PULSE™ Production Test System

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The PULSE Production Test System (PPTS) is a turnkey solution for noise and vibration quality control testing. The system is designed to interface with a production test stand for complete automation while performing the required analysis techniques to detect product noise and vibration faults. The system consists of the PULSE Multi-analyzer and the Production Test Advisor software.

The PULSE Multi-analyzer System (PULSE) is the measurement platform that performs the analysis techniques needed to quantify noise and vibration characteristics. The ability of PULSE to perform multiple analysis techniques simultaneously in real time allows the highest probability of defect detection with no cycle-time impact.

The Production Test Advisor (PTA) software evaluates the noise and vibration data to provide a pass/fail for the unit tested. This software provides a range of evaluation techniques, interfaces with the production line controller, stores the data in a database and much more.

Uses and Benefits

Uses
- Quality control testing for automated production lines
- Automatic sorting of compliant and non-compliant units using noise and vibration analysis
- Nonquality control applications such as durability and test stand monitoring
- Continuous monitoring for trending and automated shut down if limits are exceeded
- Customised noise and vibration measurement solutions

Benefits
- Pass/Fail evaluation with fault identification if the unit under test fails
- Real-time analysis for no cycle-time increase
- Multiple analysis techniques to detect multiple fault types
- Fully automated via PLC or serial interface
- User configurable via Windows$^®$ graphical user interface (no custom code)
- All off-the-shelf components
- Tools to calculate limits based on statistics of measured units
- Scalable in number of channels and analysis capabilities

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Features

- Reduces test time and maximizes probability of detecting faults with real-time, multichannel, and multi-analysis capabilities:
  - FFT, Zoom FFT
  - Envelope analysis
  - Order analysis
  - Rotational synchronous order tracking
  - Multiple tacho input
  - Time-domain analysis
  - 1/n-octave analysis
  - Loudness (Sones)
  - Overall or frequency band level vs. time
- User-friendly graphical user interface (GUI)
- 1 to 1000 channels
- Quick limit setting based on statistics of acquired data
- Advanced statistical tools to evaluate pass/fail criteria and acquired data
- User-definable opto-isolated PLC interface
- User-definable test sequence including multiple pass/fail criteria
- Serial interface via COM port or UDP ports
- Automatic model change over
- Automatic data export to a Microsoft® Access file for custom reports and archiving
- Advanced math functions including:
  - Total Area above or below limits, math functions, peak picking, etc.
  - Complex functions, statistics, signal processing
  - MATLAB® script interface
  - Preference equations
- Manual data export in a variety of formats for use with external applications
- Report generation using Pareto charts
- Post-processing capabilities, product review, data filtering, histogram and trending
- All software runs under Windows® XP and Windows Vista®
- Data analysis, trending and review

Fundamentals of the PULSE Production Test System

Manufacturing and assembly tolerance issues often result in unacceptable noise and vibration levels in manufactured products. The PULSE Production Test System (PPTS) is a multi-platform test system designed for use on a production line to detect, evaluate and sort faulty units. The PPTS consists of the Production Test Advisor (PTA) software and the PULSE Multi-analyzer System (PULSE). PULSE is a measurement platform that performs multiple analysis techniques in real time. Real-time analysis, along with the ability to perform multiple analysis techniques in parallel, eliminates the need for increased cycle time and increases the probability of detecting faults. PTA is the control software that provides complete automation via digital I/O or serial interface, evaluates the noise and vibration data, interfaces with a barcode reader and stores data in a database. The PTA software also provides many statistical tools for setting and evaluating limits in order to optimize the fault detection capabilities.

The PPTS is intended for use on automated production lines as well as off-line audit applications. By analysing and sorting good/bad units in real-time, the PPTS enhances quality and speeds the process. (Managers have reported scrap being reduced from 4% to 1.5% after installing PPTS.) User-selectable evaluation criteria let the system adapt to single or multiple model production requirements. Post-production report features are a powerful tool for yield and productivity analysis. The PPTS is fast becoming the system of choice for manufacturers of automotive components, household appliances and aerospace equipment.

This system is designed to meet the objectives of a Quality Control test system, characterised by the following:

- Different fault types require different analysis techniques. The multi-analysis capabilities allow multiple analysis techniques to be performed simultaneously
- Cycle time is important, thus all analysis techniques are performed in real time
- By screening faulty parts from reaching the customer, a perceived quality improvement is achieved. By determining why the part fails, a true quality improvement can be achieved. We provide the tools to do both
- Overall confidence in the pass/fail decision relies on the size of the gray area. The best of the best are easy to pass and the worst of the worst are easy to fail. The size of the area in between these, the gray area, will provide confidence or doubt. This system provides a wide range of methods for setting limits, including using the statistical information from a normal population along with tools to evaluate the limits against good and bad populations to determine the probability of passing a faulty unit and rejecting a good unit
- Data can be made available for an end user, if required. Data can be exported after each test to a Microsoft® Access database for SPC, custom reporting or any other use
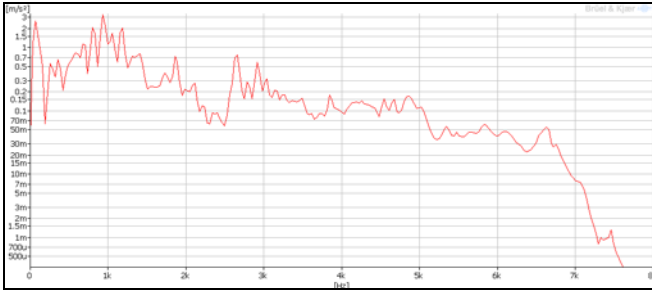
PULSE Software Description

Fig. 1 *FFT*

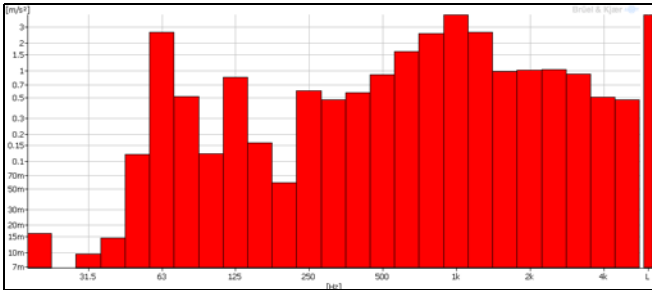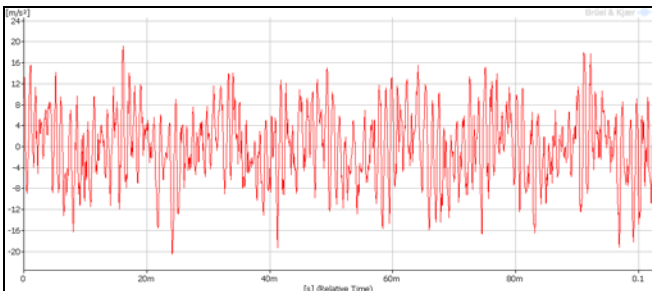**Fig. 2** *1/3-octave Analysis*

Fig. 3 *Time Data*

The proper analysis techniques are essential for detecting and quantifying faults.

PULSE software provides all of the analysis techniques needed to detect sound and vibration related faults. The analysis techniques available include, among many others:

- FFT (up to 6400 line resolution) (Fig. 1)
- Zoom FFT
- 1/1-, 1/3-, 1/12- and 1/24-octave (Fig. 2)
- Overall dBA or Loudness (Sones)
- Level (overall of freq. band) vs time
- Order tracking (order spectra and order slices)
- Time and rotational synchronous averaging
- Cepstrum
- Time domain (Fig. 3)
- Time data recording

For additional information on the PULSE capabilities please refer to the PULSE software and hardware data sheets.

Multiple Model Test Stand

The system can handle multiple models and multiple tests for each model. Adding additional models as needed is easy.
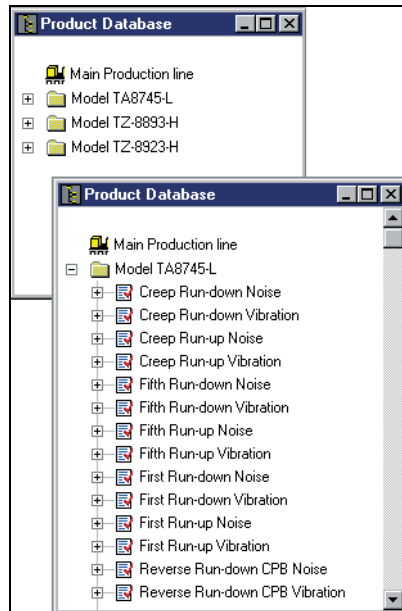
PTA can handle automatic model changes because every model type to be tested can be defined in the PTA database with all of the corresponding test criteria. Following a model change, the PLC line controller issues a command to PTA initiating the reset of the test conditions.

The test list for a given model can be as simple as only one test with a single sensor for a unit running at a constant speed.

For more involved tests, like a manual transmission, the number of tests can be larger. In this case, it is a repeat of a simple test but done under several operating conditions and at several operating speeds. The complete test list for a manual transmission can include all the gear positions for the run-up and coast-down, which can reach 10 to 12 tests. There is no preset limit to the number of tests that can be used.

Adding New Models
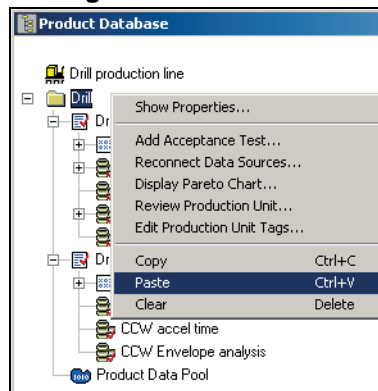
A single test stand is often used for a family of models derived from a common design, where there can be verification on the gear ratio, coupling design, mounting methods, etc.

When a new model is added to the database, it is quick and convenient to simply "Copy/Paste" an existing configuration similar to the new model and rename it in accordance to the new model ID. In this way, all the basic settings and limit parameters are copied. What is left is to acquire new data for this model and refresh the limits calculation.

Individual Limit Set Up

The tools for setting limits are powerful enough to properly set limits yet easy to use.
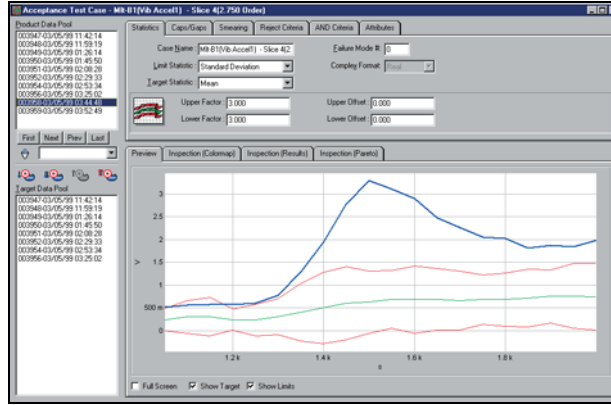
Each pass/fail criterion can be easily set and adjusted using the graphical interface. Various statistical tools are available to set and evaluate the limits properly and effectively. Limits can be set using statistics from acquired data or manually entered to set the limit to a preset value.

If limits are changed after data acquisition, the previously acquired data can be compared to the new limits to verify the new reject-criteria efficiency.

Limits Evaluation

The size of the gray area will make or break a system. Very good units are easy to pass and very bad units are easy to fail. It is the ability to detect faulty units in the gray area between these extremes that will provide confidence in the system. Tools are available to evaluate the probability of detecting faulty units and the probability of passing faulty units.
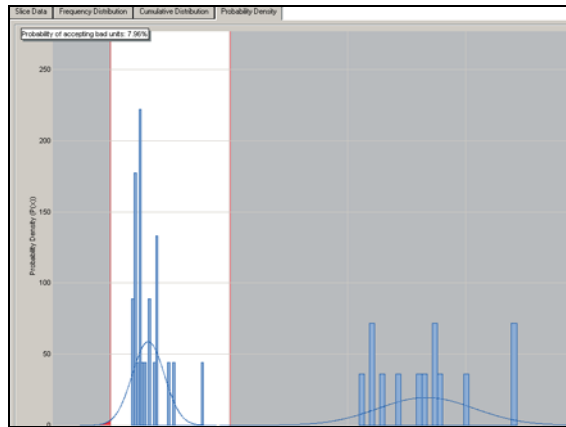
Using software tools, the acceptance limits can be evaluated against acquired data to determine the capability of the system. If the distributions between good and bad units are well separated, then the probability of shipping a bad unit will be reduced.

Configurable PLC Interface and Production Test Sequence

The ability to have custom communication protocols with each test stand is configurable via the graphical user interface. No custom software code is required.
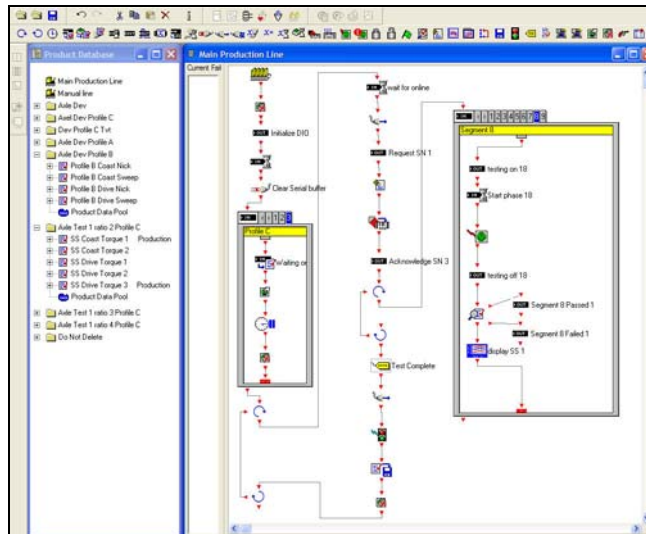
The steps in the test process are defined in the production loop. The production loop is created by the use of various icons joined together to form a loop. The properties of each icon will define its actions either with the PLC, the analysis front end or the pass/fail evaluation process.

There is no limit to the number of test segments that can be incorporated. Graphic tools are used to facilitate the display and presentation of a large number of segments.

Running Production

The displays and information presented on-screen are flexible and configurable to each user's requirements.
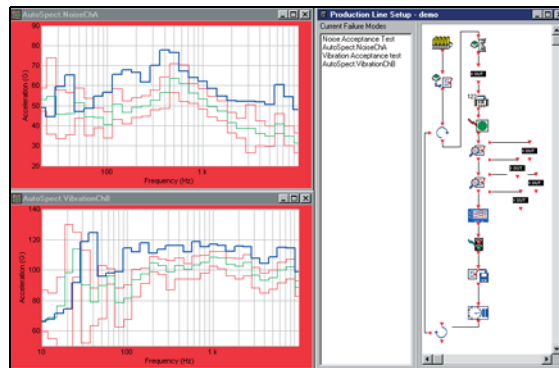
The Production Loop allows complete configuration of the display and the number of traces to be shown.
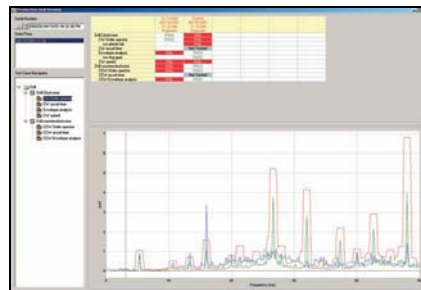
Additional information is also compiled, such as the total number of parts tested, the number of failed parts and the type of failure detected.

All of this information can be used in the production report and exported to a Microsoft® Access file.

Product Review

Reviewing data is quick and easy.

Stored test results can be easily reviewed using the Production Data Review function. The data for specific serial numbers, dates, etc., can be retrieved for easy review. Graphs and numerical data can be copy/pasted to Excel® or Word.

All the test results can be seen for selected test units simply by scrolling through the Test Cases in the left-hand column. Furthermore, if pass/fail limits have been changed since a unit was first tested, any changes in its current pass/fail status will be shown on the Product Review report.

Data can be sorted by using filters that facilitate searching by date, tag, test status, etc.

Filters and Tags

The ability to put data into groups using tags and filters is a very powerful tool for reviewing data.
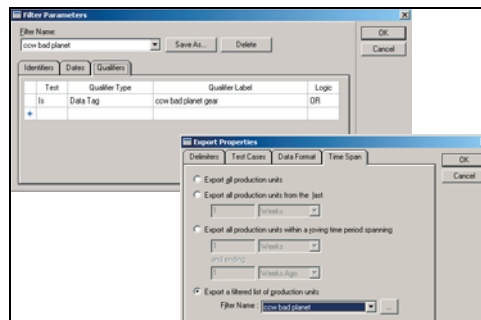
After several weeks of production, a large number of test results can be found in a product database. To facilitate searching, test results can be sorted with the help of user-definable filters that allow searching using criteria such as tags, serial numbers, test dates, test status or other descriptors.

Filtered test results can be viewed using the Production Data Review function or the individual Test Case display.

The filters can also be used in conjunction with the Export functions, the Histogram functions and many other applications.

Advanced Math Option

Additional post-processing features allow users to create custom algorithms and proprietary functions. This gives added capability.

Fig. 12
Input 1 and 2 are filtered, summed, and then multiplied with Input 3, before calculating the area difference between Input 4
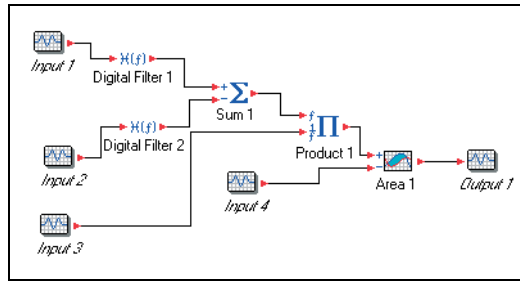
Post-processing math options allow you to perform additional calculations on the test. Post-processing calculations can include, for example, functions such as area of the curve above the target or limits to quantify the severity of the failure.

Fig. 13
Digital filter example
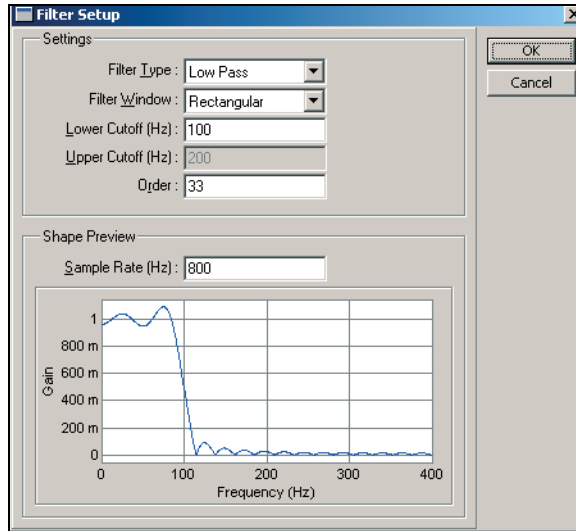
Optional Advanced Post-processing functions are also available. This option includes digital filtering, FFT, Envelope analysis, SQ parameters, etc. Each Advanced Math icon has a property field where analysis parameters can be selected. In the case of the digital filter, the following parameters can be selected, and the resulting filter shape can immediately be seen on the screen:

• Filter Type
• Filter Window
• Low Cutoff
• Order number

Fig. 14
MATLAB script example
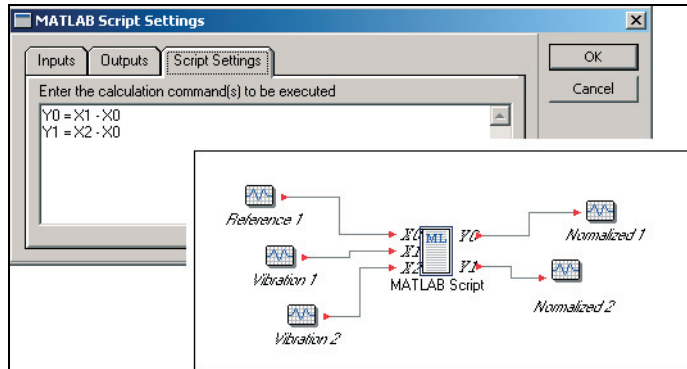
A MATLAB script can also be used as a post-processing step. Once a MATLAB script is part of the post-processing, it provides extended flexibility in the choice of calculations since most MATLAB equations can be part of a PTA pass/fail evaluation. A valid MATLAB license must be present on the PC operating system.

Reports

A quick overview of the reject percentage for each model and the breakdown of each failure type is a powerful tool for evaluating production stability.

Fig. 15
Pareto Chart
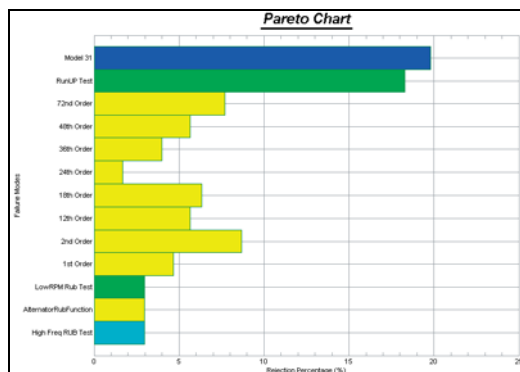
Pareto Charts are one type of production report that can be generated by PTA. The Pareto chart shows the percentage of rejects for a specified model, and a breakdown of the failure modes.

Custom reports are also available when using the Data Export capabilities described below.

Data Export

When systems are utilised to their full capability, the data may be used for custom reports or Source Path Contribution. By exporting the data to a Microsoft® Access® or SQL database, the capabilities are endless and open to the end user.
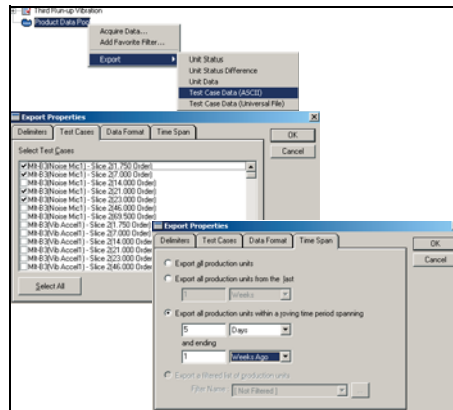
Data export can be performed manually and automatically.

When done manually, a number of options are available to select which results to export and in what format. You can select detailed test results for each function or just the test status (Pass/Fail).

When performed automatically, the test results are exported and saved in a Microsoft® Access file after each test is performed. Queries can be issued to extract data that will form the basis of a given report.

By adding the SigDistro option, the individual databases on each test stand can be either manually or automatically queried and the data backed up and distributed to a server-based SQL or MDB database.

You can simultaneously record the time data for later listening or additional post-processing.
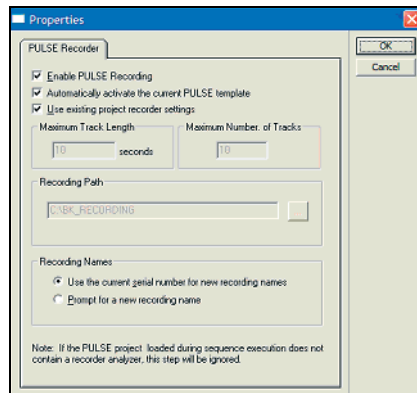
Time data can be easily recorded to the PC hard drive during each test while simultaneously performing the analysis techniques needed to determine pass or fail. These time data can be used for subjective evaluation (listening) or for additional processing.

Start Up Assistance, Training, Consulting and Support

Our success depends upon your success. We have a dedicated staff of Application Engineers to provide assistance throughout the life of your test system.

Brüel & Kjær provides on-site feasibility studies, start-up assistance and training for all types of Sound and Vibration production test applications.

Once systems are in place, system support is provided via phone, WebEx Courses or personnel on site. We realise the importance of quickly resolving production equipment issues; therefore, we have a hotline with engineers taking calls during business hours and an answering service to locate an on-call engineer after business hours.

Brüel & Kjær has been providing the best equipment and service in the Sound and Vibration industry for over 60 years. We have the staff and expertise to provide the assistance needed for continued success and successful start-ups.

Specifications – PULSE Production Test System

SYSTEM COMPUTER CONFIGURATION
Windows Vista® or XP
Pentium 4 or better
1 GB RAM or more
40 GB hard disk, 4 GB minimum free space
SVGA Display with 8 MB graphic card
Uninterrupted power supply is recommended

ANALYSIS TOOLS
FFT analysis
1/n-octave analysis
Order analysis with multiple tacho input
Order analysis with synchronous averaging
Total Zwicker loudness
Overall (SLM analysis)
Time synchronous averaging
Envelope analysis
Time data recording
(plus all PULSE-generated functions)

ADVANCED MATH FUNCTIONS
Advanced math includes:
• Time data filtering
• Area calculation
• Kurtosis
• Statistic
• Block arithmetic
• MATLAB script interface

EVALUATION FUNCTIONS
All PULSE-generated functions
All post-processing functions

TARGET FUNCTION CALCULATION
Mean, RMS, Median, Mid-point
Data source from process data
Multiple target function

PASS/FAIL CRITERIA
Single or multiple criteria per data source
Advanced statistical calculations
Fault diagnostic capability
Boolean logic capabilities

STATISTICAL DATA REVIEW
Histogram
Probability distribution
Cumulative distribution

PRODUCTION LOOP
Completely user-definable
Easily configured using icon properties
Multiple test, either concurrent or sequential
Unlimited number of test and sequence segments
Multiple model capability
Automated change over of model type and pass/fail criteria

PRODUCTION STEPS
Product steps include:
- Input wait step
- PLC output step
- Barcode reader input
- Analyzer start/stop
- Data inspector
- Data display and storage
- P/F count
- Data storage and export
PLC and Serial communication
Com ports and UDP ports
Interrupt functions and safe shut down
Multiple test and branching capabilities
Automatic data export
Automatic data base maintenance

REPORTING
Pareto analysis
Statistical analysis
Plots and report on all data recorded
Selectable export of data to Microsoft® Excel®
Automatic data export to Microsoft® Access® file
Data filtering on multiple parameters such as tags, dates, pass/fail status, and data type

Ordering Information

EG-6409   Signalysis PTA-1-BK, Production Test Advisor Software for End of Line Production Testing

EG-6410   Signalysis PTA-1-BKMS, Technical and Software Maintenance Contract for PTA Advisor PTA-1-BK

PULSE

7700-x^{a}yy^b PULSE FFT & CPB Analysis

7770-x^{a}yy^b PULSE FFT Analysis

7771-x^{a}yy^b PULSE CPB Analysis

For more information and additional analysis tools, please refer to the System Data for PULSE Software (BU0229)

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a. x specifies license type: F (floating) N (node-locked)

b. yy specifies license count: 1–16 (16 indicates unlimited channels)

DIGITAL I/O

EG-6403   National Instruments PCI-6527, 48-bit, Isolated Digital I/O Card

EG-6404   National Instruments CB-100, I/O Connector Kit with 1 m R1005050 Cable

PULSE HARDWARE

For information please refer to LAN-XI Data Aquisition Hardware for PULSE and Test for Ideas Product Data (BP2215)

TRANSDUCERS

For information on available accelerometers see the Accelerometers & Conditioning catalog (BF0212)

For information on available microphones see the Microphones & Conditioning catalog (BF0208)

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