Analog, MEMS & Sensors Group

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Revenue overview - AMS

AMS Group Revenue $B

2021

$4.62B

AMS Sub-Group Revenue $B

Analog Sub-Group

2021

$1.85B

MEMS & Sensors Sub-Group

2021

$2.77B

36% of ST FY21 Revenues
AMS strategy addressing underlying trends

Trends
- Sensorization & digitalization
- Smarter & more efficient energy use

Products
- Analog
  - Application specific
  - General purpose
- MEMS & Sensors
  - MEMS sensors & actuators
  - Optical sensing solutions
Growing and balancing revenue streams across ST end markets

<table>
<thead>
<tr>
<th>Core business</th>
<th>High-growth areas</th>
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<td>MEMS</td>
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<td>IMAGING</td>
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Personal Electronics
Industrial
Automotive
Communication Equipment, Computer & Peripherals

2021

2025-2027
Optical sensing solutions
Optical sensing solutions

**Core business**

- Smartphone front facing
  - Face authentication
  - Biometrics
  - Ambient Light Sensing

- Smartphone world facing
  - Camera assist (bokeh, laser autofocus..)
  - Ambient Light Sensing

- PC / Laptops
  - Low power presence detection
  - Face authentication
  - Security

**High growth areas**

- Automotive
  - Driver monitoring
  - Occupancy monitoring
  - LiDAR

- Industrial
  - Robotics
  - People counting
  - Touchless operation
  - Smart home
  - Depth sensing

**Emerging applications**

- AR / VR / MR
- Consumer LiDAR
- Gesture control
- AI computer vision
ST leadership positions in 3D & depth sensing

> 200 smartphones adopting ST depth sensing solutions

Leadership in ToF with > 1.7 Billion units shipped

Leadership in global shutter sensors

> 90 computers / laptops / tablet / monitor models including ST optical sensing solutions

Personal electronics

Camera assist

Biometrics

Computer & Peripherals

Presence detection

Security

Leadership positions in 3D & depth sensing

[Image of a smartphone and a laptop]
ST addresses a variety of optical sensing solutions thanks to differentiated proprietary technologies.

- **Direct Time-of-Flight**
  - 40 nm SPAD, 3D-SPAD

- **Indirect Time-of-Flight**
  - 4.6 µm fast photodiode, 3D-BSI

- **Global Shutter pixels**
  - Smallest pixel pitch, FSI & 3D-BSI

- **All-in-one ToF modules**
- **3D ToF sensors**
- **Global Shutter sensors**
- **ALS & Proximity combo**

**BSI** Back-side illumination
**FSI** Front-side illumination
Safer driving with ST optical sensors

Fast-growing market driven by regulatory push
Cars equipped - 10M in 2022 - 50M in 2027

Driver monitoring systems
- Drowsiness detection
- Distraction monitoring
- Driver authentication
- Driver identification

Occupancy monitoring
- Passenger detection
- Child surveillance
- Intrusion detection
- Accident recording

Positioning & strengths

- Leading global shutter technology & products
- Target all Tier1s, all OEMs, all regions leveraging ST automotive ecosystem
- Mass production since 2021 with early adopter
- Additional design-wins with Chinese, European & US OEMs, mass production in 2022
- Key customer program design-ins driving 2024 volumes
- Diversification enabling long-term revenue stream

Source: Yole
MEMS
MEMS sensors and actuators

Core business

- **Smartphones and wearables**
  - User Interface
  - Gaming
  - Optical stabilization
  - Smart watches & Fitness bands

- **CECP**
  - Printheads
  - Memory array
  - Temperature sensing

- **Automotive safety and infotainment**
  - Electronic stability control
  - Navigation
  - Telematic box

High-growth areas

- **Emerging applications**
  - TWS
  - AR / VR / MR
  - Health data sensing

- **Industrial**
  - Industry 5.0
  - Predictive maintenance
  - Building structure monitoring
  - Presence detection

- **Automotive**
  - ADAS
  - Electrification
  - Powertrain management
  - LiDAR
Leadership positions in MEMS

**Personal electronics**
- 1.1 Billion units in 2021
- #1 in inertial and pressure sensors

**Computer & Peripherals**
- 1.2 M wafers in 2021
- #1 in MEMS actuators printheads

**Automotive**
- 100 M units in 2021
- Fastest growing player in sensors for telematics and safety in 2021

Source: Omdia, Strategy Analytics, LMC Automotive, ST
Continuing to build competitive advantage in MEMS through our technologies and IP

Leveraging ST MEMS proprietary technologies and accuracy + ecosystem + AI in the edge

**Thelma**
MEMS sensor transducer technology

**PƐTRA**
MEMS actuator technology

**TMOS**
Thermal transistors MOS technology

**Sensors** - Calibration friendly
- ST factory calibrated
- High and stable performance

**Actuators** - System-integration friendly
- Small form factor and light weight
- Low-voltage driven
Creating highly efficient intelligent sensors with embedded AI engine

Maximizing efficiency and minimizing energy consumption to make large-scale sensor proliferation sustainable

Optimization
Power consumption vs. performance
Ultra-low power consumption (µW envelope)

Efficiency
Optimized algorithms
Built-in operations capabilities to create optimized functions

Interoperability
Machine Learning & Deep Learning
Easy programming, interoperable with main AI frameworks

Sensors with DSP (Intelligent Sensor Processing Unit “ISPU”) for real-time processing and AI

1000x power consumption reduction vs. traditional solutions
Targeting leadership from industry 4.0 to industry 5.0 through MEMS

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<thead>
<tr>
<th>Industry 4.0</th>
<th>Industry 5.0</th>
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<tbody>
<tr>
<td>Motion, vibration, angle measurement</td>
<td>Motion sensors, inclinometers</td>
</tr>
<tr>
<td>Temperature monitoring &amp; calibration</td>
<td>Temperature sensors</td>
</tr>
<tr>
<td>Pressure monitoring</td>
<td>Pressure sensors</td>
</tr>
<tr>
<td>Humidity monitoring</td>
<td>Humidity sensors</td>
</tr>
<tr>
<td>Acoustic monitoring</td>
<td>MEMS microphones</td>
</tr>
<tr>
<td>Advanced interface</td>
<td>Human centric&lt;br&gt;Helping workers be more efficient</td>
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<tr>
<td>Artificial Intelligence in the edge</td>
<td>Resilient&lt;br&gt;Based on versatile technology</td>
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<tr>
<td>Automation</td>
<td>Sustainable&lt;br&gt;Conceived to optimize processes</td>
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<tr>
<td>Visual aid Laser Beam Scanning</td>
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<tr>
<td>Infrared TMOS</td>
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</tbody>
</table>
Targeting MEMS leadership in high-growth automotive applications

MEMS sensors

- Electrification
  - Road noise cancelling
  - Condition monitoring

- Connectivity
  - Navigation / V2X
  - Telematics boxes
  - Personal key entry

MEMS actuators

- ADAS
  - Driver assistance systems

- Self driving
  - Accurate positioning
  - LiDAR
  - Head-up display

AI in the Edge
<table>
<thead>
<tr>
<th>Core business</th>
<th>High-growth areas</th>
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<tbody>
<tr>
<td><strong>Motion control</strong></td>
<td><strong>Factory automation &amp; industrial infrastructure</strong></td>
</tr>
<tr>
<td>Industrial motor drive SoC and SiP IGBT and MOS Driving Real-time connectivity</td>
<td>Smart meters Digital power conversion Digital motion control Embedded galvanic isolation Advanced industrial connectivity NB-IoT</td>
</tr>
<tr>
<td><strong>Smart grid &amp; industrial IoT</strong></td>
<td><strong>Consumer industrial</strong></td>
</tr>
<tr>
<td>Power Line Communication Smart metering SoC Wired connectivity and IO-Link</td>
<td>Power conversion Galvanic isolated SiC &amp; GaN Drivers Smart power GaN Battery operated tools Home appliances</td>
</tr>
<tr>
<td><strong>Power conversion</strong></td>
<td><strong>Application specific analog for personal electronics</strong></td>
</tr>
<tr>
<td>AC/DC and DC/DC converters LED Driving Power management ICs</td>
<td>Wireless charging Battery management Display PMICs PMIC for portable &amp; wearable electronics</td>
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<tr>
<td><strong>PMIC for CECP</strong></td>
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<tr>
<td>High-efficiency server power management Printer driver PMIC for storage</td>
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## Analog leadership positions

### Motion control
- 1 Billion low-voltage motors driven by ST
- > 1 Billion I/O channels in factories
- 9% market share

### Smart grid & Industrial IoT
- #1 in powerline communication
- 20% market share, 150 Million smart meters installed
- Leadership in industrial analog ASICs

### Power conversion
- #2 in high-voltage converters
- > 5% market share
- 3 Billion high-voltage converters delivered

### PMIC for CECP
- #1 in PMIC for HDD
- > 90% market share
- > 3 Billion PMICs delivered

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Source: Omdia, ABI research, ST estimate, ST

- Broad & diversified portfolio of more than 7,000 products
- Serving more than 75,000 customers
ST offers advanced analog & digital technology and IP combined with deep system knowhow.

- **Smart power BCD**
- **Smart power GaN**
- **Analog & RF CMOS**
- **eNVM CMOS**
- **Vertical Intelligent Power**
- **Galvanic isolation**

**Packaging technologies**
- Leadframe – Laminate – Advanced SiP – Wafer level

**Digitalization**
Advanced connectivity, AI in the edge, digital power management

**Efficiency**
Improve power density for greater energy efficiency & portability

**Safety**
High-voltage applications, safer, more robust with improved noise immunity
ST leading the digitalization trend in application-specific analog

System-level integration  +  Flexibility  +  Connectivity

Motor control ICs
- AFE
- Logic
- Smart Power
- BCD8 160 nm
  100k gates/mm²

Wireless charging ICs
- AFE
- DSP
- Cortex M4
- Smart Power
- C90D 90 nm
  > 300k gates/mm² – ePCM

ASIC for smart industry
- Cortex M4
- DSP1
- DSP2
- DSP3
- AFE
- NVM
- Smart Power
- BCD40 40 nm
  > 2M gates/mm² – eNVM

Digitally-managed power provides configuration, monitoring and supervisory functions to meet advanced system needs
ST capturing increasing value of analog content in smart meters

Functionality increase in smart meters is directly linked to the semiconductor content

<table>
<thead>
<tr>
<th>Legacy: $$</th>
<th>Today: $$ x2*</th>
<th>Tomorrow: $$ x4*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analog</strong></td>
<td>+ <strong>Digitalization</strong></td>
<td>+ <strong>Safety &amp; efficiency</strong></td>
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<tr>
<td>MCU</td>
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<tr>
<td>AFE Metering</td>
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<td>Security</td>
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<tr>
<td><strong>e-meter</strong></td>
<td><strong>Smart e-meter</strong></td>
<td>Sensing &amp; Processing</td>
</tr>
<tr>
<td>Local reading</td>
<td>Remote reading</td>
<td>Hybrid communication</td>
</tr>
<tr>
<td>AFE: Analog Front End</td>
<td>Low speed connectivity</td>
<td>Powerline + RF</td>
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<td>Cellular IoT</td>
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<td>Multi-utility smart meter</td>
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<td>High speed connectivity</td>
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<td>AI for energy usage prediction</td>
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<td>Security &amp; power quality</td>
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* vs Legacy

Source: ST
Adoption of wide bandgap materials for power conversion drives semiconductor content value

Gallium Nitride drives a step function in power conversion efficiency and density enabling smaller, less power-hungry adapters

**Legacy: $$**

- Analog control
- Power MOS

**Today: $$ x2***

- Low power density: < 10 W / inch³
  - MasterGaN
    - HV Driver
    - Power GaN
    - Analog control

- Medium power density: > 20 W / inch³

**Tomorrow: $$ x4***

- High power density: >> 30 W / inch³
  - MasterGaN II
  - ST-ONE
    - USB-PD
    - Digital Power
    - Galvanic isolation

* vs Legacy
Source: ST
ST capturing increasing value and volumes of wireless charging market

Leveraging core technologies and proven volume manufacturing capabilities to capture significant market share in wireless charging

2021: $$

2023: $$ x3*

2025: $$ x5*

RX
Low power

AFE
Cortex M0
Smart Power

Fast RX/TX
High power

AFE
Cortex M4
Memory
Smart Power

Protection

10X volume

Fast RX/TX
+ Battery management
High power / Advanced features

AFE
Cortex M4
DSP1
DSP2
Memory
Smart Power

Protect.
Logic

20X volume

* vs 2021
Source: ST
AMS has a large, diversified customer base

A small selection of the over 75,000 AMS customers
Maximizing ST content in industrial applications

Typical industrial application

- AC-DC
- DC-DC

Control Unit
STM32

Gate Driver
MOSFET/IGBT

Signal conditioning

Sensors

Connectivity

ST analog, power, sensors, …

Driving ST Growth

Charging stations
STM32 $6
AMS $60

Factory automation
STM32 $8.8
AMS $30

Photovoltaics
STM32 $17.1
AMS $16

Metering
STM32 $1.8
AMS $6

Actual implementation based on selected customer products
Supporting ST $20B+ revenue ambition

Continuous investments in technology & product innovation for balanced and profitable long-term growth

Two strong pillars of growth in AMS
- Double digit growth in industrial & automotive
- Continuous leadership in Personal Electronics and CECP

Solid, growing analog market position
- Targeting double digit market share in application specific products
- Wireless charging, battery management, smart grid, power conversion

Broatest portfolio of MEMS sensors and actuators
- Diversification to industrial and automotive

Continued leadership in optical sensing solutions
- Expanding through diversification in all markets served by ST
Our technology starts with You

Find out more at www.st.com