

# Automatic Transmission Testing

## using the WaveBook™

Automotive

Application Note #72

### Application Summary

Automatic transmissions for passenger cars and light trucks must meet tough OEM requirements for quality and durability. The shift quality issue embraces both objective and subjective parameters that include the smoothness of a shifting event in synchronism with the overall feel of vehicle handling. It also deals with maintaining uniform repeatability of shift events from the time the transmission is new to after having accumulated thousands of miles. In comparison, durability testing addresses the predictable life of the hardware, software, and the control electronics. Transmission manufacturers are constantly striving to improve their products through exhaustive component and material tests in laboratories and test facilities.

Borg Warner, Auburn Hills, Mich., for example, recently erected a new facility for developing robust transmission systems and components, transfer cases, all-wheel drive systems, and engine thermal systems for numerous automobile manufacturers around the world. Tom Brand, Lead Product Engineer for transmission systems at the new research center helps develop unique clutch systems and runs stringent tests of the transmissions in vehicles, on a chassis dynamometer, and on electric double-ended dynamometers. He measures temperatures, hydraulic pressures, solenoid states, acceleration, speeds, throttle position,

and torque, and attempts to assign realistic numbers to what are usually considered "subjective ratings." All this activity requires an accurate and reliable data acquisition system capable of monitoring up to 32 channels simultaneously and recording the variables while observing the trends in real time.

### Potential Solution

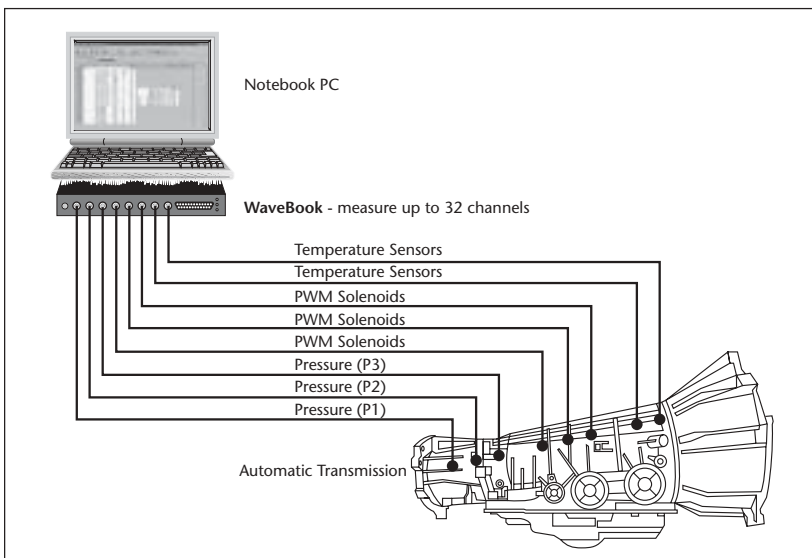
Brand and his associates had been using strip-chart recorders for many years to accumulate the data, but they were constantly hobbled by several problems. For one, the early charts were typically traced on paper in black ink only, making them difficult to read and store. Subsequent units were digital, but like the early ones, they lacked a sufficient number of channels to run full transmission tests. Moreover, they were unable to post-process test results. All the information and data had to be read, interpreted, and scaled from the print out.

### IOtech's Solution

Brand began investigating and evaluating other data acquisition systems while working with a leading automobile manufacturer that required he simultaneously measure up to 32 channels and print out the data quickly. Brand replaced the strip chart recorders with IOtech WaveBook™ data acquisition systems and was able to record the 32 channels. (He has since added three additional WaveBook systems.) Says Brand, "We had a lot of data to collect, and the WaveBooks let us configure and create graphs as we were taking data. We could watch the graphs and immediately verify that they were good. Initially, we went through a bit of a learning curve because we were not familiar with digital data acquisition systems, having only used the manual systems. But after the first set up, we can say the WaveBooks have been easy to use and trouble free."

Brand uses WaveBooks to record numerous variables during both quality and durability testing. Shift-quality testing is an evaluation of how well the vehicle feels over various shift profiles. WaveBooks measure shift-solenoid timing, oil pressure and flow, and temperatures of the hydraulic oil and clutch material. This is accompanied by a subjective evaluation during initial testing and after break-in.

"When we do a full evaluation for durability," says Brand, "we insert pressure transducers in all the clutch supply circuits to monitor how they control the clutches and produce the output torque. Control functions in most automatic transmissions are now electronically controlled, although they are still basically mechanical systems. And we continue to



WaveBooks measure the full range of transmission hydraulic temperatures from  $-40^{\circ}$  to  $150^{\circ}\text{C}$ , and with companion telemetry systems, clutch plate temperatures up to  $500^{\circ}\text{C}$ . Voltages range from one mV to the maximum battery system voltage, about 15V. Pressures are from 300 psi on standard transmissions to 800 psi on a continuously variable transmission. These data help put engineering numbers to the otherwise subjective feel that is essential to satisfying customers.



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work with the delays that are typical in hydraulic systems. We take a snapshot of control-solenoid duty cycles, pulse-width modulated solenoids, and force solenoids with the WaveBook.”

Brand determines a balance between defining clutch materials and systems that provide optimized shift feel versus long-term durability. And that decision also depends on the OEM controller’s architecture and calibration. “Our friction materials are controlled differently among the big three automakers,” says Brand. “The OEM supplies the controls that we typically can’t change. But sometimes, for evaluation purposes, a customer will let us make a small change to see how it impacts the shift quality.”

Shift quality tests usually take a couple of days, depending on the number of maneuvers at a certain temperature to get repeatability. Enough cycles must be run to get a full range to determine if shift repeatability is within the allowed variability. Durability testing, by comparison, can take 3 to 4 weeks on a chassis dynamometer, or three months on a test track, depending on the test requirements.

“I especially like the post-processing capability of the DASyLab® software,” says Brand. “This is essential to providing complete information for my customers. I also like the fact that I can create the graph as I am acquiring the data, and the post-processing time is virtually zero. I just pull the file back up, read it in, identify the maneuver, and print it.” Brand doesn’t have to post process the data in Excel or another spreadsheet format, configure graphs, or scale it to get everything on a common axis. That can be done up front which reduces the post-processing time. Brand further claims that when doing thousands to hundreds of thousands of graphs, it substantially reduces the amount of time spent giving the customer what he wants, which is typically the graph of the event.

## Conclusion

A leading transmission system and component manufacturer, Borg Warner, uses IOtech WaveBooks to acquire test data on a

chassis dynamometer, electronic double-ended dynamometers, and in vehicles to help engineers establish a balance between shift quality and clutch material durability.

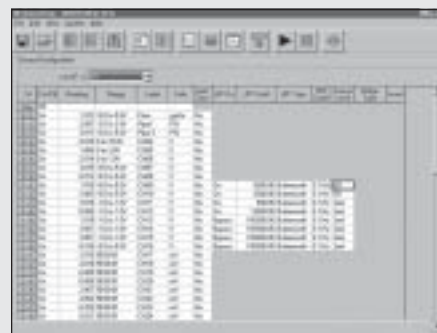
The WaveBooks can record and post process data for a single event or full transmission evaluations that can include up to 32 channels of simultaneous data.

## WaveBook Series

The WaveBook™ series of portable and desktop digitizers offer multi-channel waveform acquisition and analysis for portable or laboratory applications. All WaveBook models include 8 built-in channels expandable up to 72 channels of voltage, accelerometer, microphone, strain gage, thermocouple, position encoder, frequency, high voltage, and other signal types. For applications beyond 72 channels, up to four WaveBooks can be combined within one measurement system, for a total capacity of 288 channels. WaveBooks are available with an Ethernet connection to a PC.

### Features

- PC connection via Ethernet
- 1 µs/channel scanning of any combination of channels
- Expandable up to 288 high-speed channels
- SYNC connection allows multiple units to measure synchronously
- Add up to 224 lower-speed thermocouple channels
- DSP-based design provides real-time digital calibration on all channels
- Single and multichannel analog triggering with programmable level and slope
- Digital TTL-level and pattern triggering
- Pulse trigger and external clock
- Programmable pre- and post-trigger sampling rates
- Sixteen 1-MHz digital inputs
- Operable from AC line, a 10 to 30 VDC source, such as a car battery, or optional compact rechargeable battery module



Using WaveView software’s spreadsheet-style interface, you can easily set up your application and begin taking data within minutes

### Included Software

- WaveView™ for *Out-of-the-Box™* setup, acquisition, and real-time display:
  - Scope mode for real-time waveform display
  - Logger mode for continuous streaming to disk
- eZ-Analyst™ for real-time spectrum analysis
- Export data in third-party formats
- Includes drivers for Visual Basic®, Delphi™, C++ for Windows®, DASyLab®, and LabVIEW®
- ActiveX/COM development tools

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