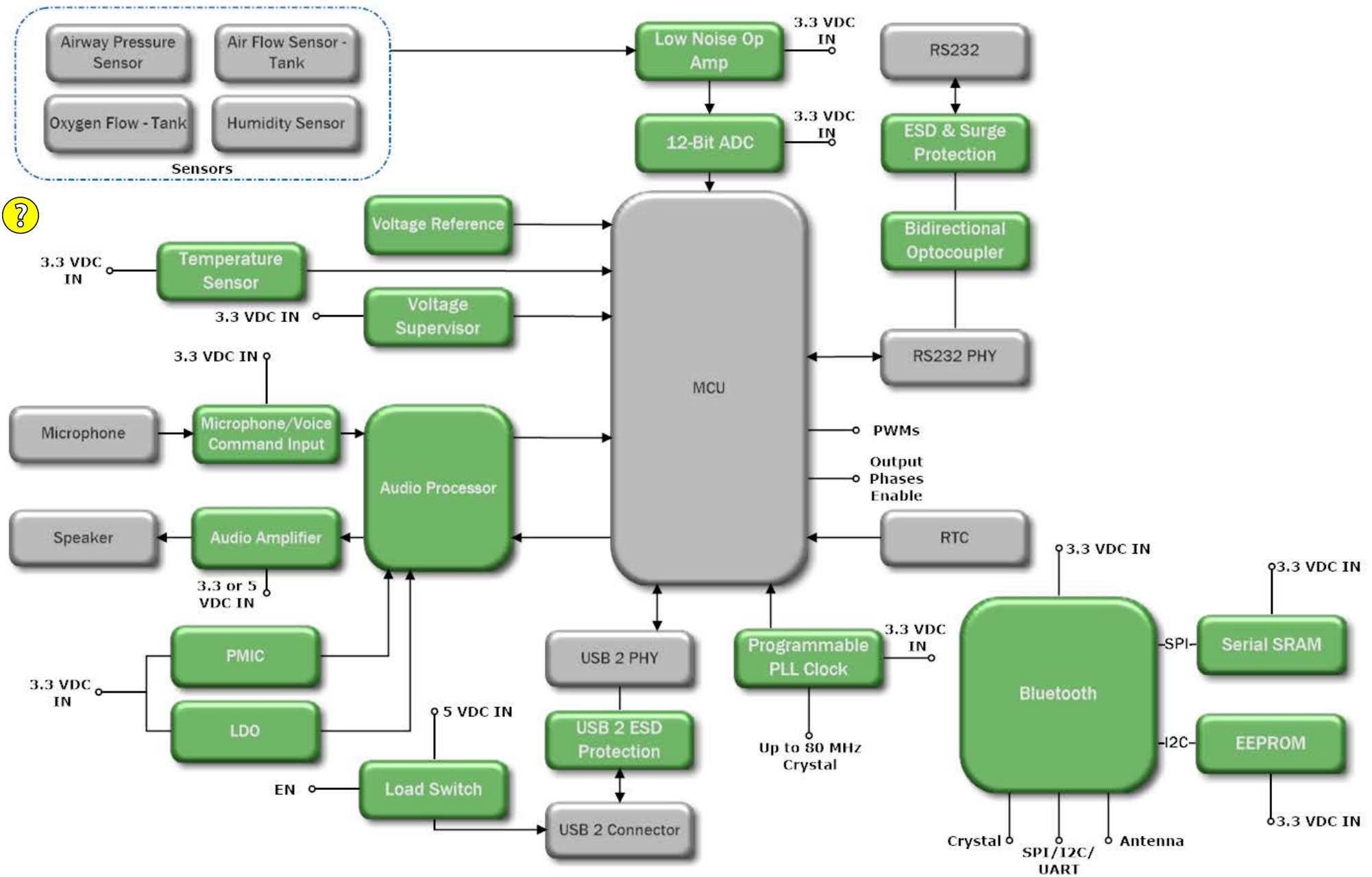
LCD Display & Touchscreen Drive Module



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MCU and Processing



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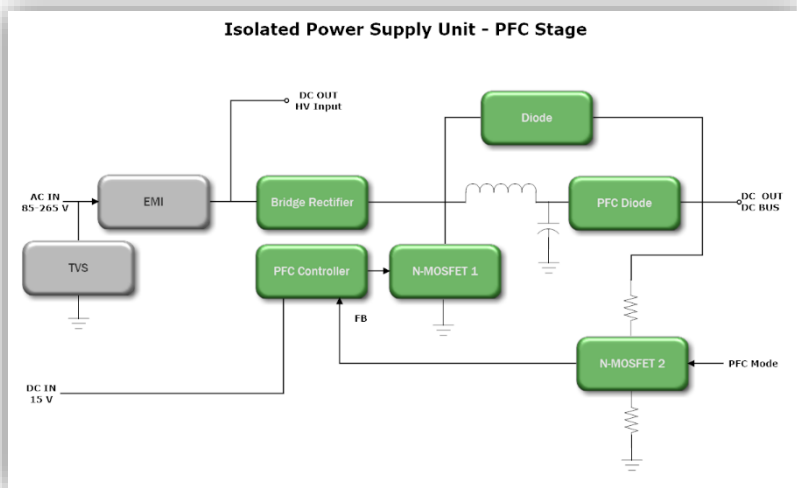


Medical Ventilator Solution Description

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).

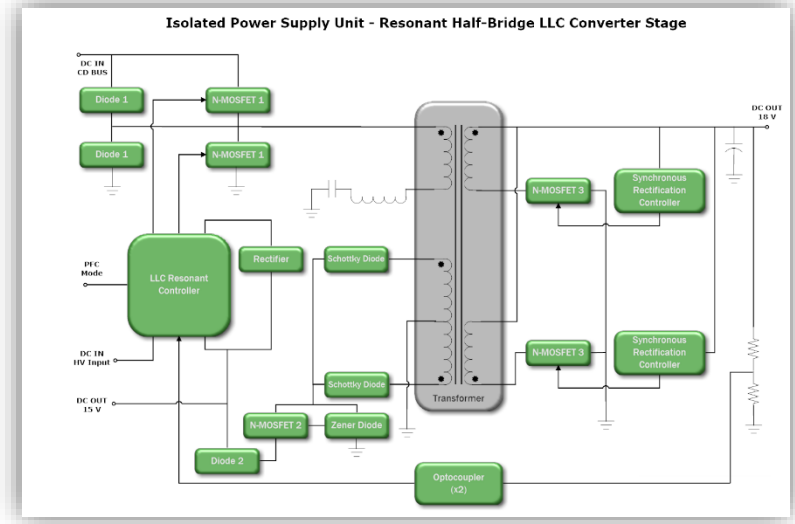
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Isolated Power Supply Unit – Resonant Half-Bridge LLC Converter Stage

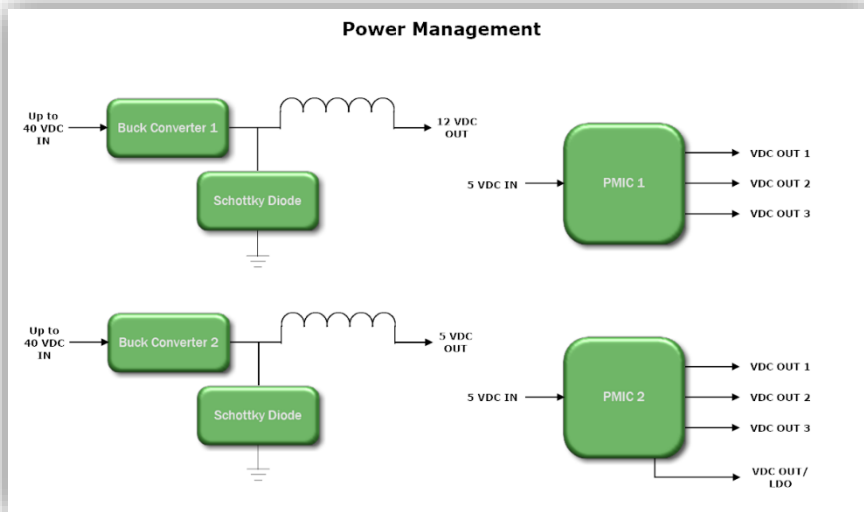
Output from the PFC stage is converted to 18V by resonant half-bridge LLC converter. The main controller **NCP1399** drives high-side and low-side N-MOSFETs **FCD260N65S3** (650 V, 12 A, 260 mΩ). It features a dedicated output to drive the PFC controller. This feature, together with dedicated skip mode 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

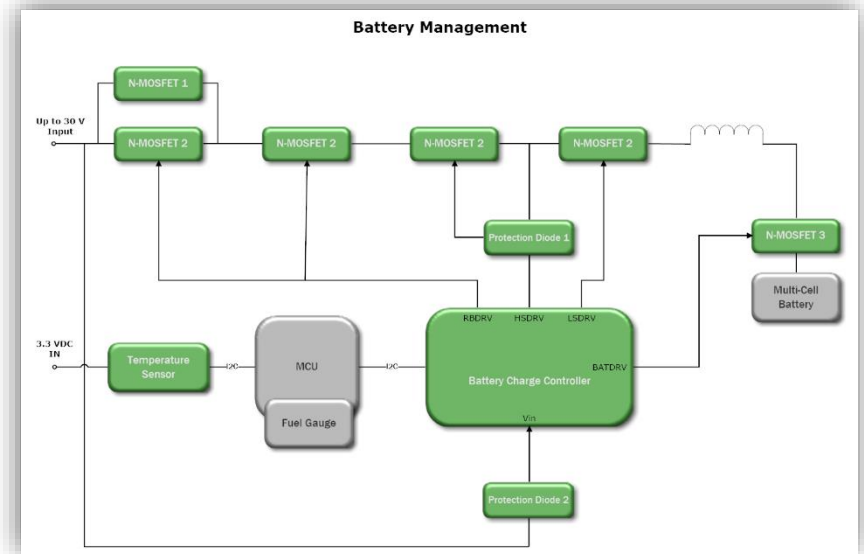


As a power management solution, two **LM2576** buck converters are used to lower the input voltage from a LLC stage. They are followed by two power management integrated circuits. The **NCV97310** is three output regulator consisting of a low-Iq battery-connected 3 A 2 MHz non-synchronous switcher and 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.

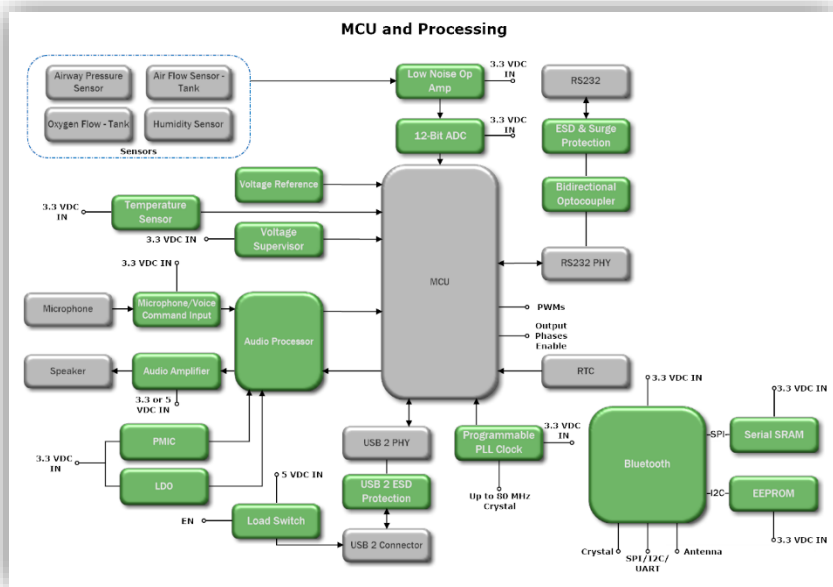
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Battery Management

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.

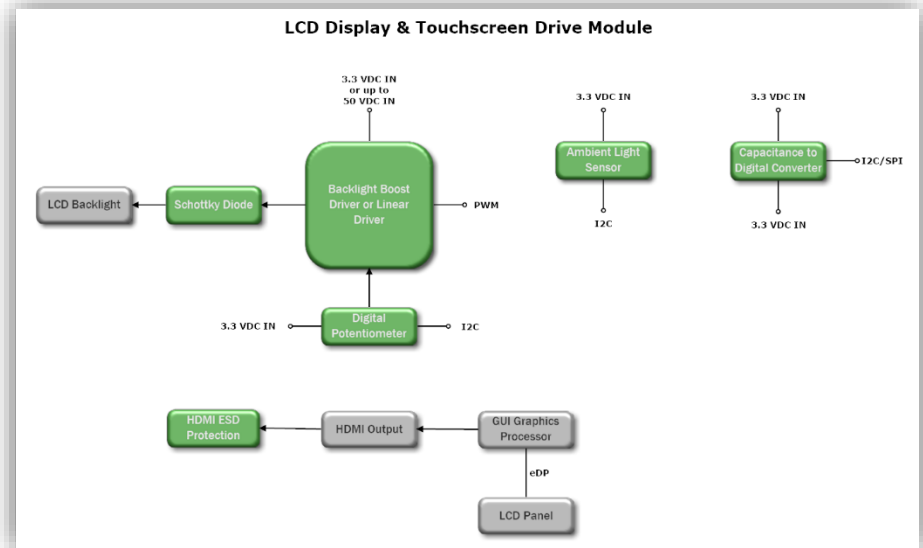
To process the input from sensors, we are proposing our low noise operational amplifiers and analog to digital converter **NCD98010**. To control optional USB devices connected to the device, load switch **FPF1048** and **ESD8472** protection were offered. As for the connectivity, a medical variant of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

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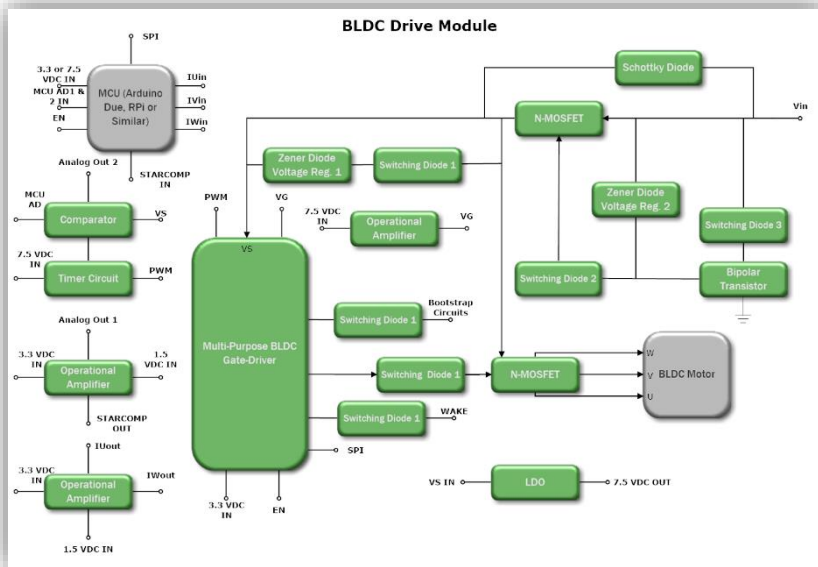


LCD Display and Touchscreen Module

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



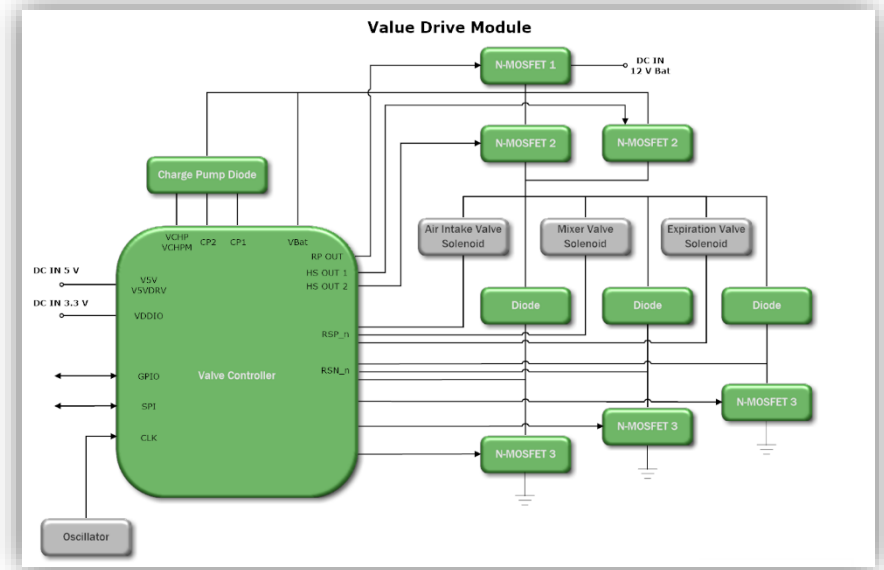
As a driver for the main component of the air pump, BLDC compressor, we can offer the **LV8968** BLDC gate driver with support for programming via SPI interface, PWM inputs, six gate drivers provide 400 mA gate current to external power bridges allowing use of low-resistance power FETs, as well as logic 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.

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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.

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Suggested Block	Qty.	WPN	WPN Description
Isolated Power Supply Unit - PFC Stage			
Bridge Rectifier	1	GBU8K	8 A Bridge Rectifier
PFC Controller	1	NCP1654BD133R2G	Power Factor Correction Controller for Compact and Robust, Continuous Conduction Mode Pre-Converters
N-MOSFET 1	1	FCPF250N65S3ROL	Power MOSFET, N-Channel, SUPERFET® III, Easy Drive, 650 V, 12 A, 250 mΩ, TO-220F
PFC Diode	1	MSR860G	Power Rectifier, Soft Recovery, Switch-mode, 8 A, 600 V
Diode	1	MUR4100EG	Power Rectifier, Ultra-Fast Recovery, Switch-mode, 4 A, 1000 V
N-MOSFET 2	1	FQT1N60CTF-WS	Power MOSFET, N-Channel, QFET®, 600 V, 0.2 A, 11.5 Ω, SOT-223
Isolated Power Supply Unit - Resonant Half-Bridge LLC Converter Stage			
LLC Resonant Controller	1	NCP1399AADR2G	Current Mode Resonant Controller (Integrated High Voltage Drivers, High Performance)
Optocoupler	1	FOD8173S	4-Pin DIP Phototransistor Optocouplers
Optocoupler	Alternative	FODM1008	Single Channel, DC Sensing Input, Phototransistor Optocoupler In Stretched Body SOP 4-Pin
Synchronous Rectification Controller	2	NCP4306DAHZZAASNT1G	Secondary Side Synchronous Rectification Driver for High Efficiency SMPS Topologies
Diode 1	2	1N4937G	600 V, 1.0 A Fast Recovery Rectifier
Diode 2	1	MMDL914T1G	100 V 200 mA High Speed Switching Diode
Rectifier	1	MURA160T3G	Power Rectifier, Ultra-Fast Recovery, 1 A, 600 V
Schottky Diode	2	MBR2H200SFT1G	Schottky Power Rectifier, Surface Mount, 2.0 A, 200 V
N-MOSFET 1	2	FCD260N65S3	Power MOSFET, N-Channel, SUPERFET® III, Easy Drive, 650 V, 12 A, 260 mΩ, DPAK
N-MOSFET 1	Alternative	FCP360N65S3RO	Power MOSFET, N-Channel, SUPERFET® III, Easy Drive, 650 V, 10 A, 360 mΩ, TO-220
N-MOSFET 2	1	BSS138	N-Channel Logic Level Enhancement Mode Field Effect Transistor, 50V, 220mA
N-MOSFET 3	2	FQP55N10	Power MOSFET, N-Channel, QFET®, 100 V, 55 A, 26 mΩ, TO-220
N-MOSFET 3	Alternative	NTMFS6H848NLT1G	Power MOSFET, Single N-Channel, 80V, 59A, 8.8 mOhm
Zener Diode	1	MMSZ15T1G	500 mW 15 V ±5% Zener Diode Voltage Regulator
Power Management			
Buck Converter 1	1	LM2576D2TR4-012G	Buck Regulator, Switching, 3.0 A, 15 V, 3.0 A, 12 V, 52 kHz
Buck Converter 2	1	LM2576D2T-005G	Buck Regulator, Switching, 3.0 A, 15 V, 3.0 A, 5.0 V, 52 kHz
PMIC 1	1	NCV97310MW33AR2G	Multi-output Power Management Unit (PMU) with 3 Buck Regulators, NCV97310A 3.3V version
PMIC 2	1	NCP6922CDMTTXG	LDO Regulator, Dual, 4-Channel PMIC, Dual DC-DC Converters
Schottky Diode	2	FSV340FP	Surface Mount Schottky Barrier Rectifier
Battery Management			
Battery Charge Controller	1	NCP1871MNTXG	Battery Charge Controller, Switching, NVDC, 2/3/4 Cell, with SMBus Interface
N-MOSFET 1	1	2N7002LT1G	N-Channel Small Signal MOSFET 60V 115mA 7.5 Ω
N-MOSFET 2	4	NTTFS4C10NTWG	Power MOSFET 30V 44A 7.4 mOhm Single N-Channel u8FL
N-MOSFET 3	1	FDN028N20	N-Channel PowerTrench® MOSFET 20V, 6.1A, 28mΩ
Protection Diode 1	1	MBRM120ET1G	Schottky Power Rectifier, Surface Mount, 1.0 A, 20 V
Protection Diode 2	1	MBRA340T3G	Schottky Power Rectifier, Surface Mount, 3.0 A, 40 V
Temperature Sensor	1	NCT72DMNR2G	±1°C Temperature Monitor with Series Resistance Cancellation
Valve Drive Module			
Valve Controller	1	NCV7120FP0R2G	Hex Solenoid Current Controller with N-FET Predrivers
N-MOSFET 1	1	NTMFS5C442NL	Single N-Channel Power MOSFET 40V, 130A, 2.5mΩ
N-MOSFET 2	2	NTMFS5C468NL	Single N-Channel Power MOSFET 40V, 37A, 10.3mΩ
N-MOSFET 3	3	NTMFD5C680NL	Dual N-Channel Power MOSFET 60V, 26A, 28mΩ
Diode	3	MURS210T3G	Power Rectifier, Ultra-Fast Recovery, 2 A, 100 V
Charge Pump Diode	3	HN2D02FUTW1T1G	Ultra High Speed Switching Diode

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Suggested Block	Qty.	WPN	WPN Description
BDLC Drive Module			
Multi-Purpose BLDC Gate Driver	1	LV8968BBUWR2G	Multi-purpose BLDC Pre-driver, For Automotive
N-MOSFET	7	FDP8447L	N-Channel PowerTrench® MOSFET 40V, 50A, 8.7mΩ
Timer Circuit	1	MC1455DR2G	Timer Circuit
Zener Diode Voltage Regulator 1	1	MM3Z39VT1G	300 mW 39 V ±5% Zener Diode Voltage Regulator
LDO	1	LM317MBSTT3G	Linear Voltage Regulator, 500 mA, High PSRR, Adjustable, Positive
Schottky Diode	1	MBR540MFST1G	Schottky Power Rectifier, Switch-mode, 5.0 A, 40 V
Zener Diode Voltage Regulator 2	1	BZX84B18LT1G	Zener Diode Voltage Regulator, 250 mW, 18 V, ±2% Tight Tolerance
Switching Diode 1	12	MMDL6050T1G	70 V Switching Diode
Operational Amplifier	3	MC33202VDR2G	Operational Amplifier, Rail to Rail I/O, High Output Drive
Switching Diode 2	2	BAV74LT1G	50 V Dual Common Cathode Switching Diode
Comparator	1	LM2903DR2G	Comparator, Dual, Low Offset Voltage
Bipolar Transistor	1	BC846ALT1G	NPN Bipolar Transistor
Switching Diode 3	1	MMSD914T1G	Switching Diode, High Speed, 100 V
LCD Display & Touchscreen Drive			
Backlight Boost Driver	1	CAT32TDI-GT3	White LED Driver
Linear Driver	Alternative	NSI50150ADT4G	LED Driver, Adjustable Constant Current Regulator, 50 V, 150 - 350 mA
Ambient Light Sensor	1	LV0104CS-TLM-H	Ambient Light Sensor, I2C Interface
Capacitance to Digital Converter	1	LC717A10AR-NH	Capacitance-Digital-Converter for Electrostatic Capacitive Touch Sensors
Schottky Diode	1	MBR0530T1G	Schottky Power Rectifier, Surface Mount, 0.5 A, 30 V
Digital Potentiometer	1	CAT5138SDI-10GT3	Digital Potentiometer (POT), 128-Taps, I2C Interface
HDMI ESD Protection	1	ESD7104MUTAG	ESD Protection, Low Capacitance, High Speed Data
MCU and Processing			
Bluetooth	1	NCH-RSL10-101Q48-ABG	Radio SoC, Bluetooth® 5 Certified, SDK 3.2
Serial SRAM	1	N01S830BAT22IT	Serial SRAM Memory, 1 Mb, Ultra-Low-Power, 2.5 to 5.5 V, TSSOP-8 (Industrial) 3000 Units/ Tape & Reel
EEPROM	1	N84C163WD28TG	EEPROM Serial 16-Kb CPU Supervisor
Load Switch	1	FPF1048BUCX	IntelliMAX™ 3A-Capable, Slew-Rate-Controlled Load Switch with True Reverse Current Blocking
Low Noise Operational Amplifier	4	NE5534ADR2G	Operational Amplifier, Low Noise, Single
Low Noise Operational Amplifier	Alternative	NCS2003SN2T1G	Operational Amplifier, High Slew Rate, Low Voltage, Rail-to-Rail Output
Low Noise Operational Amplifier	Alternative	NCS333ASQ3T2G	Low Power, Zero-Drift Operational Amplifier with 10 μV Offset
12-Bit ADC Converter	4	NCD98010XMXTAG	12-Bit Low Power SAR ADC Unsigned Output
ESD and Surge Protection	1	SMDA15CDR2G	ESD / Surge Protector
Bidirectional Optocoupler	1	FOD8012A	High CMR, Bi-Directional, Logic Gate Optocoupler
Programmable PLL Clock	1	FS7140-02G-XTP	I2C Programmable 1-PLL Clock
USB 2 ESD Protection	2	ESD8472MUT5G	Ultra-Low Capacitance RF ESD Protection
Audio Amplifier	1	NCP2820FCT1G	Audio Power Amplifier, Class D, 2.65 W, Filterless, Mono
Audio Processor	1	LC823455	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.
PMIC	1	NCP6925	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)
LDO	1	NCP705	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.
Temperature Sensor	1	N34TS108C6ECT5G	Low-Voltage Digital Temperature Sensor, Low-Voltage Digital Temperature Sensor
Voltage Supervisor	1	NCP308MT300TBG	Voltage Supervisor, Ultra Low Quiescent Current, Programmable Delay Time, Low Quiescent Current, Delay Time Programmable Supervisory Circuit
Microphone/Voice Command Input	1	LA74309FA-BH	Microphone Amplifier
Microphone/Voice Command Input	1	FAN3852UC16X	Microphone Pre-Amplifier with Digital Output
Voltage Reference	1	KA431SLMF2TF	Adjustable/2.5 V, 0.5% Tolerance Shunt Regulator

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