



Case Study – Job computer for modern agricultural technology

Embedded modules for fields and farmland

Embedded modules based on the Sitara AM243x and AM64x series

Technologie
in Qualität





TQ as a system provider in the agricultural technology market

TQ supports a wide spectrum of companies – whether start-up or traditional companies – in finding answers to major technological questions and in doing so defining future proof industries. From the industrial sector to energy, medical technology, logistics, aerospace, building automation or agricultural technology, TQ offers all companies support in every phase of the product life cycle.

TQ develops and manufactures electronic systems to support processes in agriculture and to put and put smart farming into practice. Our products and solutions for agriculture simplify the work of farmers in many areas – in the field, in the stable and in the processing of agricultural products.

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Embedded modules for field and farmland

The demands on agriculture to produce more, at lower prices, with higher quality and at the same time protect the environment, seem contradictory at first glance. Thanks to modern agricultural technology and electronics, this can nevertheless be achieved. With the new module series TQMa64xxL and TQMa243xL, TQ provides the appropriate technology basis.

Automation to improve yield whilst reducing costs and protecting the environment

Crop failures due to climate catastrophes or wars in combination with a growing world population can only be countered with yield increases. Added to this are environmental protection and rising fertilizer and spraying costs. And to make matters worse, fewer and fewer people are willing to work in agriculture. Smart or precision farming is the way out of this tricky situation: by optimizing sowing, crop protection and harvesting using highly automated agricultural equipment, yields are improved, costs are reduced, and the environment is protected.

This is made possible by the increased use of electronics: sensors record numerous factors such as soil quality and crop volume in correlation to the respective location. The data collected is partly used on site but is also extensively analyzed in the cloud to create detailed plans for the next operation.

Specialized job computers for added intelligence

The necessary electronics are being installed in more and more agricultural machines and vehicles. Depending on equipment and task there are job computers (electronic control units, ECUs) that provide the extra intelligence. For example, a field sprayer that used to produce only a continuous spray mist, now uses the job computer to apply crop protection in a targeted manner. To do this, the job computer is connected to the tractor's main ECU – usually via the ISOBUS – and takes over the intelligent nozzle control. To achieve the required precision, various sensors, GPS data and valve states must be read out and processed in real time. All of this is correlated to the travel route so that crop protection is not applied unnecessarily to areas that have already been sprayed. This is good for the farmer's wallet and the environment at the same time.

The added intelligence is not only integrated into new equipment, but also into existing vehicles and machines by means of retrofit solutions. This places special requirements for the electronics:



Requirements applying to electronics used for farming applications

- ✓ Small and robust, so that they can be used in any weather and terrain conditions
- ✓ Low power consumption to avoid waste heat problems and ensure long service life
- ✓ Real-time capability to evaluate sensors and control the equipment for greater precision
- ✓ Functional safety for accident prevention and reliable emergency stop.
- ✓ Interfaces for data acquisition
- ✓ Connectivity for control and data transmission incl. CAN for ISOBUS
- ✓ Updates via USB or Over-the-Air (OTA)
- ✓ Scalable computing power, as farmers have very different requirements for their equipment and agricultural machinery manufacturers and their suppliers have to react accordingly
- ✓ Plenty of memory for data collection but also for different language versions
- ✓ Security functions also for blockchain and loaner equipment management
- ✓ Consistent development environment
- ✓ Long-term availability
- ✓ Cost-effective

Embedded technology with Sitara AM64x and AM243x devices fits the requirement profile of modern agricultural technology

At first glance, this list of requirements seems difficult to realize. However, with the new controllers of the Sitara AM64x and AM243x family from Texas Instruments, there is now a very suitable starting point: Thanks to the Arm Cortex-R5 cores, the devices are pronounced real-time experts. An additional Cortex-M4 is designed as an "isolated core", which can perform its duties independently and uninfluenced by the other cores and is thus predestined for functional safety tasks – Texas Instruments is planning IEC-61508 certification accordingly. Functions like runtime safety diagnostics, voltage, temperature and clock monitoring, windowed watchdog timer (WWDT) and CRC engine for memory integrity checks are predestined for the M4 core. If even more computing power is required, the AM64x can rely on up to two A53 cores.

Core features and benefits of the TQMaX4XxL module family

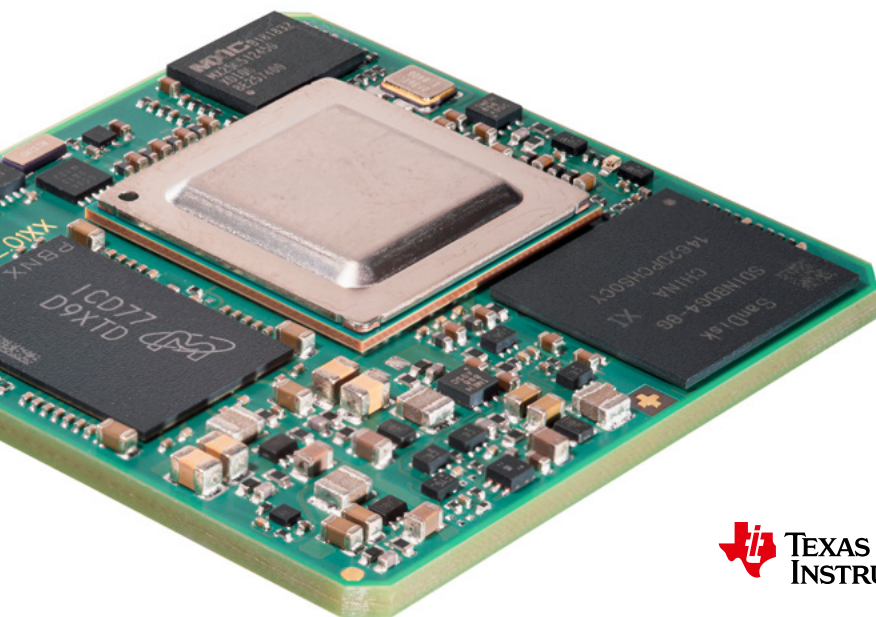
TQ uses the new AM64x and AM243x devices for the TQMa64xxL and TQMa243xL module families. Both module families are pin-compatible with each other and thus scale over a very wide performance range - ideal for meeting the different needs of job computers..

Thanks to the LGA concept, the TQ modules can be soldered directly onto the carrier board, eliminating

the need for connectors and ensuring a constant and extremely good connection – shock and vibration in the field are therefore no problem. In addition, this also saves space, as the installation height is correspondingly lower. Due to the low power consumption of the module, typically 1 W to 2 W, extensive cooling solutions are not required; the connection to the housing is sufficient in most cases. This allows the standard temperature range of -25 °C to +85 °C; an extended temperature range of -40 °C to +85 °C is also available as an option. In addition, the concept allows the use of protective coatings against natural moisture and liquids to be discharged. With dimensions of 38 mm x 38 mm, the modules still find their place even in very tight installation situations, which is of particular importance for retrofit solutions.

Convenient storage situation of the modules

The memory situation of the modules is convenient: Up to 2 GB RAM, up to 256 MB NOR flash and up to 64GB eMMC as well as the connection option for an SD card are available. This means that not only is there sufficient memory for the numerous Smart Farming measurement data, but user guidance and status messages can now be stored in several language variants simultaneously. The latter is not only helpful for device export, but also responds to the situation in agriculture: employees of different nationalities with different native languages are not uncommon on a farm or during the harvest season – the machines they operate should be designed for this.



Embedded module TQMaX4XxL

Based on AM243x or AM64x for headless applications with real-time requirements

[Learn more about the TQMa243xL](#)

[Learn more about the TQMa64xxL](#)



Interface equipment and other features

Interfaces are essential for the control of valves, servomotors and other actuators as well as for the data acquisition of sensors. Here, the TQ modules score particularly well since all I/O signals available from the processors are also available via the module pads. Thus, among other things, up to 6 x I2C, 9 x UART, 1 x USB 2.0, 1 x USB 3.0 as well as a 12-bit analog-to-digital converter (ADC) are available.

The ADC can be used particularly conveniently with the help of TQ's MBaX4XxL Single Board Computer (SBC) based on the modules: The integrated analog front end enables uncomplicated measurement of current, voltage and resistance, and thus thus enables classical measurement technology with its countless special sensors. To meet the growing importance of communication between the job computer and the tractor's main ECU, as well as (radio) connections that go beyond this, the aforementioned new Sitara processors feature the Programmable Real-Time Unit subsystem (PRU). This provides 2 x CAN-FD as the basis for ISOBUS and TSN-capable Ethernet for high-performance fieldbuses. In total there are up to four real-time Gigabit Ethernet ports (GbE) available. In addition, there is also the option of using two classic GbEs. This lays the foundation for independent TCP/IP-based radio connections of the job computers, i.e. independent of the the Traktor ECU, for example for updating software (OTA). Alternatively, USB sticks can be used for updating, although this would require considerably more effort.

If this range of interfaces and communications is not sufficient, a PCIeExpress lane (Gen2) can be used for high-speed expansions to meet even unusual requirements.

Security and encryption functions

The numerous security and encryption functions of the new TQ modules can be used not only to protect against the usual dangers of networked computer technology, but also as tamper and billing protection for loaner equipment in machine rings. Likewise, these functions are the basis for secure proof of origin using blockchain: each individual production step can be given a cryptographic and thus tamper-proof "stamp" to provide the end user with full traceability to the end consumer.

A module family with six CPU variants

Currently there are three versions available of the TQMa64xxL as well as of the TQMa243xL, which means a performance scaling from a single Cortex R5F with M4F up to dual Cortex-A53 with four Cortex-R5F and one M4F. Thanks to pin compatibility of the modules, this can be used with a common carrier board design, ensuring maximum flexibility.



The compatibility also benefits the development tool chain. Instead of having to deal with the tools of various CPU/MCU manufacturers, one tool chain covers the wide scaling range of modules and simplifies the reuse of software components – which has a positive effect on development time and costs. In addition, it simplifies the adaptation of job computers to special customer requirements.

Conclusion

The TQMa64xxL and TQMa243xL module series meet the current needs of job computers and ECUs in agricultural technology and have performance reserves for the further development of existing product lines. In addition, they are also suitable for new concepts such as agricultural robots. Other Sitara modules from TQ can also be used here, such as the TQMa65xx for demanding graphics tasks. As an experienced E²MS company and system supplier, the TQ Group can offer numerous services in addition to the modules and thus provide support in many phases of product development and manufacturing. This is of particular importance for start-up companies that have limited manufacturing resources and see their core competence more in software and cloud services – the hardware part of their projects is gladly taken over by TQ.

	TQMa6442L	TQMa6421L	TQMa6411L	TQMa2434L	TQMa2432L	TQMa2431L
Cortex®-A53	Dual Core	Single Core	Single Core	-	-	-
Cortex®-R5F	2x Dual Core	Dual Core	Single Core	2x Dual Core	2x Single Core	Single Core
Cortex®-M4F	Single Core	Single Core	Single Core	Single Core	Single Core	Single Core
R5F Tightly Coupled Memory	256 Kbyte	256 Kbyte	128 Kbyte	256 Kbyte	256 Kbyte	128 Kbyte
CAN BUS	2x	2x	2x	2x	2x	2x
Full CAN-FD Support	Ja	Ja	Nein	Ja	Ja	Nein
Ind. Com. Subsystem Support	Ja	Ja	Nein	Ja	Ja	Ja
Programmable Real Time Unit	2	2	2	2	2	2
AD-Wandler (12 Bit)	Ja	Ja	Nein	Ja	Ja	Ja
Krypto. Beschleuniger	optional	optional	optional	optional	optional	optional
General-Purpose Timer	16	16	16	16	16	16
Erweiterte PWM-Module	9	9	9	9	9	9

The fine granular gradation of the modules makes it easy to find the optimal module for the respective application.