Universal Process-Controller
For monitoring press-fit and joining operations, torque and process curves, plus spring and switch testing, including resistance measurement, signal testing and leak detection
DIGIFORCE®
Series 9307

Application
The DIGIFORCE® 9307 monitors processes in which precisely defined functional relationships between two or more measured quantities need to be demonstrated. These measured quantities are recorded synchronously during the manufacturing process or subsequent functional testing to produce a measurement curve, which is then assessed using graphical and mathematical evaluation techniques. After internal evaluation, the measurement curve and computed evaluation results are visualized on the color display and are also output at the external control interfaces. The processes in the controller are optimized by a powerful real-time operating system to achieve an extremely fast evaluation cycle: it typically takes just 15 ms to deliver the global OK or NOK evaluation result, which can then be analyzed by the higher-level controller.

In addition to the traditional evaluation windows with defined entry and exit sides, the DIGIFORCE® 9307 also offers thresholds, trapeziums of type X or Y and envelopes as graphical evaluation elements. Individual evaluation results from the graphical tools can then be combined by mathematical operations to provide even more analysis flexibility for a huge range of signal curves.

DIGIFORCE® has a wide range of process control applications, including monitoring processes such as joining, riveting or caulking, or checking torque curves, for instance for hinges or high-quality rotary controls. Even complex signal/time curves (e.g. pressure curves, leaks etc.) can be monitored using the large choice of evaluation techniques.

Simultaneous recording of up to two Y variables (Y₁ and Y₂) with respect to a common X variable allows many applications to use one DIGIFORCE® controller to monitor two synchronous processes. Alternatively, this feature can be used to evaluate an application with three process variables, for instance the force/displacement curve and associated current consumption of a lifting electromagnet. While DIGIFORCE® is used in many automated production areas, it is equally at home in the manual workstation, for instance to monitor force/displacement when using hand presses for assembly or for random spot-checking in goods inwards.
**Measurement data acquisition**

With an active measurement, which can be triggered by different events, the synchronously measured quantities \(X, Y_1\), and optionally \(Y_2\), are saved in the measurement data memory. Real-time signals can indicate whether measurements are exceeding set signal levels while the measurement is still in progress. The evaluation phase follows immediately after the measurement. In this phase, DIGIFORCE® checks whether the recorded measurement curve(s) satisfy the stored graphical and mathematical evaluation criteria. If any of these criteria has been infringed, the measurement is classified as BAD (NOK), otherwise it is rated as GOOD (OK). Once this evaluation is complete, the measurement curve, the global OK or NOK result and numerous process-related values are displayed in a suite of measurement windows and updated at the Fieldbus interface. The processing steps of the evaluation phase, which finishes when the equipment is ready for the next measurement, have been optimized so that even dynamic manufacturing processes can be monitored.

**Evaluation of a measurement curve**

As a universal evaluation tool for a vast range of curve shapes, the DIGIFORCE® 9307 provides configurable evaluation elements, which can be used to classify a measurement curve as OK or NOK. In addition to the traditional evaluation windows with defined entry and exit sides, the DIGIFORCE® 9307 also uses thresholds, trapeziums of type \(X\) or \(Y\) and envelopes as graphical evaluation elements. Individual evaluation results from the graphical tools can then be combined by mathematical operations to provide even more analysis flexibility for a range of signal curves. The graphical evaluation elements can be configured both numerically and graphically in setup mode using one or more recorded measurement curves. They can be used in any combination, even overlapping in an \(X/Y\) graph.

**Window evaluation**

**Symbol**

Max. number: 10

The Window evaluation element tests whether the curve has passed through the defined entry side and exit side in the window area. The user can configure these entry/exit sides as required, and can even set multiple input/output sides. A live signal can be assigned to up to two windows, which is enabled immediately during recording if any infringement occurs. It is also possible to define windows of type NOT (no entry/exit) or BLOCK (curve ends inside the window) by suitable configuration of the entry/exit sides. This evaluation element also calculates the values listed below, which can optionally be displayed and also input to user-definable mathematical functions for further processing and evaluation:

- Entry and exit coordinates (measurement pairs)
- Local minimum/maximum
- Absolute minimum/maximum
- Mean value \(Y_{\text{mean}}\)
- Integral (area below curve to \(Y_{\text{MIN}}\) limit inside window)
- Curve gradient
- Inflexion point

![Measurement window M1-1 contains a graph of the measurement curve. Shows a curve containing a forward and return section and detailed evaluation using windows, envelopes, thresholds and mathematical operations.](image-url)
Trapezium evaluation element

Symbol

Max. number: 4

The DIGIFORCE® 9307 offers two different types of trapezium: the type-X trapezium window with fixed $X_{\text{MIN}}, X_{\text{MAX}}$ limits and type-Y trapezium with fixed $Y_{\text{MIN}}, Y_{\text{MAX}}$ limits. The trapezium evaluation element tests whether the curve has passed through the defined entry and exit sides; only one entry side can be configured for this element. The entry/exit values are calculated.

Threshold evaluation element

Symbol

Max. number: 4

The threshold evaluation element can be used to calculate and monitor where the measurement curve passes through a defined X-value or Y-value. The user can choose between threshold type X or Y. Threshold type Y provides the following extra results:

- Local minimum/maximum
- Absolute minimum/maximum
- Mean value $Y_{\text{MAX}}$
- Integral (area between curve and X-axis in the threshold region $X_{\text{MIN}}$ to $X_{\text{MAX}}$)
- Curve gradient
- Inflexion point

Envelope evaluation element

Symbol

Max. number: 2

The DIGIFORCE® 9307 can use one or more measurement curves to generate up to two envelopes. The user can then customize a generated envelope in the X-domain, and also set tolerances for the Y-domain. For a measurement curve comprising a forward and return curve section, the envelope cannot lie over the turning point.

When subsequently monitoring a measurement in measurement mode, DIGIFORCE® tests whether the measurement curve lies within the defined envelope band i.e. is classified OK, or whether the curve passes outside the valid envelope and hence must be classified NOK.

Rotary switch evaluation element

Symbol

Max. number: 2

The Rotary switch evaluation element enables haptic testing of rotary switches and rotary or rotating controls comprising up to 32 control positions. This evaluation tests whether the number and level of force maxima and minima satisfy the saved criteria. In addition, the angular distance and Y-mean value of the extreme values will be monitored.

Mathematical operation

Symbol

\[ A + B/2 \]

Max. number: 10 of which 6 can be evaluation

Specific measurement curve variables and results from the graphical evaluation elements can be combined using basic mathematical operators (+, -, x, ÷) and evaluated. A result can be processed further in a subsequent operation. The evaluation is fed into the global evaluation result. The results of a mathematical operation can be displayed in a measurement window and retrieved via the Fieldbus and/or communication interfaces.

Flexible process integration

The DIGIFORCE® 9307 has the versatility to integrate into practically all process environments. A huge number of detailed requirements can be implemented using the numerous I/O (23 inputs / 31 outputs), some of which can be assigned user-defined functions. A measurement can be started and terminated at variable times by different internal and external events.

Sampling and recording measurement signals

Signals can be sampled as a combination of time interval ($\Delta t$), X-interval and Y-interval ($\Delta X$, $\Delta Y$) to provide a flexible yet also compressed measurement recording. Curve areas containing a constant or steadily changing signal can be reproduced with just a few stored measurement points, while steep signal slopes or alternating waveforms require many points.

Start/Stop conditions for measurement recording

The DIGIFORCE® 9307 lets the user define independent start/stop logic.

Start conditions: Ext. control signal, measurement above or below a definable X-value or Y-value.

Stop conditions: Ext. control signal, measurement above or below a definable X-value or Y-value, timeout, definable number of recorded measurements reached.

Recording and evaluating two synchronous processes

Two signal curves $Y_1$ and $Y_2$ can be recorded with respect to a common X-channel and evaluated in one measurement phase. For the evaluation, the user assigns the required graphical evaluation elements to each graph, and the evaluation is performed independently using separate process signals (OK-$Y_{i,j}$). Alternatively, it is possible to monitor an application that has three process variables.

Limit monitoring in real time

$S1 \ldots S4$

The user is able to assign the switching signals $S1 \ldots S4$ to the three measurement channels $X, Y_{1,2}$ as required, and can set their polarity. The associated PLC I/Os and Fieldbus signals are updated both in standby mode and also in real time during the measurement cycle (response time < 10 ms).

NOK ... ONLINE$_{i,j}$ Up to two live signals (NOK-ONLINE$_{i,j}$) can be used if the curve does not pass through the permitted region of the window evaluation element. This allows preemptive termination of a joining process in ultra-quick time if the two components get intertwined, protecting parts, tools or even the entire system from damage.
Process data

The DIGIFORCE® 9307 visualizes a comprehensive set of process data during measurement mode and automatic production mode. All relevant process data can be transferred to the controller or PC environment immediately after a measurement. The user can switch between the following process windows:

► M1-1/2 Graph of $Y_1(X)$ or $Y_2(X)$ measurement curve
► M1-3 General display of $Y_1(X)$ or $Y_2(X)$ curves
► M2-1/2 General display of $Y_1(X)$ or $Y_2(X)$ curves
► M3 Full-screen PASS/FAIL or smiley
► M4 Entry/exit data for evaluation elements
► M5 List of user-specific process values (up to 24 values)
► M6 Statistics on all graphical evaluation elements (trend/histogram)
► M7 Job sheet containing process, worker and parts data for transfer to process-data acquisition

Each process window displays the global header containing information on the selected measurement program, the associated part quantities and NOK figures, and the global OK/NOK evaluation. The status field on the right shows the evaluation elements that are active in the measurement program and their individual results.

Sensor configuration and adjustment

The user can choose which physical channels A...F to assign to the measurement graphs ($X$, $Y_{1,2}$ coordinates) and set the graph scale. This gives the user the freedom, for instance, to use a preferred mounting for a displacement sensor, and then set the scale to display/evaluate a decreasing or increasing, positive or negative displacement. There are several options for adjustment: adopting the sensor specification from the burster TEDS electronic data sheet, manual input from the sensor certificate data, or using the teach-in process.
Fieldbus interface
An independent communication processor provides the Fieldbus interface via PROFIBUS, PROFINET, EtherCAT or EtherNet/IP.

Cyclical realtime process data
- Process control
- Retrieval of specific measurement results
- Live values of the active sensors

Non cyclical parameter/ADMIN/result data
- Transfer of component/worker/job data for logging
- Complete device configuration
- Retrieval of large amounts of process and curve data

32/128 measurement programs
The DIGIFORCE® 9307 comes with the capability to manage up to 32 measurement programs, which can be rapidly selected via I/O, Fieldbus or keypad. Each measurement program contains the full configuration of sensors, measurement procedure and evaluations. The PC software DigiControl can be used to download alternative DIGIFORCE® 9307 firmware, which has the capability to handle up to 128 measurement programs. This firmware re-allocates the internal memory so that up to 400 measurement pairs/triplets can be recorded. The intelligent sampling tool, with its facility to combine variables (∆t, ∆X and ∆Y), ensures that these 400 value pairs are normally sufficient to reproduce and evaluate a measurement curve.

DigiControl PC software for DIGIFORCE® 9307, 9310 and 9311
The basic version of this software, available free of charge, offers full device configuration, data backups, and export and display of measurement curves including all evaluation results. An especially convenient feature is the facility to define graphical evaluation elements such as envelopes, windows, trapeziums and thresholds from a set of curves measured for master or reference parts. Alternatively, pre-archived measurements can also be analyzed to create new evaluations. In addition to these basic functions, the Plus version (9307-P100) of the DigiControl PC software provides an automatic production mode, allowing log measurement data during production with clear parts referencing, for example. The resultant measurement reports are not only available in the internal program format, but can also be ported into the following formats: ASCII raw data, EXCEL, PDF Print and SQL.

Even for synchronous processes involving large amounts of data, logging of measurement data is optimized to achieve an ultra-short cycle time. For more complex tasks, the software also supports an additional remote interface, for instance for loading a new device configuration or transferring component names for measurement-data logging.

User-definable function keys
The function keys F1...F4 below the display can be assigned to various functions as required. The following functions are available for selection for example: browse measurement screens, tare, start/stop measurement, change program, confirm OK/NOK evaluations, sensor test.

Porting DIGIFORCE® 9306 to DIGIFORCE® 9307
DigiControl can be used to create a DIGIFORCE® 9307 device configuration from a DIGIFORCE® 9306 backup file. This is done by importing the sensor and evaluation settings and selecting as close a configuration as possible for the DIGIFORCE® 9307. Then just a few minor final adjustments and settings are needed to resume production under process control.
**General Technical Data**

- Sampling rate: 10 kHz
- Signal sampling: ΑX, ΑY, Δt in any combination
- Measurement curves: \( Y_1(X) \) and \( Y_2(X) \)
- Digitalization: 16 bit
- Evaluation time: 15 ms
- Measurement programs: 32 (5,000 value pairs) / 128 (400 value pairs)
- Power supply: 90 ... 264 VAC / 47 ... 63 Hz / typically 30 VA
- Delay in real-time limit signals S1 ... S4: < 10 ms
- Operating temperature range: +5 ... +23 ... +40°C

**Keypad**

- Numerical, configurable function keys

**Display**

- 5.7” TFT LCD (640 x 480)

**Protection class**

- IP30 / IP65 panel-mounted

**Operating temperature range**

- +5 ... +23 ... +40°C

**Protection class**

- IP30 / IP65 panel-mounted

**Display**

- 5.7” TFT LCD (640 x 480)

**Keypad**

- Numerical, configurable function keys

*Factory-installed device firmware. Firmware can be changed via PC software DigiControl.*

**Compatible Sensors**

- Flexible assignment of physical channels A ... F to measurement graphs (X/Y1/2 coordinates)

**Channel A, B (strain gauge, potentiometer, process signals)**

- **Strain gauge sensors**

  - Measurement ranges: ±1 ... 40 mV/V
  - Bridge resistance: 120 Ω ... 5 kΩ
  - Excitation voltage: 2.5 V, 5 V, 10 V
  - Excitation current: 35 mA or 70 mA @ 10 V
  - Cut-off frequency: 5 ... 5,000 Hz in discrete bands
  - Total error: < 0.05% F.S. @ ≥ 1 mV/V
  - Total error: < 0.1% F.S. @ < 1 mV/V

- **Potentiometer, process signals**

  - Excitation voltage: 5 V / 10 V
  - Transmitter excitation: 24 V, 150 mA
  - Measurement ranges: ±5 V, ±10 V
  - Excitation current: 100 mA max.
  - Cut-off frequency: 5 ... 5,000 Hz in discrete bands
  - Total error: < 0.05% F.S.

**Channels A and B**

- Support burster TEDS (SN 530000 onwards)

**Channel C incremental sensors, EnDat 2.2, SSI**

- Signal: TTL / RS422, sinusoidal voltage Vpp = sinusoidal current 11 µA
- Counter depth: 32 bit, ±2EXP31
- Cut-off frequency: 1 MHz
- Reference mark: single, multipoint, distance-coded
- Absolute value: EnDat 2.2, SSI
- Transmitter excitation: reference travel for distance encoding
  - 5 V, 300 mA

**Channel D combined channel analog/incremental (option)**

- Strain gauge or process signal: ±1 ... 40 mV/V, ±5 V, ±10 V
- Total error: according to channels A, B
- Incremental interface: TTL/RS422, Sinus 1 Vpp, Sinus 11 µA
- Transmitter excitation: 5 V, 300 mA / 15 V, 200 mA

**Channel E resistance measurement (option)**

- Measurement ranges: 200 mΩ, 2 kΩ, 100 kΩ
- Total error: < 0.5% F.S. @ 200 mΩ, 2 kΩ
- < 1% F.S. @ 100 kΩ

**Channel F Piezoelectric (option)**

- Measurement ranges: 1 nC ... 1 µC in discrete bands
- Cut-off frequency: 5 ... 5,000 Hz in discrete bands
- Total error: < 1% F.S.

**Fieldbus Interfaces**

- **I/O interface**

  - Two parallel PLC ports to EN 61131-2, 24 VDC, opto-isolated
  - 23 inputs D-SUB-37 (male)
  - 31 outputs, of which 23 configurable, maximum load \( I_{max} \): 200 mA, D-SUB-37 (female)

- **PROFINET (option)**

  - D-SUB9
  - Bau date: max. 12 MBit/s
  - Communication protocol: cyclic service DP-V0, acyclic service DP-V1

- **PROFINET, EtherNet/IP, EtherCAT (option)**

  - 2 port western-socket (RJ45)
  - Communication protocol: cyclical real-time process data
  - non-technical parameter data

**Communication Interfaces**

- Device parameterization, data backup (up/download), high-speed measurement data logging
  - USB Slave port (model B) / front panel
  - Data rate – 1 Mbaud

- RS232 D-SUB9
  - (PC connecting using 1 : 1 cable 9900-K333)
  - Formatted 8.1
  - Data rate 9600 baud ... 115.2 Kbaud
  - Ethernet 10/100 Mbit, Western socket (RJ45)

**Housing**

- Combined desktop/panel-mounted housing (W x H x D): 205 x 160 x 240 [mm]
- Desktop version: 4 rubberized feet (fitted as standard)
- Front panel (W x H): 220 x 175 [mm]
- Front panel cut-out (W x H): 206 x 161 [mm]
- Weight: approx. 5 kg

**Accessories**

- Fixing kit for panel mounting
  - Model 9300-Z003

- **PC-Software**

  - DigiControl PC software for convenient device configuration including backup function (upload/download), laboratory mode for manual reading and analysis of measurement curves, and data-log wizard with print and export functions.

  - Supplied with the instrument and available free of charge from www.burster.com

  - DigiControl PC software including USB data cable 9900-K349
  - Model 9307-P101

- **Cables and connectors**

  - Connecting cable for burster displacement sensors 8710 ... 8719 series, length 3 m
  - Model 99209-591A-009000
  - Connecting cable for torque sensor model 8651/8661 incl. angular measurement to option channel D, length 3 m
  - Model 99163-540A-0150030

  - Adapter cable (Y-type) for torque sensor model 8661 incl. angular measurement to standard channels A/B and C (only to use together with model 99163-540A-015000)
  - Model 99209-215A-0090004

  - Connecting plug for A, B and E channel, D-SUB-9 (pack of 2 included with device)
  - Model 99900-V209

  - Connecting plug for C and D channel, D-SUB-15
  - Model 99900-V163

- **burster TEDS**

  - Connecting plug 9-pin, Min-D including memory chip for the transducer electronic data sheet
  - Model 99900-V229

- **Fitting the connector including programming of the electronic data sheet**
  - Model 99011

**Adjustment of a complete measuring chain**

- Adjustment and scaling of up to 3 sensors including test certificate
  - 93ABG

**Order Code**

- DIGIFORCE® 9307 - V

- Standard

  - Analog option
    - Piezo interface
    - X
    - Combined channel analog / INCR (D) and resistance measurement (E)
    - X

- **Fieldbus option**

  - EtherCAT
    - X
    - PROFINET (DP-V0/DP-V1)
    - X
    - PROFINET
    - X
    - EtherNet/IP
    - X

- **Fitting the connector including programming of the electronic data sheet**
  - Model 99011

Technical changes reserved. All data sheets at www.burster.com