Power Management for Industry 4.0 and IoT applications

Industry 4.0 has sparked one of the most significant demand streams for high-end technologies with systems implementing increasingly advanced IoT deliverables.
The same key IoT technologies are expected to come together in many different applications, to the point that sensors, microcontrollers and connectivity devices will become mainstay components across the majority of industrial applications, with many block diagrams and BOMs converging over a wide range of solutions.
ST's IoT range can satisfy the full BOM requirements of comprehensive industrial systems, such as the turnkey condition monitoring solution figured below.

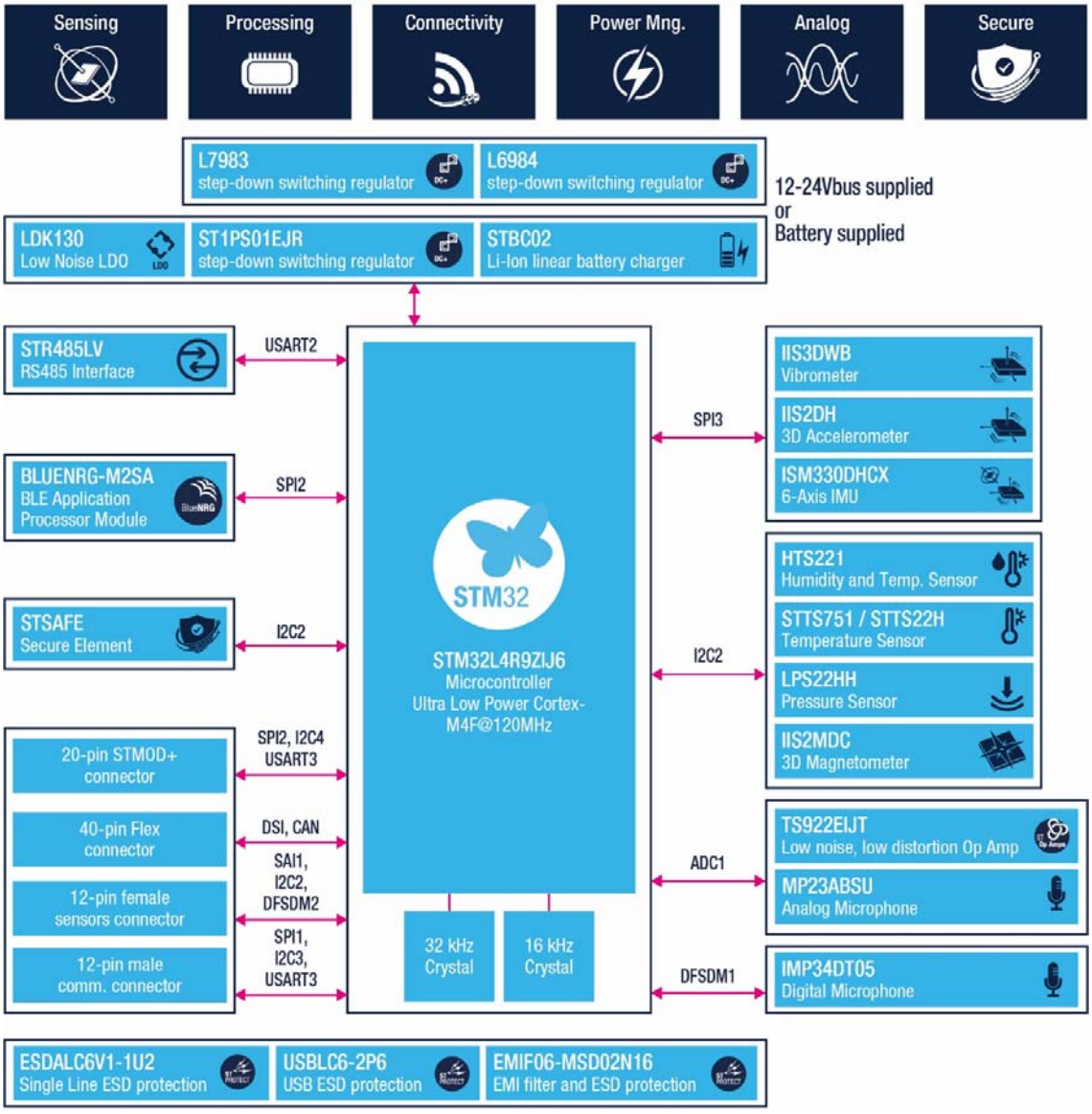


Fig. 1. Condition Monitoring turnkey solution

Power management solutions for such comprehensive ecosystems need to satisfy both the power requirements of the peripherals and final application performance targets, so dedicated power management ICs must deliver a wide range of features and premium performance.

The L7983 is a perfect choice for smart industry applications, as it offers a compact 3.5V-60V, 300mA synchronous DC/DC buck converter solution with flexible dynamic-mode selection for noise-sensitive applications and high efficiency at light load. Its wide input-voltage range allows the L7983 to operate on 12V and 24V industrial buses with a generous safety margin and can also manage 48V applications. The converter is well suited to battery-powered applications and is suitable for use in industrial fail-safe systems, decentralized intelligent nodes, appliances, robotics, telecom equipment, and precision-sensing applications, which can take full advantage of the low-noise mode.
The collection of sensors, microcontrollers and connectivity ICs can be supplied with same Voltage value or diversified to exploit performance opportunities. Either way, the noise friendly architecture and the inherent wide spectrum capability allow both.
The figure below shows a typical ultra-low quiescent complete power management solution with additional noise immunity allocated to the RF subsystem.

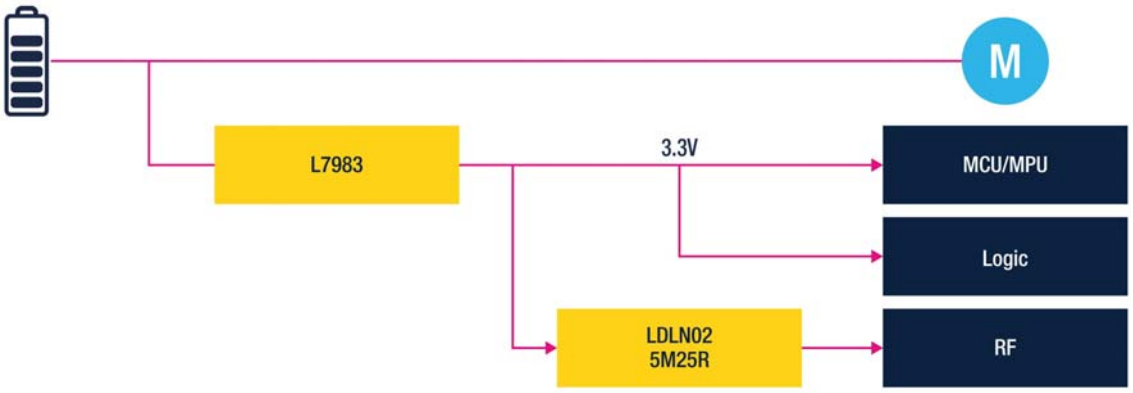


Fig. 2. Power management tree for 24V-36V Battery Pack Smart Industry systems

In terms of EMI, the L7983 offers on-the-fly selection between forced PWM, which offers the highest noise immunity, and Low consumption mode, which can be adopted when very low energy consumption is desired and data transmission is not involved. The second benefit is the embedded spread-spectrum dithering option, which can further reduce electromagnetic interference by cutting harmonic disturbances in the operating frequency range. This proven technology can reduce conducted emissions by up to 7-8dB/µV.
The following EMI/EMC graphs clearly show the impact on interference when the Frequency dithering option (known also as Spread Spectrum - SS) is enabled. The measurements provided demonstrate compliance with CISPR25 (red line for Peak Demodulator Receiver, and yellow for Average), while a Bead is used as an input filter (BLM18AG102SN1 - 1000Ω/450mA)

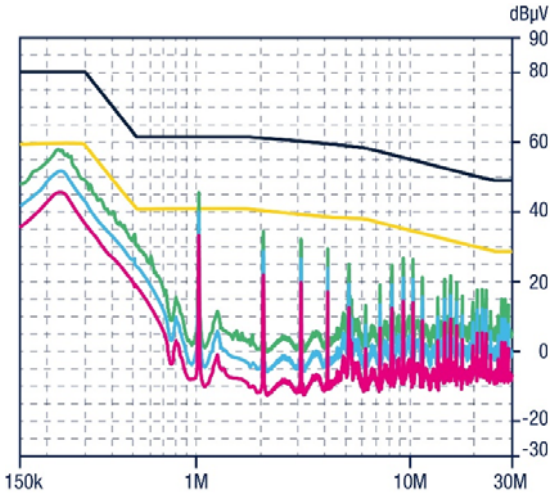


Fig. 3. Vin =24V Vout 3.3V, Fsw = 1 MHz, SS = OFF

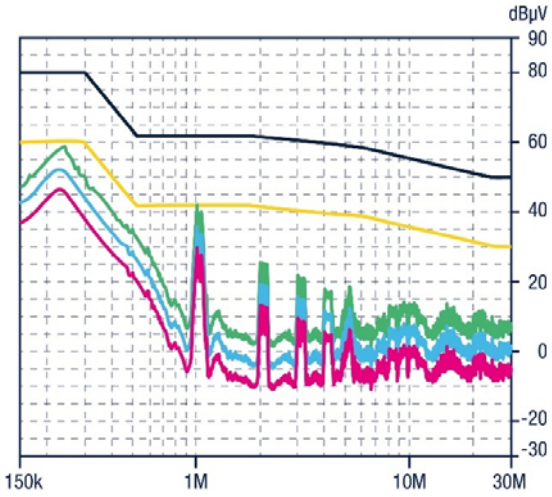


Fig. 4. Vin =24V Vout 3.3V, Fsw = 1 MHz, SS = ON

The other major performance benefit is the ultra-low consumption capability. The Enable pin allows the L7983 to draw as little as 2.3µA leakage when it is off, and not more than 10µA when operational (L7983PU33R, V_{IN} > 24V, LCM).
What renders this device particularly suitable for IoT applications is the ability to maintain efficiency above 80% even at a few tens of milliampere loads (LCM – Low Consumption Mode), and over 90% when the application is drawing full power (LNM - Low Noise Mode).

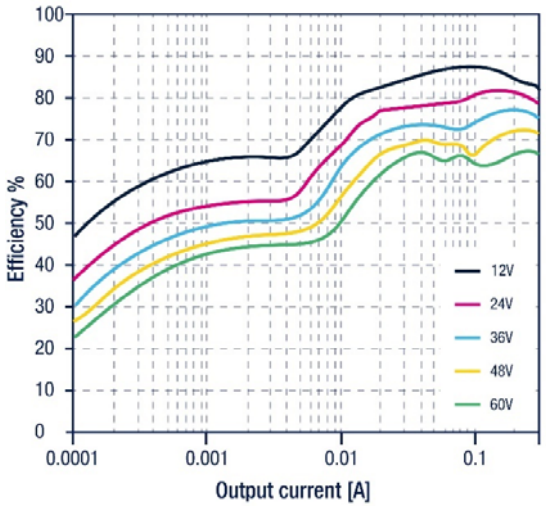


Fig. 5. Efficiency vs load, Vout 3.3V, **LCM**, Fsw = 1 MHz

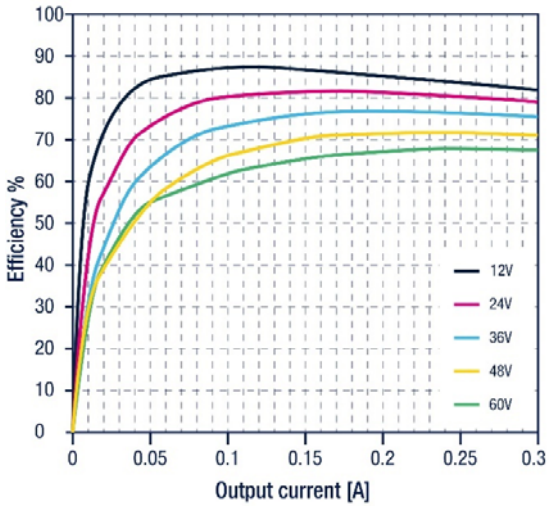


Fig. 6. Efficiency vs load, Vout 3.3V, **LNM**, Fsw = 1 MHz

Another significant feature is the way the device facilitates overall size reduction by virtue of its tiny package and high level of integration, which reduces the external component requirements and therefore allows very small solution footprints, as shown in the image below.

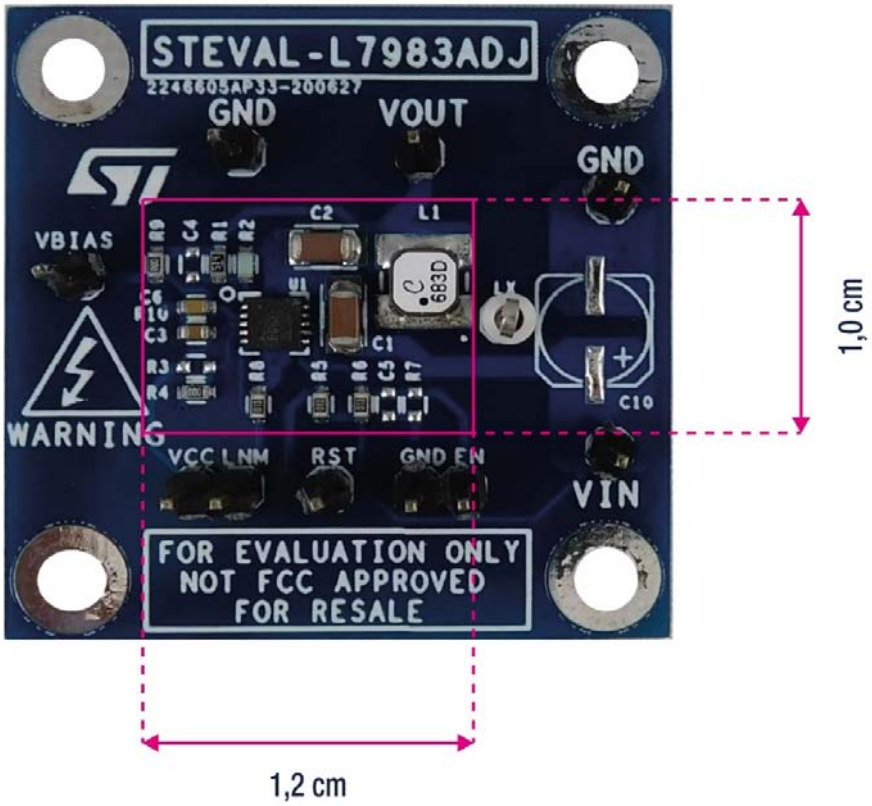


Fig. 7. L7983 Footprint

Additional features include support for power sequencing and synchronization with an external clock, and embedded safety and protections, including soft-start, overtemperature protection, current limiting with pulse-by-pulse sensing, overvoltage protection, and adjustable undervoltage lockout (UVLO), depending on the input voltage. Furthermore, integrated compensation circuitry helps simplify designs and lower bill-of-materials costs.

IoT applications may also require relevant current loads for different peripherals such as HMI, audio amplifiers, image sensors, connectivity, and other intelligent ICs included to enhance the IoT functionality.
While the abovementioned regulation is most advisable loads upwards of several tens of mA, very light loads in the order of a few mA may just as well be managed via linear regulation. To accommodate this, ST can complete your solution with an ultra-low quiescent POL.
The ST730/ST732 family of MPN lines allows you to choose the right device from a variety of adjustable or fixed output voltage solutions with or without enable pins.
In the SOT32-5L package, this 5µA quiescent current device can easily regulate 12 or 24V bus rails down to any light peripherals above 1.8V, ensuring the best energy efficiency even in always-on applications.

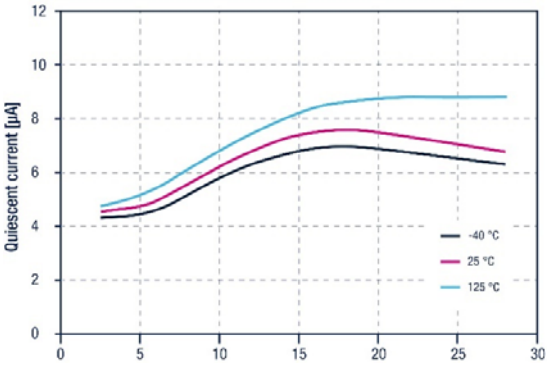
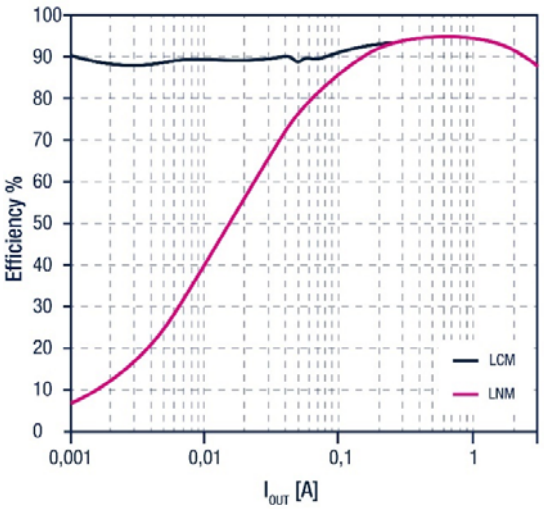


Fig. 8. ST73x family quiescent current vs V_{IN} (@I_{OUT}=0mA)

For larger current loads, another new Buck regulator is available with same IP and design philosophy as the L7983.

L6983 38V/3A synchronous DC/DC converters maintain ultra-high efficiency across all loads, with an almost 95% peak value, and integrate synchronous MOSFET on-chip to save external components and simplify designs. The figures below show the efficiency at V_{IN}=12/24V and V_{OUT}=5V in both Low Consumption Mode and Low Noise Mode.



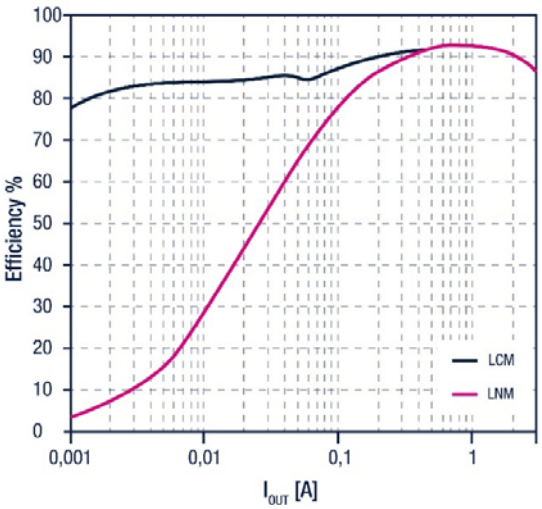


Fig. 9. VIN = 12V; VOUT 5V, **LCM-LNM**, Fsw = 400 kHz

Fig. 10. VIN = 24V; VOUT 5V, **LCM-LNM**, Fsw = 400 kHz

With a wide input-voltage range from 3.5V to 38V, the L6983 represents another efficient and flexible solution for 12V and 24V industrial bus-powered systems, battery-powered equipment, and decentralized intelligent nodes such as smart-building controllers.

Low quiescent and low noise considerations are also inherent features, meaning the 17µA quiescent current of the L6983 is particularly useful for always-on devices tasked with sensing strategic application environment conditions.

In order to achieve the highest possible compactness, the low-noise and low consumption variants of the device are fixed (L6983C and L6983N, respectively), with the L6983C device implementing pulse-skipping mode when the load current is below 0.6A.

Finally, system designers may need to implement post regulation to refine the specific power tree requirements for their applications.

As already mentioned, it is advisable to post-regulate via a linear regulator in RF sensitive environments in order to suppress as much noise as possible for peripherals that require such clean signals, and the LDLN series is the best-in-class LDO for this purpose. The sizes are scaled to allow selection of the best fit for specific current loads. The 250mA LDLN025 is the most popular option because it is able to meet typical system power demands with just 12µA quiescence and 6.5µVrms noise.

When linear regulation is not sufficient and switching benefits are still required, we recommend the ST DCDC nano quiescent series. The ST1PS01/02 is supplied in a range of packages for many application requirements and can provide regulation up to 400mA with on-the-fly V_{OUT} selection using external signals to meet specific power demands in different usage conditions. This device is used to very good effect in many ST battery-powered reference designs such as the STEVAL-STWINKT1B SensorTile Wireless Industrial Node (block diagram in **Fig.1**), with more designs under development.

This DC/DC converter features an ultra-low 500nA leakage current in no-load condition, contributing to a dramatic reduction in system stand-by consumption. With immediate wake-up, the converter can achieve 95% efficiency in certain conditions, as shown by the graph in in **Fig.12**. The ST1PS02 also embeds an auxiliary switch to facilitate the integration of a secondary peripheral supply.

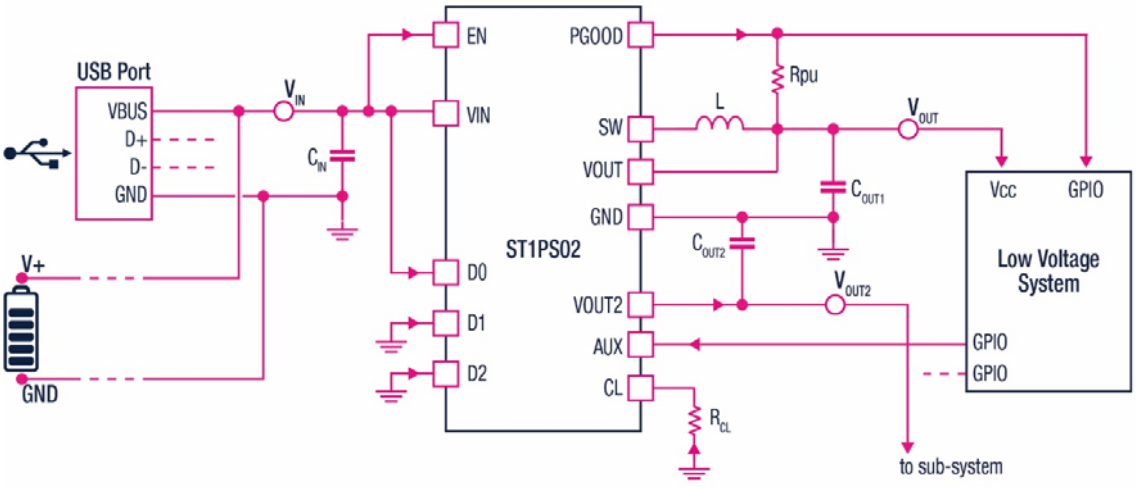


Fig. 11. ST1PS02 application design

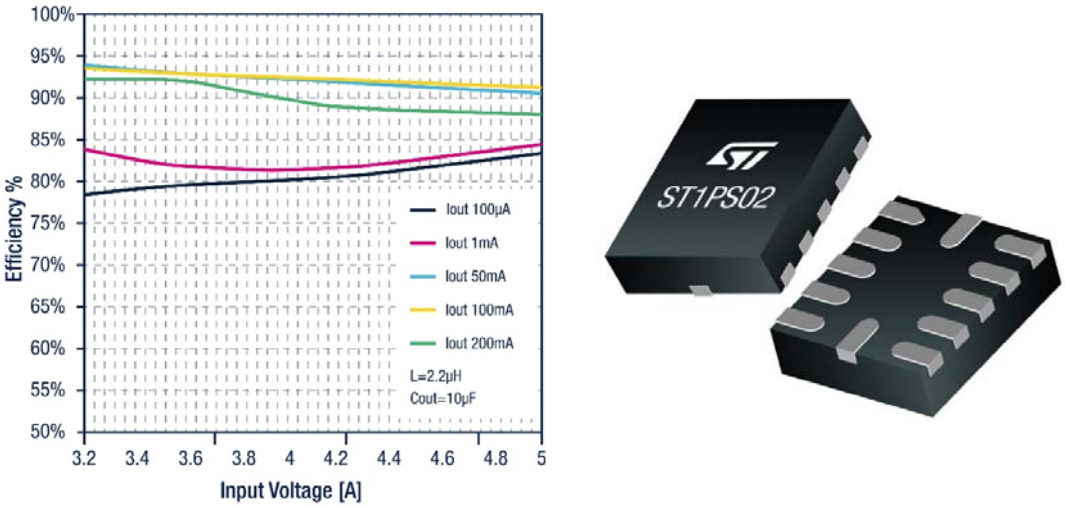


Fig. 12. Efficiency vs V_{IN}, V_{OUT} =3.3V

ST is constantly researching, designing and releasing new power management solutions that help customers reduce development effort and achieve maximum performance and efficiency. For any design challenges you may be facing, do not hesitate to reach out to your regional ST contact for information and support.