ST sensor solution for AR glasses

Johnny YANG
Smartphone Competence Center
STMicroelectronics
Most of the Big Tech companies are racing to create AR/MR glasses

All the smartphone companies are working on some form of smart glasses or headset

Instead of a phone to talk to people or interact with apps, we may do these things simply by speaking to, and looking through, a set of glasses.

There’s a race to be the first to make a set of glasses that everyone will wear, which means they have to be fashionable and sleek.

Both 2 companies have new models in ‘23
AR glasses enrich the user experience

From “phone” to “glass”, enlarging the screen to be more immersive!

https://www.juegostudio.com/blog/tech-foresight-augmented-reality

https://www.queppelin.com/ar-glasses-for-navigation/
Which glasses would you wear… everyday?

<table>
<thead>
<tr>
<th>Target</th>
<th>Key factors/enablers</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-Day-Wear</td>
<td>Lightweight (&lt;60gr)</td>
</tr>
<tr>
<td>All-Day-Wear</td>
<td>Small form factor</td>
</tr>
<tr>
<td>Long life battery</td>
<td>Low Power (&lt;1W)</td>
</tr>
<tr>
<td>Display quality image</td>
<td>High brightness for outdoor use</td>
</tr>
<tr>
<td>User friendly</td>
<td>Advanced UI controls (Gesture, voice)</td>
</tr>
<tr>
<td>Environment sensing</td>
<td>Cameras + Depth sensing sensor</td>
</tr>
<tr>
<td>Easy communication</td>
<td>Wireless communication</td>
</tr>
<tr>
<td>Easy charging</td>
<td>Quick wireless charging</td>
</tr>
</tbody>
</table>
What functions are essential for AR glasses?

- HD display & large FOV
- Audio and Voice control
- Image capture
- Gesture control
- Wireless connection
- Wireless charging
What’s inside the AR glasses?

- Speakers
- Battery
- Microphone
- Projector
- Waveguide
- 3D/Depth sensor
- Camera
- Sensors
- Processing
- Wireless charging
- Wireless communication

ST already has much corresponded products for these functions!
Our sensor solution for AR glasses

**ST demo app**

Full ST solution portfolio for Smart Glasses in such tiny PCB size 43.3 *13.3*3.2mm
Functionality #1: BLE pairing

BLE pairing can be authorized automatically to enter Demo app
Functionality #2: sensor data synchronized by BLE

Visualization of data from **multiple sensors** present on board in the app:

- Acceleration & angular rate
- Pressure
- Temperature
- Quaternion
- Battery level
- Magnetic field

Main sensor part number:

- LSM6DSV16BX
- ILPS22QS
- LIS2MDL
- STWLC38
IMU quaternion demonstration

Head movement tracking by LSM6DSV16BX
Global shutters – AR / MR glasses

Product – VD55G0, VD55G1, VD56G3, VL53L4CD, VL53L8CX

Augmented Reality

GS: 2D Image Sensor
ToF: Depth Sensor (Time-of-Flight)

Mixed Reality

6DoF Head positioning
Room mapping & SLAM
See-through
Scene analysis
Gesture
Proximity
Touch control
Eye-tracking
Mouth, Chin & Cheek
Functionality #3: QR code reader

QR code reader supported by sensor
Qvar stands for: Electric charge (Q) variation (var)

Qvar senses variations in the electrical fields in proximity or contact of the product via electrodes.

- **Electrodes on body** (In contact with human skin): Improved activity detection
- **Electrodes in proximity** (Radar function): Presence sensing

Adding functionality of an existing sensor

- **Pressure**
- **QVAR™ engine**
- **ILPS22QS/ILPS28QSW**
- **6x IMU**
- **3x Accel**

**QVAR™ engine**

**LIS2DUXS12**
**LSM6DSV16X/BX**
Functionality #4: Qvar finger slide controller

Content switch supported by Qvar
Our technology starts with You

Find out more at www.st.com
Advanced MEMS sensors in the sustainable onlife era

Kay LIN
APeC, AMS, MEMS Sub-Group
STMicroelectronics
Sustainable sensorization of the world
MEMS sensors sending only the meaningful data to the cloud

Smart sensors making our world a better place

Offline Era
Online Era
Onlife Era
Sustainable Onlife

2000
A paradigm change in the man-machine interface
MEMS technology: from a concept to a product.

2010
Sensor proliferation and connections to the Cloud
Performance improvement and technology fusion.

2020
The fusion of technology and life
MEMS sensors able to sense, process, and act.

Sustainable sensorization of the world
MEMS sensors sending only the meaningful data to the cloud
Sensors at the heart of our interactions with the digital world

**Human centered**

Sensors are the key components to **bridge** the **physical** and the **digital** worlds

**Sustainable**

Sensors becoming **smart** answer **human expectations** while ensuring a **sustainable** future
Track and monitor orientation in 3D space

Detect and track device orientation with the **embedded low power sensor fusion** algorithm with **30 µA**

Plug and play solution that provided **6x game rotation vector** (accelerometer + gyroscope) & **Gyro-bias calibration**

**Static accuracy**\(^{(1)}\): 0.5, 1.5, 1.5 deg

**Low dynamic accuracy**\(^{(1)}\): 0.7, 0.5, 0.5 deg

Calibration time\(^{(2)}\): 0.8 s

Orientation stabilization time: 0.7 s

**Extra power**: 30 µA @ 120 MHz

**Ultra-low power** operation

50% power reduction vs. external MCU\(^{(3)}\) processing
Adding intelligence in the edge with MLC and FSM

**Embedded MLC and FSM** process XL & Gyro data to detect usage conditions with **no interaction required** with external processor.

<table>
<thead>
<tr>
<th>Power Consumption</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 µA</td>
<td>Identify activity and inactivity (i.e., wake up the system only when needed)</td>
</tr>
<tr>
<td>6 µA</td>
<td>Gym activity recognition</td>
</tr>
<tr>
<td>6 µA</td>
<td>Wrist tilt detection for display wake up</td>
</tr>
<tr>
<td>From 1 µA to 35 µA</td>
<td><strong>Scalable</strong> solution to detect <strong>free fall</strong>, <strong>shock</strong> and fall <strong>height estimation</strong> (or Man Down)</td>
</tr>
</tbody>
</table>

*Power consumption values related to MLC & FSM only.*
Adaptive self configuration (ASC)

From “Always-On” to “Smart, Always-Aware”

The device automatically reconfigures itself, based on the actual context, maximizing the system efficiency.

MLC and FSM detect the context without the need of additional data processing.

ASC allows to independently configure Gyro and XL channels. No tradeoff required!
Qvar electrodes to improve UI: Touch and Swipe

- Sensor fusion between Qvar and 6x IMU improves the user experience accuracy reducing false positives
- Support for single/long and multiple touch and swipe
Free fall height estimation

Beware: LSM6DSV16X can track your shock!

Scalable solution to detect shock, free fall, and estimate height of the free fall

Embedded processing and FSM detect the context without the need of additional data processing at system level

From free fall height exceedance detection, to the accurate height estimation, from 1 µA to 35 µA, always the right algorithm

* Power consumption values are related to the embedded processing.
Moving the intelligence at the edge

**Sensor + MCU**
- Microcontroller
- Sensor connected to MCU
- MCU standalone or hosted in the sensor package
- Standard
  - MCU runs the algorithms
- Runs any kind of SW
  - Provided it matches the MCU specs

**MLC**
- reconfigurable Processing Unit (rPU)
- rPU integrated in the sensor ASIC
- Optimal
  - reconfigured through register setting
- Constrained
  - Runs same model/mapping (MLC, FSM)

**ISPU**
- Intelligent Sensor Processing Unit
- ISPU integrated in the sensor ASIC
- Programmable
  - ANSI-C plus AI dedicated instruction set
- Runs several AI algorithms
  - Full precision to 1-bit NN
Highly specialized DSP* for machine learning and processing

**Unique solution** for TinyML with machine learning (ML), binary neural network (BNN), and **processing** capabilities

**Lowest power consumption IoT node in the market** with AI in the edge

**Productivity**: empowers 10M+ C language developers

**Complement** STM32 MCU portfolio for AI

*DSP: Digital Signal Processing*
vAFE, because the world is analog

MEMS sensing
• We use a high performance AFE in MEMS sensors: it reads and converts capacitance change ~ 0.1aF*
• We have developed specific low noise IP and silicon technologies

an additional AFE: vAFE
• An auxiliary AFE enables reading of analog signals, that are complementary to motion signal

vertical AFE
vAFE and Motion signals are intrinsically synchronous.

The result is a unique context aware analysis done in-the-edge, thus low power and with the minimum possible latency.
And we do it in standard package dimensions.

* 1aF = 10^{-18}F
vAFE: opening new application frontiers

<table>
<thead>
<tr>
<th>Smartphone &amp; Camera</th>
<th>TWS</th>
<th>Wearable</th>
<th>IoT</th>
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</thead>
<tbody>
<tr>
<td>Presence detection</td>
<td>In-Ear detection</td>
<td>Presence detection</td>
<td>Presence detection</td>
</tr>
<tr>
<td>Activity tracking</td>
<td>Touch-Multiple Touches</td>
<td>Enhanced activity tracking</td>
<td>Energy Saving</td>
</tr>
<tr>
<td></td>
<td>Long press</td>
<td>Biometric data</td>
<td></td>
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- **Presence detection**
- **Activity tracking**
- **In-Ear detection**
- **Touch-Multiple Touches**
- **Long press**
- **Presence detection**
- **Enhanced activity tracking**
- **Biometric data**
- **Energy Saving**
Smart Ring: the 2023 trend runs ST sensors

Battery constrained solutions require **low power, in-the-edge processing**

**LIS2DUX** features single-digit µA power consumption with embedded AI (MLC, FSM, ASC)

**LIS2DUXS** also features a vAFE

**LSM6DSV16X** includes a gyro for more functionalities
STHS34PF80 IR Sensor based TMOS technology starts finally in Mass Production, we are ready to go market.

**ST IR sensing element**
Sensor measures in the wavelength range from 5 to 20 um

**Human body**
radiation is ~9.8 um, at in the center of the sensor’s range

**Biometric**
Presence detection and temperature measurement
MEMS sensors roadmap
New generation MEMS sensors

**Features**

- **iNEMO® Inertial Module:**
  - Embedded ISPU N version for NEAI
  - MLC, FSM, ASC, SFLP, Qvar, Audio AXL, BC

- **Accelerometers:**
  - ULP, 12b resolution, AAF, 128 samples FIFO (i.e. 0.47µA @6Hz ODR)
  - FSM, MLC, Pedometer, Qvar™

- **Pressure Sensors:**
  - Water resistant & WP, better accuracy, lower power consumption, Dual FS Qvar™

- **IR Sensor:**
  - Presence Detection up to 4 meter
  - 80° Field Of View
  - TMOS sensor

**Products**

- LSM6DSO16IS
- ISM330IS/N
- LSM6DSV16X
- LSM6DSV32X
- LSM6DSV16BX
- LIS2DU12
- LIS2DUX12
- LIS2DUXS12
- LPS22DF
- LPS28DFW
- ILPS22QS
- ILPS28QSW
- STHS34PF80

**Applications**

- Sports
- Fitness
- Health
- Security
- Home automation

**Abbreviations:**
- FS: Full Scale
- FSM: Finite State Machine
- ASC: Adaptive Self Configuration
- AAF: Anti-Aliasing Filter
- ISPU: Intelligent Sensor Proc Unit
- WP: WaterProof
- ULP: Ultra Low Power Mode
- MLC: Machine Learning Core
- SFLP: Sensor Fusion Low Power
- Qvar: Electrostatic Charge Variation
- NEAI: Nano Edge AI
- TDM: Time Density Modulation
Takeaway
<table>
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<tr>
<th>Takeaways</th>
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<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>2</strong></td>
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<tr>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>
Our technology starts with You

Find out more at www.st.com/MEMS
STM32 wireless & IoT solutions

Watson Chang
Wireless Product Marketing, APAC
STMicroelectronics
Distributed artificial intelligence approach

Leverage billions of devices at the Edge!

- Data center Cloud
  Analytics, storage, compute

- Edge nodes
  IoT gateways, micro datacenters

- Edge things
  Ultra-low-power devices and sensors
  Real time, local processing
The STM32 portfolio

Five product categories

- Wireless MCU: Short- and long-range connectivity
- Ultra-low-power MCU: 32-bit general-purpose microcontrollers: from 75 to 3,224 CoreMark score
- Mainstream MCU
- High-performance MCU
- Embedded MPU: 32- and 64-bit microprocessors

Enabling edge AI solutions
Scalable security
ST solutions: Sub-1G, and 2.4G
STM32
Serves all markets

Sub-1 GHz markets

Smart industry
Smart city
Smart home
Smart agriculture

Asset tracking
Metering
Alarm system
Heat cost allocator

STMicroelectronics
Serves all markets
System-on-chip made for versatility

A long-range wireless microcontroller: one die, many IoT possibilities

World first!

STM32L4 + Arm® Cortex®-M0+ + LoRa® (G)FSK (G)MSK BPSK = STM32WL
The integration pyramid

STM32WL
Sole LoRa-enabled SoC in the world

System-on-Chip (SoC)
Only one Silicon die in one package

Different silicon dice inside the same package
Source: PTI Blog

Different packages on a very tiny piece of re-packaged PCB

Different discrete packages on a BIG electronic board

System-in-Package

Module

PCB
Ultralow-power ANALOG SENSING UNIT
L-C based measurement of fluid flow metering

- Designed for cost-effective mechanic-wheel fluid metering
  - Measuring of L-C network oscillations enable detection of fluid flow metering
- Feature is based on L-C network oscillation measurement
  - Supporting up to 3x L-C networks
  - Autonomous metering circuitry (no MPU intervention, Cortex M0+ in deepstop)
  - Very few µA average current for continuous L-C metering

STM32WL ultralow power LC sensor controller (LCSC)
STM32WL

Extended battery life: dedicated wake-up radio

**Ultralow-power wireless proximity detection and system wake-up**

**Wide band:** 1 single BOM for worldwide ISM (100MHz – 2.4GHz)

**<5μA Continuous RX**

Dedicated to proximity detection (tens of meters) ~-50dBm sensivity

OOK modulated packet detection

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**Asset tracking application**

- Local or LPWAN gateway
- In-door beacon
- Asset tracker dashboard

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**Metering application**

- Wake-up signal
- Wake-up signal proprietary signal
- Walk-by/drive-by gateway

---

*life augmented*
2.4G markets
matter makes connected home simple

“Smart home devices should be secure, reliable, and seamless to use. And with Matter, they are.”

The Connectivity Standards Alliance

• **A great user experience**
  Matter ensures connected objects from multiple brands can work together seamlessly

• **Wide adoption**
  Matter is an application layer which addresses many applications in an open-source delivery and certification infrastructure
  
  • **Release V1.0 Q4’2022**
# STM32 MCU 2.4 GHz portfolio

## STM32WB series

<table>
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<tr>
<th>MCUs</th>
<th>Modules</th>
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</thead>
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<tr>
<td>STM32WB55</td>
<td>STM32WB5M</td>
</tr>
<tr>
<td>STM32WB35</td>
<td>STM32WB1M</td>
</tr>
<tr>
<td>STM32WB15</td>
<td></td>
</tr>
<tr>
<td>STM32WB50</td>
<td></td>
</tr>
<tr>
<td>STM32WB30</td>
<td></td>
</tr>
<tr>
<td>STM32WB10</td>
<td></td>
</tr>
</tbody>
</table>

**Features:**
- **Dual core & security** (Arm® Cortex®-M4 / -M0+)
- **Up to 1 Mbyte of flash memory / 256 Kbytes of RAM**

## STM32WBA series

<table>
<thead>
<tr>
<th>STM32WBA52</th>
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</thead>
</table>

**Features:**
- **Arm® Cortex®-M33 / TrustZone® 100 MHz**
- **1 Mbyte of flash memory / 128 Kbytes of RAM**
- **Up to +10 dBm output power**

## BlueNRG series

<table>
<thead>
<tr>
<th>System on Chips</th>
<th>Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>BlueNRG-1</td>
<td>BlueNRG-M2SP/SA</td>
</tr>
<tr>
<td>BlueNRG-2/2N</td>
<td></td>
</tr>
<tr>
<td>BlueNRG-LP</td>
<td></td>
</tr>
<tr>
<td>BlueNRG-LPS</td>
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</tbody>
</table>

**Features:**
- **Arm® Cortex®-M0/M0+**
- **Up to 256 Kbytes of flash memory / 64 Kbytes of RAM**

## STM32WB0 series

<table>
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<tr>
<th>STM32WB09</th>
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</table>

**Features:**
- **Arm® Cortex®-M0+ at 64 MHz**
- **512 Kbytes of flash memory / 64K bytes of RAM**
- **Bluetooth® Low Energy 5.3 (long range, 2 Mbps, Advertising ext, AoA/AoD, Isochronous channel)**
- **Up to +8 dBm of output power**
An ultralow power Bluetooth® Low Energy 5.4 platform

**Integrated 2.4GHz radio**
Bluetooth® Low Energy 5.4 (long range, 2Msp, advertising extension)
+10 dBm output power

**High performance**
- Arm® Cortex®-M33 at 100MHz
- 407 CoreMark score
- 100 K cycles for 256 Kbytes of Flash

**Enhanced security**
- TrustZone® technology, target SESIP Level 3

**Leveraging STM32U5 ultra-low-power platform**
- Low-power direct memory access (LP-DMA)
- Flexible power-saving states with fast wake-up times
- Same digital and analog peripherals

Built using **40nm process technology**
STM32WBA increases security in wireless devices

Extensive functionalities to protect your assets

**Memory protections** against illegal access control
- OTP, HDP, WRP, MPU
- Secure Debug
- Active Tamper, 4 pairs & V/T

**Cryptography** for hardware robustness
- Side channel AES, PKA
- Additional AES, SHA, TRNG, HUK (Hardware Unique key)

**Platform protection** during product lifecycle
- RDP: 4 protection level states
- Password based regression

**Code isolation** for runtime protection
- 4 isolation stages
- Arm® TrustZone® technology

**Security services**
- STM32Trust TEE TF-M
- Secure boot & secure updates
- Secure firmware install
- NIST - CAVP certified CryptoLib

**State-of-the-art security assurance level**

New features for STM32WBA are **highlighted**
Matter over thread: ST available demonstration

Bridge device demonstration

Matter Thread Border Router

Matter Thread Border Router

MP157F-DK2
OpenThread Border Router

End Device

STM32 Matter bridge

STM32 Matter bridge

Optional wired or wireless connectivity

Optional wired or wireless connectivity

Ethernet Commissioning & Control

Ethernet Commissioning & Control

Nucleo-H753
Matter & Ethernet

Nucleo-H753
Matter & Ethernet

Non Matter environment

Non Matter environment

End device demonstration

STM32WB-DK
Matter Thread & BLE

STM32WB-DK
Matter Thread & BLE

Thread

Thread

MP157F-DK2
OpenThread Border Router + Access Point

MP157F-DK2
OpenThread Border Router + Access Point

RCP

RCP

Matter app
Wi-Fi
BLE

Matter app
Wi-Fi
BLE

Smartphone

Smartphone

BLE Commissioning

BLE Commissioning

Control

Control

STM32 Matter

STM32 Matter
What’s more.....
Le audio unicast / broadcast

- Connected Audio Stream
- One-to-One
- Bidirectional

- Broadcasted Audio Stream
- One-to-many
- Unidirectional
Setup - many source many sink

- **Music Source (Laptop or Smartphone with 3.5mm jack output)**

  - **Public Broadcast Source 1**
  - **Public Broadcast Source 2**
  - **Public Broadcast Source 3**

  - **Jack 3.5mm**
  - **Use joystick to switch source**

- **Public Broadcast Sink**

- **Public Broadcast Sink**

- **Public Broadcast Sink**
Available as a module to reduce your time to market
STM32WB5M - module

Easy to integrate - Light certification for customer

Key advantages

- WLCSP100 package integrated
- Maximum of features exposed
- Low-cost PCB for the mother board
STM32WB1M - module

Easy to integrate - Light certification for customer

Key advantages

- **STM32WB15 MCU** with 320KB flash and 48KB RAM

- Internal antenna, as well as pins for attaching an external antenna.

- **STM32CubeWB MCU package** provides resources including hardware abstraction layer (HAL) firmware, Low-Layer APIs, File system, and RTOS
IPD (integrated passive device)
Two blocks required

- **Matching Network** – Transformation to 50 Ω impedance
- **Harmonic Filter** – Reduce out-of-band TX harmonic emissions and RX susceptibility

*IPD: Integrated Passive Device*
STM32 IPD integrated passive device

STM32WL RF Front end in a 1.2mm²

BEFORE

11 discretes 72 mm²

Discrete balun & matching network

AFTER

1 component 1.2 mm²

RF IPD balun & matching network

Wireless MCU
RF IPDs products companion chip to STM32WL how to pick up the right one

STM32WL

862-928 MHz

- BGA
  - High-Power mode 22dBm
  - 2-layer PCB
  - BALFHB-WL-01D3

- QFN
  - Low-Power mode 15dBm
  - 4-layer PCB
  - BALFHB-WL-04D3

470-530 MHz

- BGA
  - High-Power mode 22dBm
  - 4-layer PCB
  - BALFHB-WL-02D3

- QFN
  - Low-Power mode 15dBm
  - 2-layer PCB
  - BALFHB-WL-03D3
  - 4-layer PCB
  - BALFHB-WL-05D3
  - 4-layer PCB
  - BALFHB-WL-06D3

BAL=balun
F = Filter
HB = high-band
LB = Low-band
WL=STM32WL
D3= CSP package

N: FE= Tours, BE=Shenzhen
237: W37- 2022
G: ecopack2/Rohs
STM32 ecosystem for developers

**Hardware development tools**
- Evaluation boards
- Debug & programming probes

**Software development tools**
- Configuration, development, debugging & monitoring tools

**Embedded software**
- Drivers
- RTOS
- Stacks & application bricks

**Information and sharing**
- Developer zone
- Product selectors
- Wiki, GitHub
- Communities & social media

**Ecosystem**

**Designed by ST**

**Open source**

**Partners**

**Wiki, GitHub**

Communities & social media
Key takeaway: end-to-end ecosystem

Software tools

1. Configuration
   - STM32CubeMX
   - STM32CubeIDE

2. Development
   - STM32CubeIDE
   - IAR Systems
   - arm Keil

3. Programming
   - STM32CubeProgrammer

4. Monitoring
   - STM32CubeMonitor

Embedded software

STM32Cube MCU Package

- Drivers
- Middleware
- User application

STM32Cube Expansions & Function Packs
Prototyping made as easy as 1,2,3

STM32CubeMX/STM32CubeWB/
STM32CubeProg & STM32CubeMonitor

Code generation
Power calculation
What’s more……

BLE Sniffer by STM32WB55-Nucleo EVM
What ST offers (Today’2023)

Short Range

- BLE Application Processors
- BLE Network Co-Processors
- Thread
- Zigbee
- Ultra Wideband
- 60 GHz Contactless

Long Range

- LoRaWAN
- Sigfox
- Wireless M-Bus
- KNX-RF
- Wi-Sun
- 6LoWPAN
- Proprietary Sub-1GHz
- Narrowband-IoT (NB-IoT)

[st.com/en/wireless-connectivity.html]

AND MORE…… TO BE CONTINUED
Our technology starts with You