# SENSESTREAM SMART SOLUTIONS
## SECS/GEM GATEWAY

## PROBLEM

The SECS/GEM communications protocol (SEMI Equipment Communications Standard/Generic Equipment Model) is the main protocol for automation communications between a fab host and equipment in the semiconductor/electronics industry. It is not standardized on many sensors, devices, and solutions. For this reason, integration of many third-party devices into OEM tools requires the fab end-user to provide the means for data integration between the sensor and the host. This integration most often requires the use of a third-party SECS/GEM gateway.

## BACKGROUND

The widespread adoption of the IIoT and the Smart Fab concept within the semiconductor industry requires a standardized protocol for digital communication within and between the different tools, unit processes, and analytic and control nodes in a fab, from field level to enterprise system. SECS/GEM communications protocols are the semiconductor industry standards for digital communications between manufacturing equipment and the plant host control system. They were developed by SEMI (Semiconductor Equipment and Materials International) for equipment automation and control. The protocol enables sensor measurements, data collection and transmission, the setting of equipment configuration parameters, process recipe modification, selection, start, and stop, and other functions within automated semiconductor device fabs. SECS/GEM interfaces generally use TCP/IP networking; however, RS232 serial connections can also be used for older equipment. The protocol is extremely flexible and simple to use, and it has been adopted by semiconductor OEMs, component suppliers, and software providers.
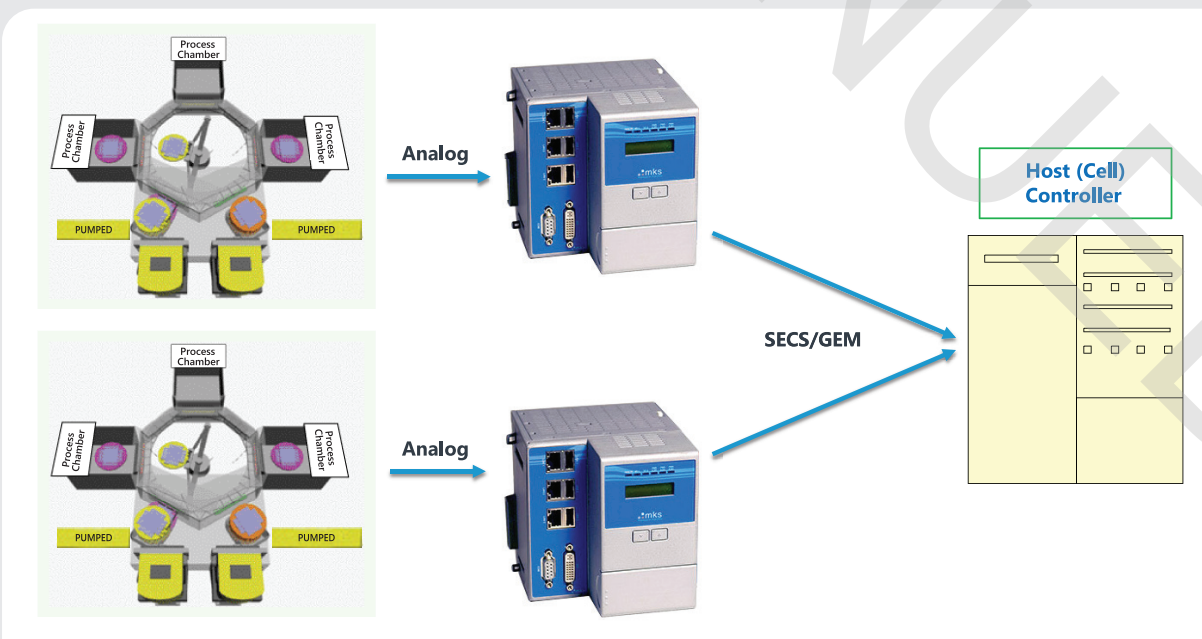


Figure 1. The function of MKS Instruments' PAC with resident SenseStream software.

The main SECS/GEM standards, as defined by the SEMI organization are:

- SEMI E30 GEM Standard – This core standard defines a common set of equipment behavior and communication capabilities to support the manufacturing automation programs of semiconductor device manufacturers.

- SEMI E5 SECS-II – This standard describes the interpretation of messages exchanged between the equipment and a host and outlines message input/output data structure, data item format, and acknowledgment codes.

- SEMI E37 HSMS – This standard describes High-Speed SECS Message Services based on the TCP/IP protocol. SECS-II messages are encoded into HSMS message format.

In a fab containing still-functioning legacy equipment, an effective way to resolve the tangle of digital communications protocols between different tools must be implemented in order to leverage SECS/GEM communications protocols for IIoT and Smart Fab operations. In many semiconductor fabs most installed machines do not share a communication protocol with host systems; therefore, they are unable to share locally generated process, product, and machine state data with the host controller or the plant Manufacturing Execution System (MES). The upfront costs to incorporate SECS/GEM communication capability into legacy machines is high and therefore retrofitting SECS/GEM capability in tools that are nearing the end of life is not deemed cost effective. As well, the vendor of a legacy tool may no longer exist or may no longer support older models which can further increase the upfront cost of retrofitting SECS/GEM communication capability. Replacement of such legacy machines with newer equipment having SECS/GEM communications, while an effective solution to the problem, is often not favored owing to the tremendous capital outlay required. Nevertheless, the establishment of a smart manufacturing environment within a modern fab requires the existence of digital communications capability between individual processes, measurement and product handling tools and host control and fab MES. For this reason, a cost-effective, easily implemented means of converting local machine state, process and control data to the SECS/GEM communication protocol and SECS/GEM host commands to the communication protocol used by legacy machines is needed.
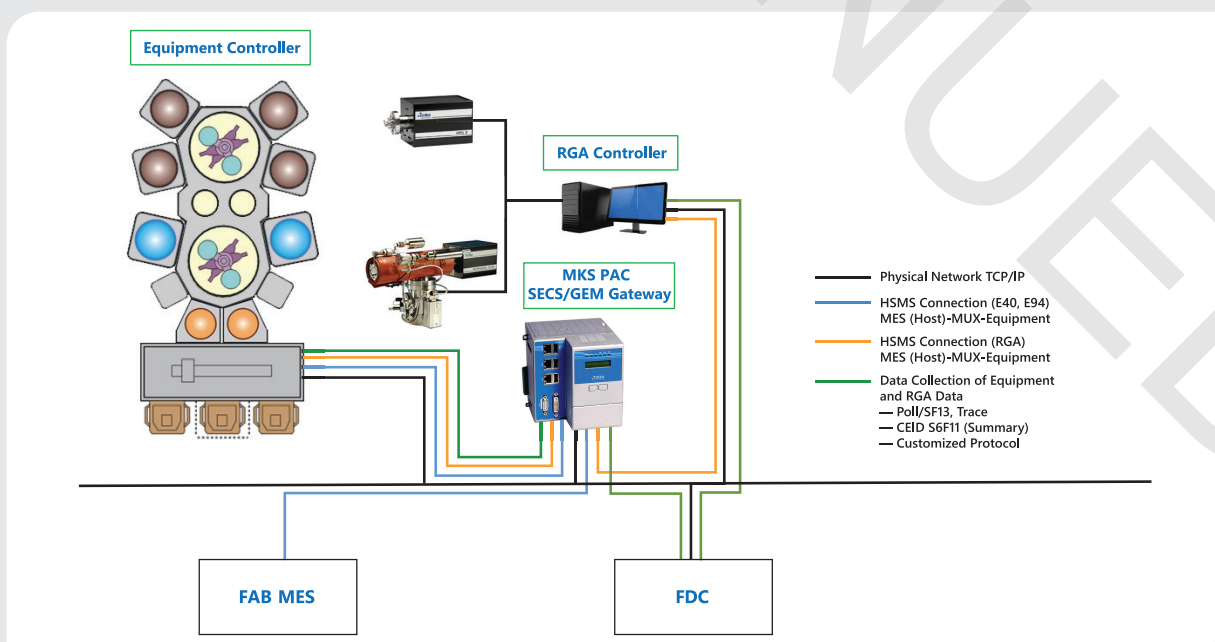


*Figure 2. A SenseStream software gateway implemented on a customer server.*

## SOLUTION

MKS Instruments' SenseStream software, resident on either the MKS PAC1000 with modular I/O, or the MKS HyperPAC Industrial PC (IPC), provides a cost-effective solution for digital communication between legacy and other machinery within the fab not equipped for SECS/GEM communication and fab host controllers or MES systems that employ SECS/GEM. SenseStream with the PAC modular I/O or HyperPAC IPC converts machine analog or digital communication protocols to SECS/GEM, transmitting the data to the host controller (Figure 1); it also acts as a data multiplexer. PAC modular I/O converts Mass Flow Controller (MFC), temperature sensor and other analog and RS232 information to SECS/GEM protocols. It will also translate Ethernet/IP protocols to SECS/GEM protocol.

SenseStream allows a fab host controller to get data with no change to the tool or host software, effectively permitting the host to manage the process tool and obtain tool variable identifications (VID). SenseStream enables both data collection and data storage for further analysis. As well, SenseStream can collect additional parameters from the tool that are exposed through the internal protocol and mapped in the PAC to virtual VIDs. In one request, a host controller can read VIDs from the tool and SenseStream with the PAC being responsible to split the message.

## APPLICATIONS

### SenseStream Software Gateway (Figure 2)

**Problem:**
The customer had multiple data sources requiring time synchronization alignment plus data conversion to SECS/GEM.

**Solution:**

- Implement SenseStream software on a virtual machine on the customer's server.

- Implement a software-only MKS Smart Solution using SenseStream with VID mapping and data multiplexing.

- SenseStream software can run on either the customer server or the MKS Residual Gas Analyzer (RGA) IPC.

**Customer Value:**

- Data now has time sync alignment.

- Tool meta-data can be passed to the host via SECS/GEM.

- The MKS SenseStream High-Speed SECS Message Services (HSMS) multiplexer can insert additional data into the data stream.

- SenseStream enables RGA control; RGA data can be fed into the SECS/GEM data stream.

### Incorporation of Analog Signals into Host SECS/GEM Data Stream (Figure 3)

**Problem:**
The customer required turbopump vibration data (from a 3rd party vibration sensor) fed into the SECS/GEM data stream.

**Solution:**
Implement the MKS Automation Platform with Linux SenseStream software, combined with SECS/GEM multiplexer.

**Customer Value:**

- The customer obtained a SECS/GEM gateway that can be integrated with multiple generic devices.

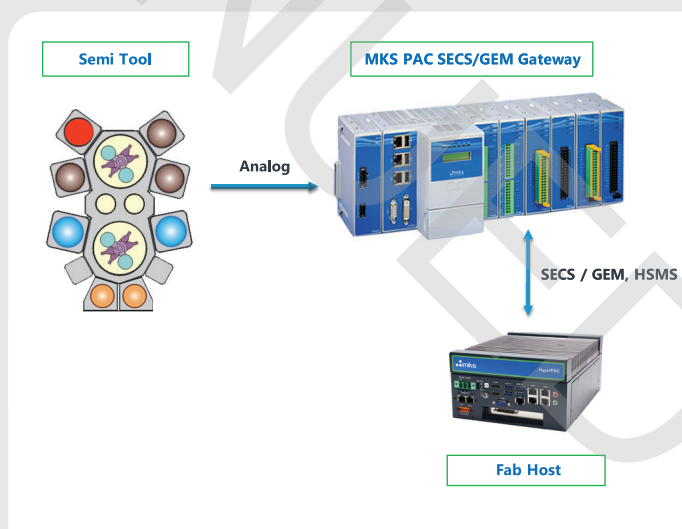- The solution was extremely cost-effective.



*Figure 3. Analog signal integration into fab host SECS/GEM data stream using MKS PAC.*

## Incorporation of Analog Signals into Host SECS/GEM Data Stream (Figure 4)

### Problem:

The customer had legacy SEM inspection tool equipped with an MKS 903 pressure sensor. The analog signal from the 903 needs to be integrated into the Modbus data stream from the SEM to provide the tool with protection from a pressure burst due to catastrophic rough pump failure.

### Solution:

The MKS Automation Platform with resident Linux SenseStream software and a special Modbus gateway driver can convert the analog signal from the 903 pressure sensor to the Modbus communication protocol. This information can then be transmitted to the customer gateway and integrated into the fab host SECS/GEM data stream.

The SenseLink GUI allowed the user to write conditional statements, where, in this case, the user would take action to close the isolation valve when a rapid pressure increase was detected by the 903 pressure sensor. This protected the chamber if the pump failed and resulting foreline pressure reached above the user-defined threshold.

### Customer Value:

With the Modbus driver installed on the MKS PAC gateway, the customer enabled protection for the SEM inspection tool and established a communication gateway by which multiple generic devices may be integrated into the SECS/GEM data stream.

## Incorporation of EtherCAT® Signals into Host SECS/GEM Data Stream (Figure 5)

### Problem:

Signals from a Paragon® Remote Plasma Source (RPS), incorporated in a semiconductor etch tool, need to be converted from EtherCAT communication protocol for incorporation into the fab host SECS/GEM data stream.

The customer had elevated failure rates with no warning of failure. They needed to incorporate additional RPS device data, available via EtherCAT Process Data Objects (PDO), into the fab host data stream to facilitate the analysis and prediction of failures.

### Solution:

Use of the MKS Automation Platform with resident Linux SenseStream software and a SECS/GEM multiplexer enabled the conversion of EtherCAT signals from the Paragon RPS
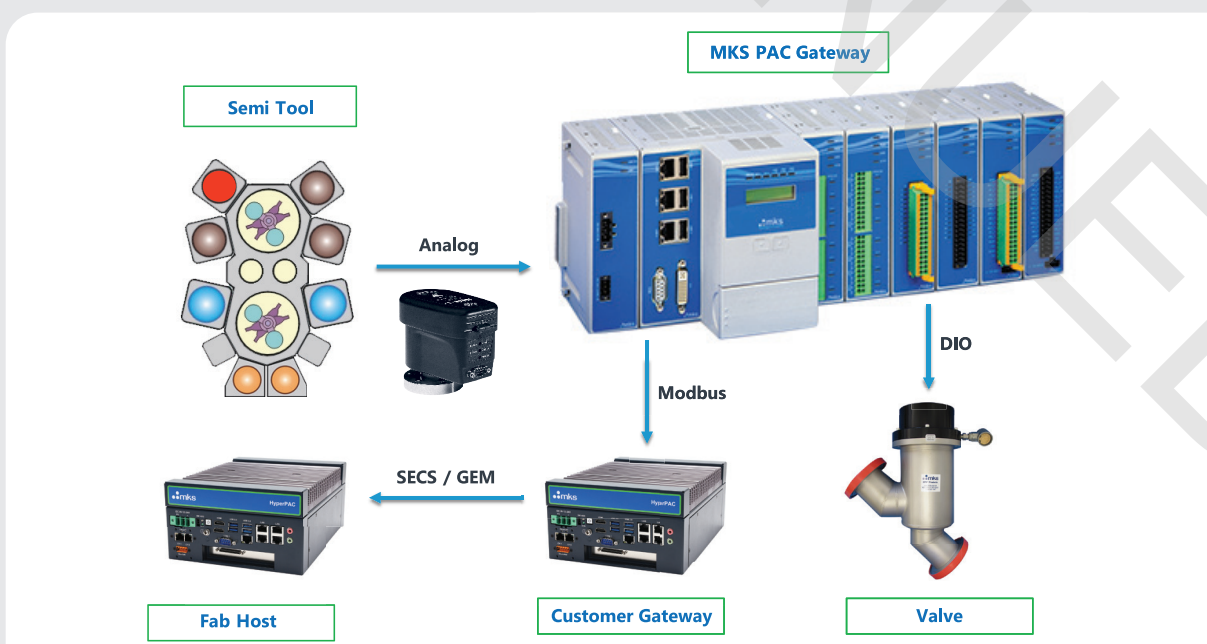


Figure 4. Analog signal integration into Modbus and SECS/GEM data stream.

and incorporated this data into the fab host SECS/GEM data stream.

**Customer Value:**

The customer had a SECS/GEM gateway that allowed them to monitor RF hours and other device data for the Paragon RPS. This enabled the development of effective maintenance protocols for the tool and avoided unexpected failures in the system.

## CONCLUSION

MKS Instruments' SenseStream software enables machine-to-machine and machine-to-host connectivity for legacy and other equipment in the semiconductor fab that are not equipped for data transmission using SECS/GEM communication protocols. SECS/GEM connectivity using SenseStream permits data sharing between fab host and process, control, and metrology tools throughout the semiconductor fab, facilitating the implementation of Industrial Internet of Things (IIoT) and Smart Fab manufacturing concepts. The modular design and distributed architecture of the SenseStream application make it relatively easy to deploy and maintain throughout the fab environment. Its ease of integration and use make SenseStream a clear leader in reducing the complexity of SECS/GEM implementation.
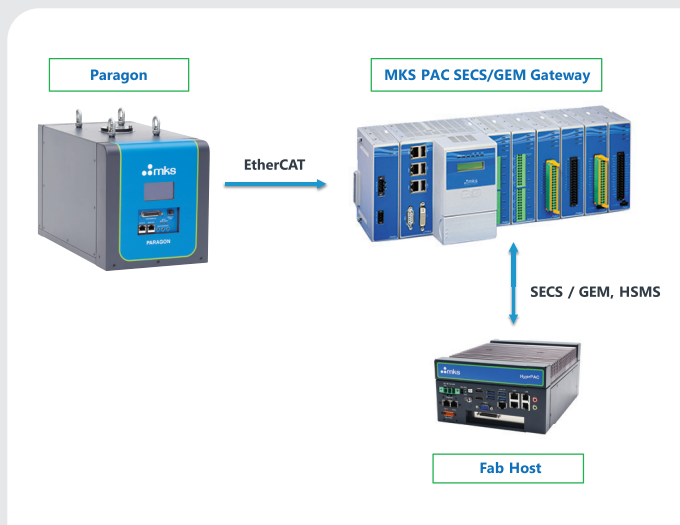


*Figure 5. EtherCAT signal integration into fab host SECS/GEM data stream.*