Tektronix®

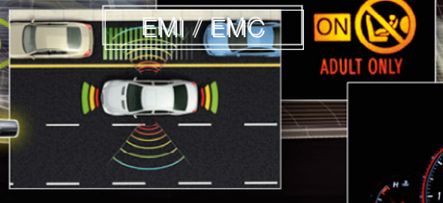
KEITHLEY
A Tektronix Company

automotive

Methods for Testing Automobile Lighting, Safety, and Infotainment Systems

LED LIGHTING

INFOTAINMENT



EMI / EMC

SAFETY

Introduction

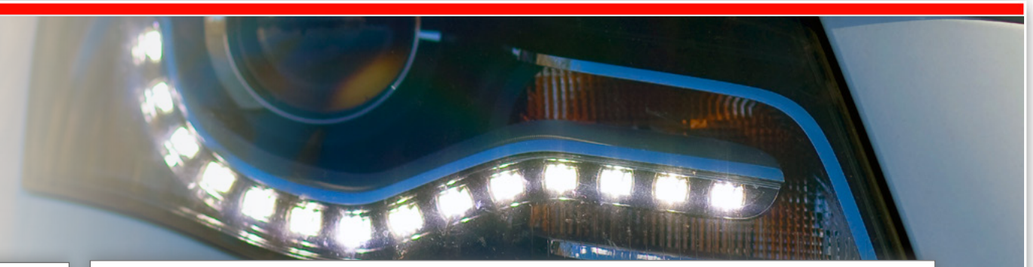
Today's automobiles increasingly feature sophisticated and complex lighting, radar, safety, information, and entertainment systems. And, while these technological advances contribute immensely to overall vehicle safety and intelligence, they introduce new testing challenges that may not previously have been a factor. This applications kit addresses test issues and suggests instrumentation that helps solve automotive test measurement challenges for automobile lighting, safety, and infotainment systems so you can learn how to resolve the challenges that are driving you.

Get advice for your application.

Send us your question or join the discussion in our **application forum**.

Visual Safety

Components: Testing Automotive LEDs



Automotive LEDs (light emitting diodes) are becoming more and more popular as automotive manufacturers use an increasing number of LEDs in interior lighting such as overhead lighting, truck lighting, mood lighting, and dashboard lighting. In addition, LEDS are being used more for automobile flood lighting, headlights, taillights, indicator lights, and other exterior lighting.

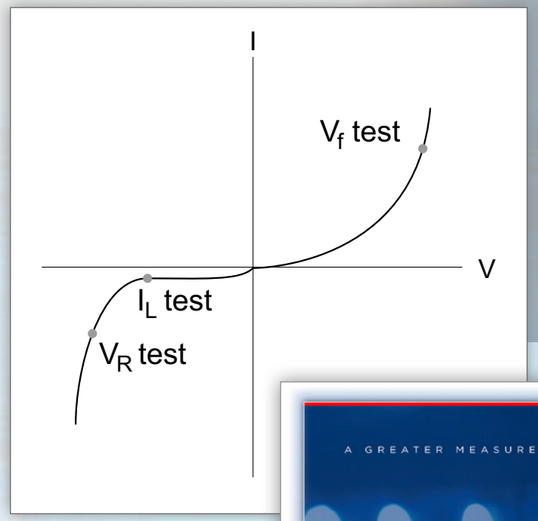
LEDs need to be verified through the following tests:

- Forward voltage
- Reverse leakage current
- Reverse breakdown
- Light output

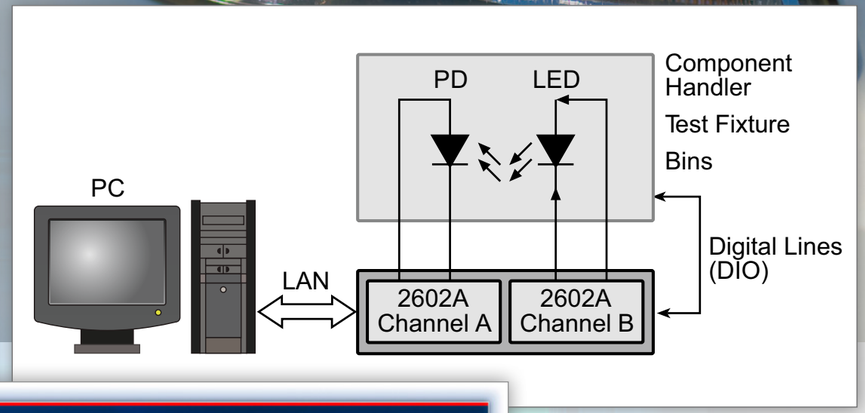
Featuring bipolar sourcing and wide current measurement range, Keithley SourceMeter® Source Measure Unit (SMU) Instruments enable complete and comprehensive LED testing with a single instrument.

Keithley SourceMeter SMU instruments offer:

- Four-quadrant operation with smooth transitions through 0V
- High current sensitivity with 0.1fA sensitivity for measuring leakage currents
- Voltage measurement with 1µV resolution and voltage sourcing with 5µV resolution
- Internal scripting language for fast automated testing
- Precision timing and channel synchronization of multiple SMU instruments with less than 500ns latency



Typical LED DC I-V curve and test points.

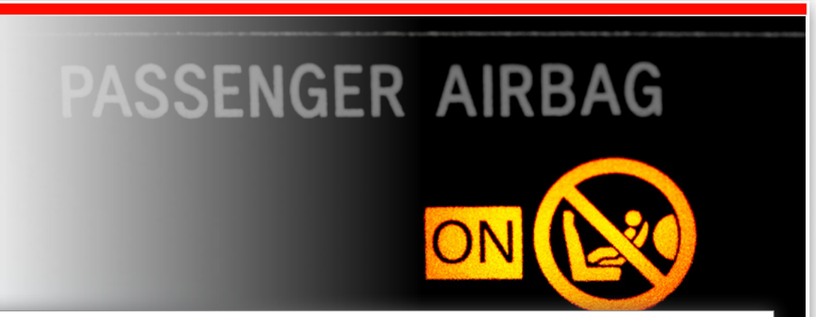


Block diagram of a Keithley Model 2602B SourceMeter-based single LED test system.

Learn how to overcome the Electrical Measurement Challenges of High Brightness LEDs. Download the e-guide.

Get advice for your application.

Send us your question or join the discussion in our **application forum**.



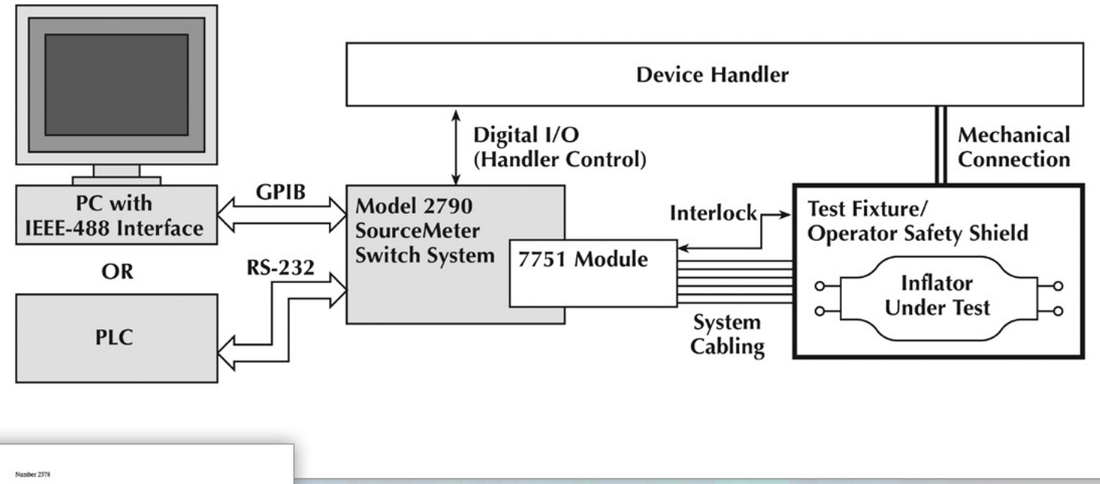
Safety Systems

Airbag Inflators and Seatbelt Pre-tensioner Actuators

Two key challenges for testing sensitive components such as airbag inflators is to do so without stressing or damaging the devices. The pyrotechnic device that actually triggers the gas discharge that inflates the airbag is called an initiator. The resistance of the initiator is a valid indication of a good device. To safely test the initiator, the test current must be kept below some specified level to prevent activating the inflator prematurely, which would not only destroy the device under test (DUT,) but also presents a potential hazard. An initiator must be electrically isolated from the inflator housing because excessive leakage current between the housing and the initiator can prevent proper operation of the device. Consequently, an airbag module requires two resistance measurements. One test (for the initiator) measures a relatively low resistance using a limited test current; the other test (for isolation) measures a relatively high resistance using a moderately high voltage. In addition to the challenge of testing sensitive components such as airbag inflators without stressing or damaging the devices, it's also challenging to find all of the testing performance required to do so in just one instrument.

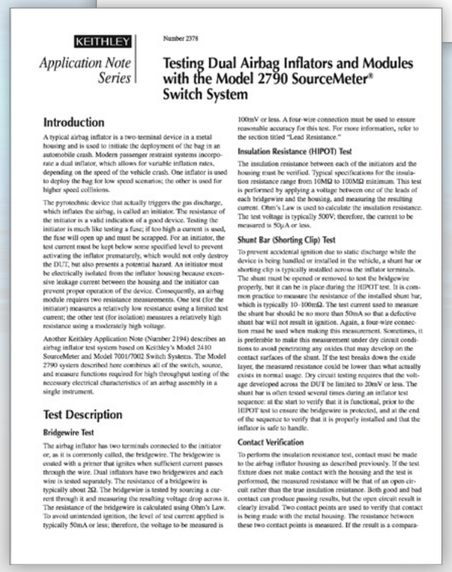
Keithley's Series 2790 SourceMeter® Airbag Test System tests single-stage or dual-stage inflators in a complete, one-instrument solution for automated testing of individual or multiple airbag inflators:

- Test inflators with source current as low as 1mA
- Test up to four devices in one setup
- Test both low resistance for continuity and high resistance for leakage resistance measurements
- Choose from five different configurations to cover a wide range of test applications
- Perform a complete test in under two seconds



Typical Dual Inflator Test System.

Learn more about testing airbag inflators. Download the application note Testing Dual Airbag Inflators and Modules with the Model 2790 SourceMeter® Switch System.



KEITHLEY
Application Note Series

Number 2378

Testing Dual Airbag Inflators and Modules with the Model 2790 SourceMeter® Switch System

Introduction

A typical airbag inflator is a two-terminal device in a metal housing and is used to initiate the deployment of the bag in an automobile crash. Modern passenger restraint systems incorporate a dual inflator, which allows for variable inflation rates, depending on the speed of the vehicle crash. One inflator is used to deploy the bag for low speed scenarios; the other is used for higher speed collisions.

The pyrotechnic device that actually triggers the gas discharge, which inflates the airbag, is called an initiator. The resistance of the initiator is a valid indication of a good device. Testing the initiator is much like testing a fuse; if too-high a current is used, the fuse will open up and must be scrapped. For an initiator, the test current must be kept below some specified level to prevent activating the inflator prematurely, which would not only destroy the DUT, but also presents a potential hazard. An initiator must be electrically isolated from the inflator housing because excessive leakage current between the housing and the initiator can prevent proper operation of the device. Consequently, an airbag module requires two resistance measurements. One test (for the initiator) measures a relatively low resistance using a limited test current; the other test (for isolation) measures a relatively high resistance using a moderately high voltage.

Another Keithley Application Note (Number 2194) describes an airbag inflator test system based on Keithley's Model 2410 SourceMeter and Model 7001/7002 Switch Systems. The Model 2790 system described here combines all of the switch, source, and measure functions required for high throughput testing of the necessary electrical characteristics of an airbag assembly in a single instrument.

Test Description

Bridgewire Test

The airbag inflator has two terminals connected to the initiator or, as it is commonly called, the bridgewire. The bridgewire is coated with a primer that ignites when sufficient current passes through the wire. Dual inflators have two bridgewires and each wire is tested separately. The resistance of a bridgewire is typically about 2Ω. The bridgewire is tested by sourcing a current through it and measuring the resulting voltage drop across it. The resistance of the bridgewire is calculated using Ohm's Law. To avoid unintended ignition, the level of test current applied is typically 50mA or less; therefore, the voltage to be measured is 100mV or less. A four-wire connection must be used to ensure reasonable accuracy for this test. For more information, refer to the section titled "Lead Resistance."

Insulation Resistance (HIPOT) Test

The insulation resistance between each of the initiators and the housing must be verified. Typical specifications for the insulation resistance range from 10MΩ to 100MΩ minimum. This test is performed by applying a voltage between one of the leads of each bridgewire and the housing, and measuring the resulting current. Ohm's Law is used to calculate the insulation resistance. The test voltage is typically 500V; therefore, the current to be measured is 50μA or less.

Shunt Bar (Shorting Clip) Test

To prevent accidental ignition due to static discharge while the device is being handled or installed in the vehicle, a shunt bar or shorting clip is typically installed across the inflator terminals. The shunt must be opened or removed to test the bridgewire properly, but it can be in place during the HIPOT test. It is common practice to measure the resistance of the installed shunt bar, which is typically 10–100mΩ. The test current used to measure the shunt bar should be no more than 50mA so that a defective shunt bar will not result in ignition. Again, a four-wire connection must be used when making this measurement. Sometimes, it is preferable to make this measurement under dry circuit conditions to avoid penetrating any oxides that may develop on the contact surfaces of the shunt. If the test breaks down the oxide layer, the measured resistance could be lower than what actually exists in normal usage. Dry circuit testing requires that the voltage developed across the DUT be limited to 20mV or less. The shunt bar is often tested several times during an inflator test sequence: at the start to verify that it is functional, prior to the HIPOT test to ensure the bridgewire is protected, and at the end of the sequence to verify that it is properly installed and that the inflator is safe to handle.

Contact Verification

To perform the insulation resistance test, contact must be made to the airbag inflator housing as described previously. If the test fixture does not make contact with the housing and the test is performed, the measured resistance will be that of an open circuit rather than the true insulation resistance. Both good and bad contact can produce passing results, but the open circuit result is clearly invalid. Two contact points are used to verify that contact is being made with the metal housing. The resistance between these two contact points is measured. If the result is a compara-

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Safety Systems

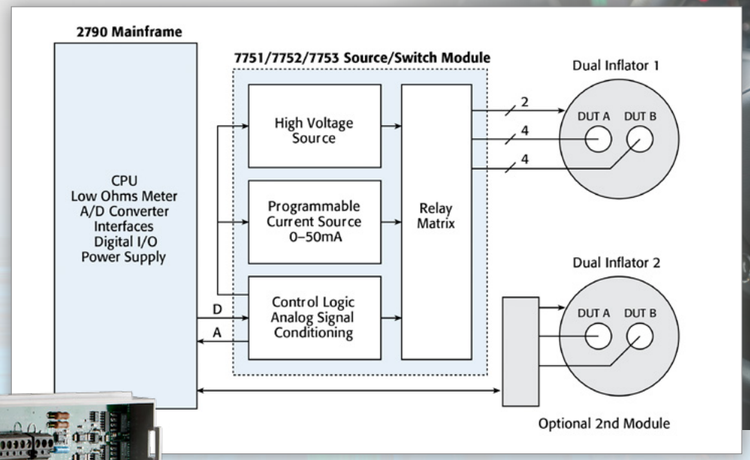
Single-instrument Solution for Simplified Airbag Assembly Electrical Characterization

The Model 2790 SourceMeter® Switch System is a high voltage, multi-channel resistance measurement solution that speeds and simplifies electrical checks of airbag inflators and many other automotive electrical test applications. It's the only commercial instrument that combines all the sourcing, measurement, and signal routing capabilities required to measure insulation resistance and conductor continuity in one compact, affordable instrument. Through the use of plug-in source/switch modules, the Model 2790 provides programmable high voltage and low current sourcing, 6½-digit DMM measurements, plus multi-channel switching support. This unique combination of capabilities establishes a new standard for price and performance in airbag inflator and other test applications.

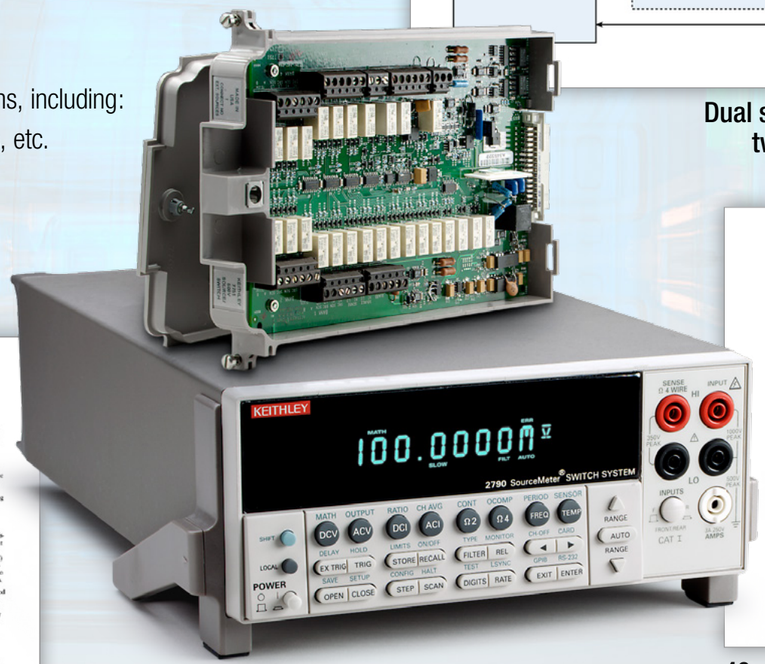
Other Applications

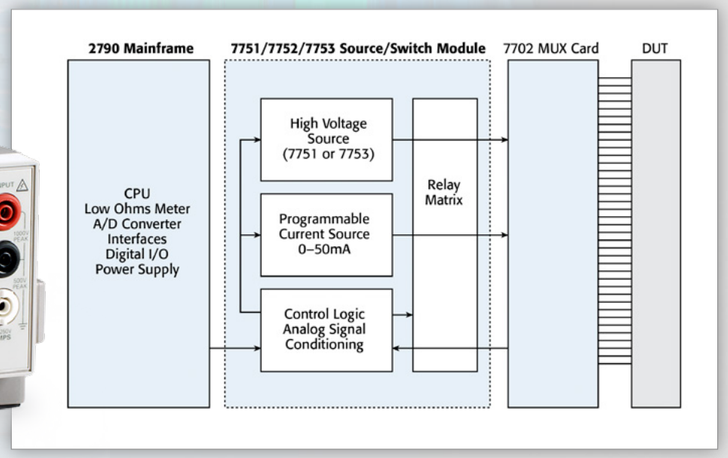
The Model 2790 is the ideal solution for a variety of automotive electrical test applications, including:

- Pinched wire, high voltage, insulation resistance testing in automotive seats, avionics, etc.
- Multipin connector/harness continuity and leakage resistance measurements
- Multicontact/switch dry circuit continuity and leakage tests
- Automotive power/fuse center continuity and leakage resistance characterization
- PCB/PWB and general purpose short/open circuits testing



Dual stage airbag inflator testing–one or two using a Model 2790 Mainframe.





40-channel wiring harness testing using a Model 2790 Mainframe.


2790 SourceMeter® Airbag Test System

Download the Model 2790 data sheet to learn more.

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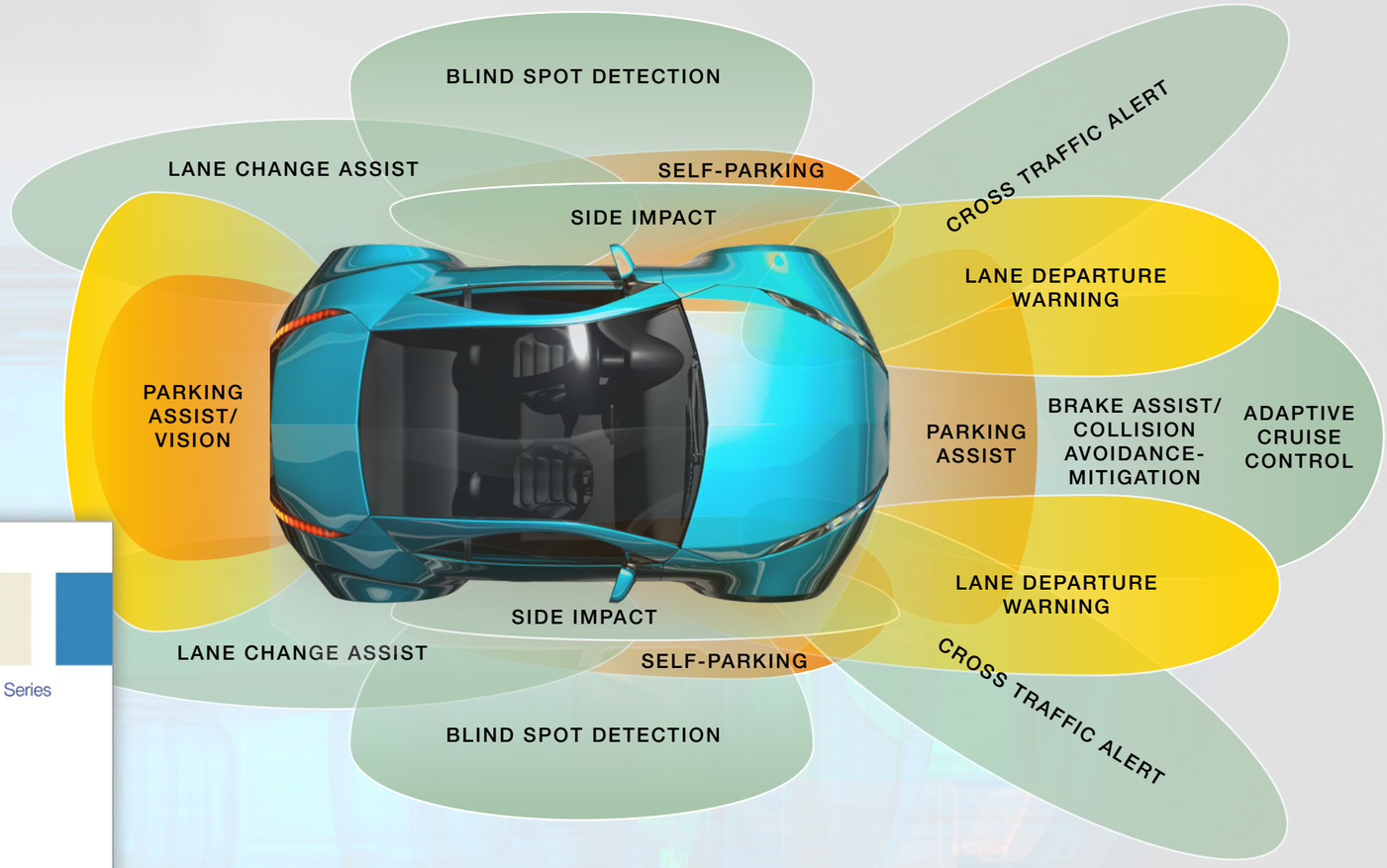
Safety Systems

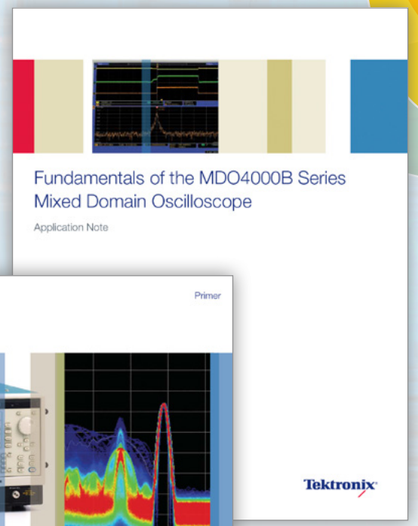
Radar for Passenger Safety

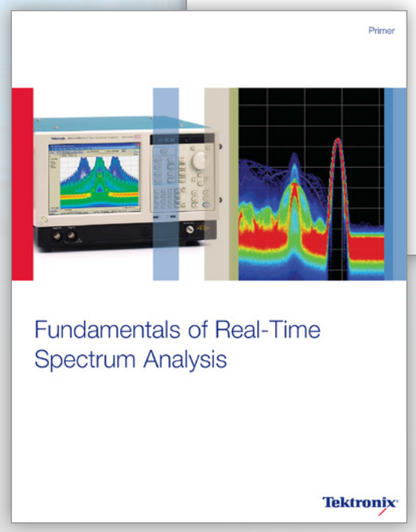
Radar technology is being incorporated into automobiles to address the ultimate goal of enhanced safety. Radar technology will take RF in automotive applications out to 79GHz and incorporate ultra-wideband (UWB) short range systems. Radar will be used for front/rear park assist, forward collision warning, lane change assist, blind spot detection, collision mitigation braking systems, and full speed range adaptive cruise control. These radar systems must have the flexibility and adaptability required for total awareness around the vehicle for complete collision detection and avoidance.

Designers of these systems need tools that can both generate and analyze extremely complex pulse patterns and can offer advanced scanning methodologies to validate the designs. These tools must be able to handle complex radar baseband, IF, and RF signals, as well as identify multi-system interference.

Tektronix offers oscilloscopes and real -time spectrum analyzers that can capture wide bandwidth data at high speed with long record lengths. With the most advanced triggering available on any measurement instrumentation, Tektronix oscilloscopes and analyzers can capture very short transients and extract small signals in the presence of large signals to help you efficiently design robust, reliable, and life-saving automotive radar systems.







Learn more about the fundamentals of the MDO4000B Series Mixed Domain Oscilloscopes.

Learn more about the Fundamentals of Real-Time Spectrum Analyzers.

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Safety Systems

Designing for Ultimate Safety – Collision Avoidance and Adaptive Cruise Control Systems

Collision avoidance and adaptive cruise control systems have the ability to quickly and automatically stop a car to prevent it from accidentally running into the car in front of it. But for drivers to trust and completely rely on this capability, the safety system must be inherently safe and robust and must operate properly 100% of the time. It cannot be susceptible to external interference nor can it generate signals with incorrect data that may cause the system to perform improperly.

Adaptive cruise control and collision avoidance systems operate with radar transmitters and receivers in the 24GHz band and in the 77GHz band. Analyzing transient events and baseband signals at these frequencies requires fast signal acquisition, instruments with wide bandwidth capture, and vector signal analysis.

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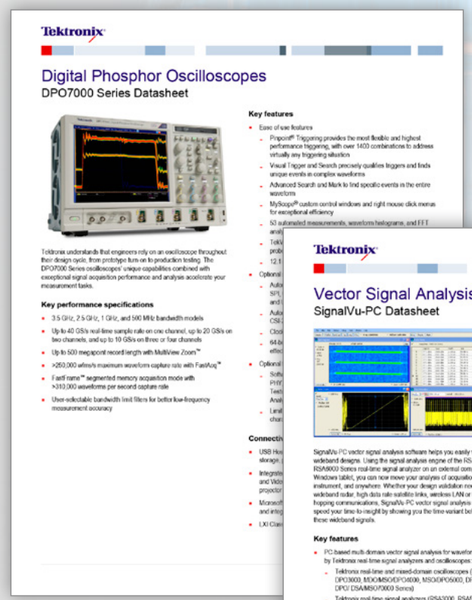
Safety Systems

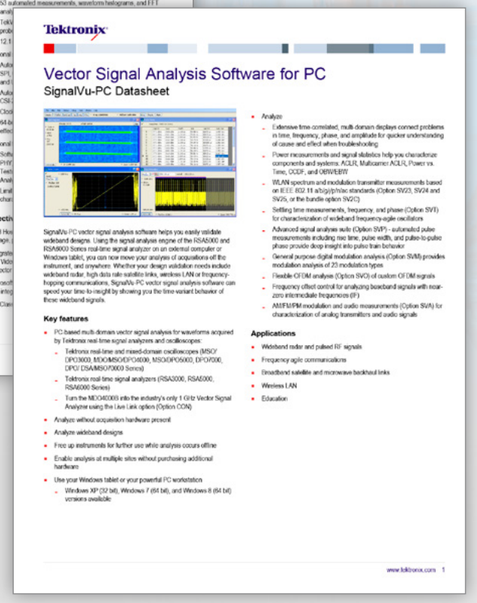
Designing and Debugging Reliable Systems for Collision Avoidance – DPO7000C Digital Phosphor Oscilloscope and Vector Signal Analysis Software

Combined with a high frequency down converter, the Tektronix DPO7000C Series Oscilloscopes and SignalVu™ Analysis Software provide the signal acquisition necessary for detecting anomalies in RF systems and can:

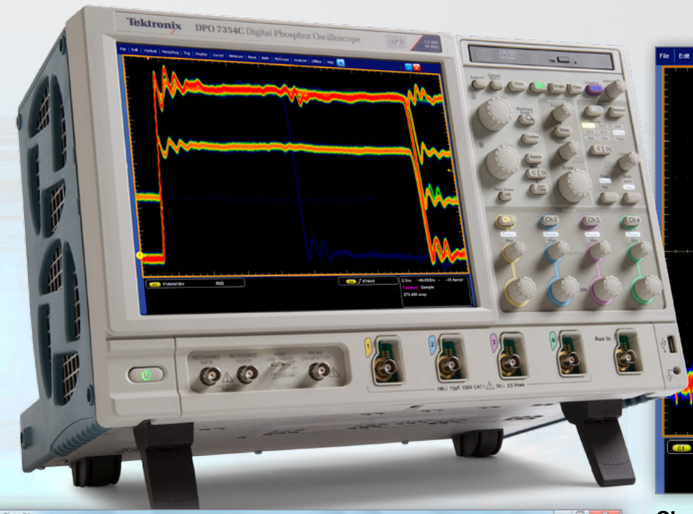
- Capture signals with bandwidths up to 3.5GHz
- Sample waveforms at rates up to 40GSamples/second
- Detect random events by using one of the 1400 sophisticated triggering options
- Store up to 500 million samples
- Obtain time resolution as narrow as 250 femtoseconds

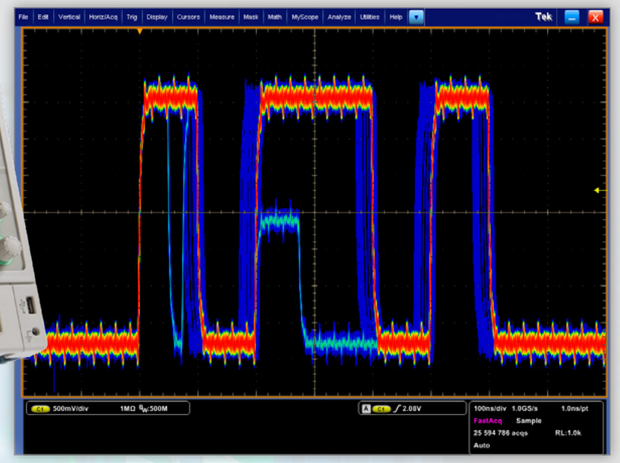

Tektronix
Digital Phosphor Oscilloscopes
DPO7000 Series Datasheet
Key features
Key performance specifications

Learn more about the DPO7000. Read the data sheet.

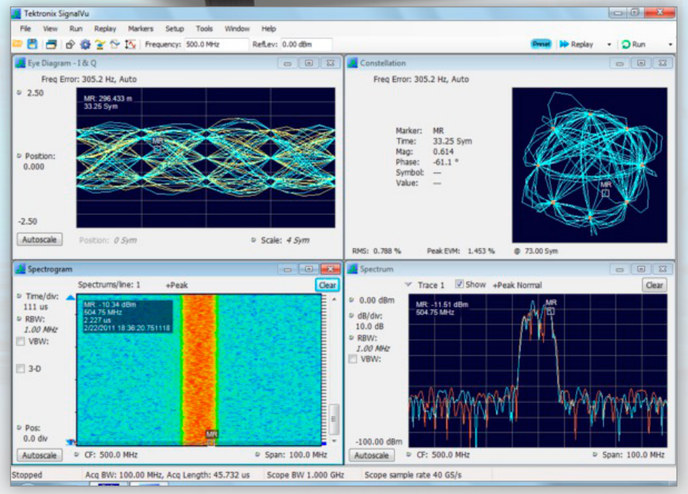

Tektronix
Vector Signal Analysis Software for PC
SignalVu-PC Datasheet
Key features
Applications

Learn more about SignalVu-PC. Read the data sheet.





Characterize pulse trains, including anomalies, with data acquired from the DPO7000C-series oscilloscopes and study pulse shapes, frequency deviation, and phase trajectory with SignalVu analysis software.



SignalVu-PC analysis software enables detailed analysis in multiple domains.

Get advice for your application.

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Safety Systems

Developing Robust Tire Pressure Monitoring Systems

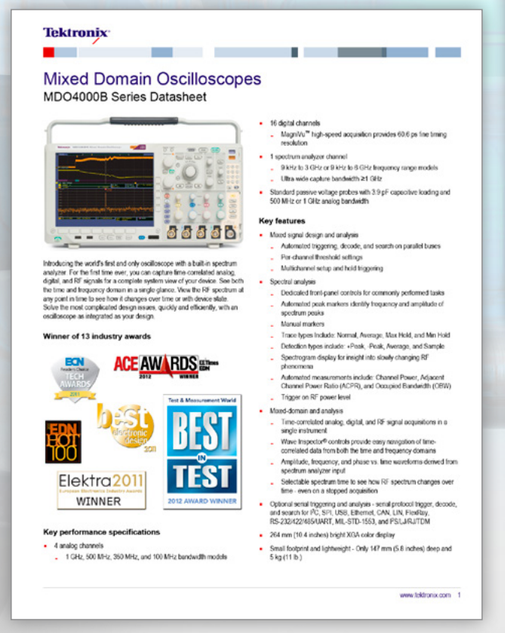
Proper pressure in the tire is critical to automobile safety and efficiency. Under-inflated tires are more susceptible to ply separation and sidewall casing breakdown and cause thousands of accidents and injuries each year. In addition, it's estimated that just a 10% under inflation of a tire will reduce fuel economy by 1%. It's no wonder that a majority of the countries where vehicles are manufactured are requiring tire pressure monitoring systems. So, a reliable tire pressure monitoring system is now an essential component of a new automobile.

Extensive verification and testing of a tire monitoring system is a critical necessity for every manufacturer of these systems. Since the sensors monitor a rotating tire, these systems must be wireless and typically operate in the range of 300MHz to 500MHz.

Robust operation with minimal susceptibility to interference of any kind is of prime concern for safety systems. Design and test engineers must ensure that their designs do not transmit incorrect information due to external interference and must also ensure that their transmission circuitry does not inject random signals that could also create incorrect tire measurements. Instrumentation is needed to evaluate the RF transmission in both the time domain and the frequency domain.

Tektronix MDO4000 Mixed Domain Oscilloscopes provide a one-instrument solution for analyzing and testing RF designs with time-correlated acquisition of time domain, frequency domain data, and digital data. The MDO4000B has these outstanding features:

- Mixed signal oscilloscope with integrated spectrum analyzer
- Four analog channels with bandwidths up to 1GHz
- 16 digital channels with 60.6ps fine timing resolution
- 1 spectrum analyzer channel
  - Frequency range 9Hz to 6GHz
  - Ultra-wide capture bandwidth >1GHz
  - Spurious-free dynamic range 65dBc (typical)


Tektronix

Mixed Domain Oscilloscopes

MDO4000B Series Datasheet

- 16 digital channels
  - MagniVu™ high-speed acquisition provides 60.6 ps fine timing resolution
- 1 spectrum analyzer channel
  - 9 kHz to 3 GHz or 9 kHz to 6 GHz frequency range models
  - Ultra-wide capture bandwidth 2+ GHz
- Standard passive voltage probes with 3.9 pF capacitive loading and 500 MHz or 1 GHz analog bandwidth

Key features

- Mixed signal design and analysis
  - Automated triggering, decode, and search on parallel buses
  - Per-channel threshold settings
  - Multichannel setup and hold triggering
- Spectral analysis
  - Dedicated front-panel controls for commonly performed tasks
  - Automated peak markers identify frequency and amplitude of spectrum peaks
  - Manual markers
  - Trace types include: Normal, Average, Max Hold, and Min Hold
  - Detection types include: +Peak, -Peak, Average, and Sample
  - Spectrogram display for insight into slowly changing RF phenomena
  - Automated measurements include: Channel Power, Adjacent Channel Power Ratio (ACPR), and Occupied Bandwidth (OBW)
  - Trigger on RF power level
- Mixed-domain and analysis
  - Time-correlated analog, digital, and RF signal acquisitions in a single instrument
  - Wave Inspector® controls provide easy navigation of time-correlated data from both the time and frequency domains
  - Amplitude, frequency, and phase vs. time waveforms derived from spectrum analyzer input
  - Selectable spectrum time to see how RF spectrum changes over time - even on a stopped acquisition
- Optional serial triggering and analysis - serial protocol trigger, decode, and search for I²C, SPI, USB, Ethernet, CAN, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, and PSI/JRA/JTDM
- 264 mm (10.4 inches) bright XGA color display
- Small footprint and lightweight - Only 147 mm (5.8 inches) deep and 5 kg (11 lb.)

Key performance specifications

- 4 analog channels
  - 1 GHz, 500 MHz, 350 MHz, and 100 MHz bandwidth models

Elektra2011 WINNER

2012 AWARD WINNER

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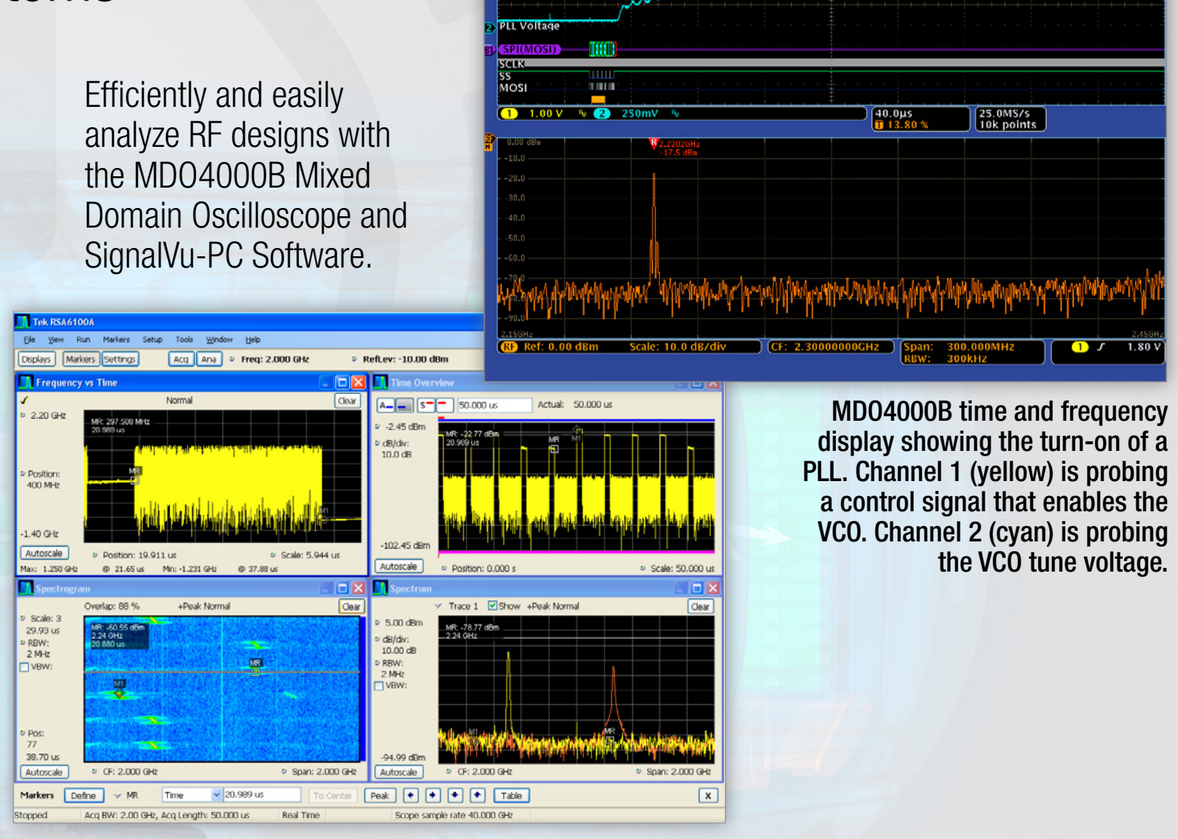
Download the data sheet to learn more.

Efficiently and easily analyze RF designs with the MDO4000B Mixed Domain Oscilloscope and SignalVu-PC Software.



MDO4000B time and frequency display showing the turn-on of a PLL. Channel 1 (yellow) is probing a control signal that enables the VCO. Channel 2 (cyan) is probing the VCO tune voltage.

MDO4000B time-correlated, multi-domain view provides a new level of insight into design or operational problems not possible with conventional analysis solutions. SignalVu-PC Vector Analysis Software (one window of four data views is shown above) provides further insight into the MDO4000B time-correlated, time domain and frequency domain data.

Get advice for your application.

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Safety Systems

Controlling Electromagnetic Interference (EMI) and Complying with Electromagnetic Compatibility (EMC) Standards

Meeting EMC standards and eliminating EMI in automotive systems requires designs that both minimize emissions and can shield circuits from the increasing sources of noise in the automotive environment. The increase in noise sources is resulting from both integrated electronics and electronics devices brought into the automobile. Internal sources of interfering noise can originate from navigation systems, engine control systems, and wireless communication systems. External sources of noise brought into the automobile can include mobile phones, tablet computers, electronic gaming devices, and radar detection devices.

EMI/EMC test challenges include:

- Testing designs to ensure that emission levels will comply with national and international EMC standards
- Identifying the sources of noise that are interfering with system performance
  - RF interference
  - Power transients
  - Electrostatic discharge
  - Changing electric and magnetic fields from drivetrain power electronics and motors
- Capturing random events

An infrequent transient is captured on a Tektronix RSA series real time spectrum analyzer using patented DPX™ spectrum display technology. The red areas are frequently-occurring signals, and the blue and green portions are transients.

View the webinar:
Practical Approach to EMI Diagnostics.

Get advice for your application.

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Safety Systems

Perform Comprehensive EMI/EMC Pre-Compliance and Diagnostics with High-Confidence Results

Tektronix real time spectrum analyzers, mixed domain oscilloscopes, along with SignalVu-PC are unprecedented in their ability to identify the source of EMI/EMC interference and to perform pre-compliance and compliance measurements.

Learn more about the Tektronix family of spectrum analyzers including real-time spectrum analyzers, mixed domain oscilloscopes, and analysis software.

Diagnostics and Debug

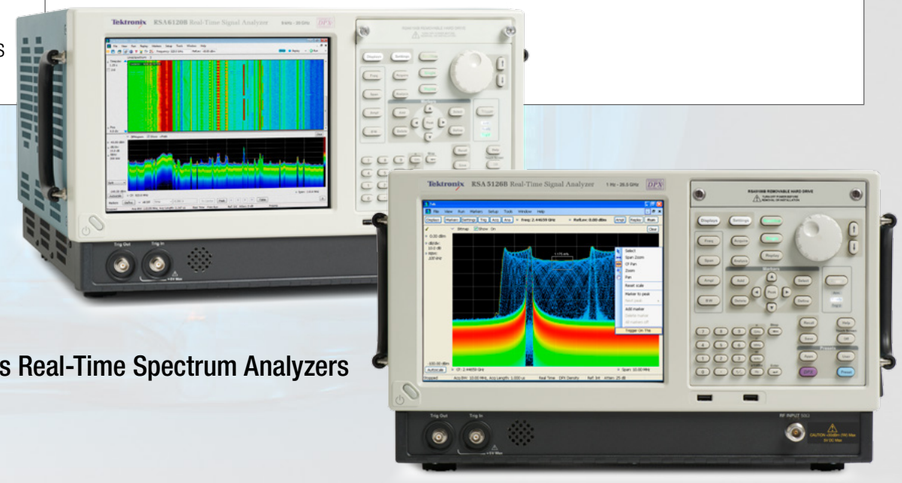
- Low feed thru
- Detecting low-level signals in broad sweeps with narrow resolution bandwidths
- Detecting and characterizing impulse noise
- Finding signals-within-signals
- Determining clock stability and settling to tuning, microphonics, and phase-hits
- Correlating transient emissions to hardware and software states

Pre-Compliance and Compliance

- Testing to standards and compliance levels with required filters and detectors
- Applying corrected measurements and limit lines

Real-Time Spectrum Analyzers

- Discover elusive transient, impulse, and signal-within-signal events with 100% probability with over 292,000/s spectrum updates and swept DPX
- Trigger and isolate spectrum events with 100% probability using patented DPX Density™, Frequency Mask, and Time-qualified Triggering, Frequency Edge, and cross-trigger oscilloscopes or logic analyzers within the event record
- Capture long event records with up to 110 MHz of bandwidth
- Analyze signals with MIL-STD and CISPR compliant filters and detectors
- Quickly assess compliance with corrected data and limit lines displayed
- Speed spur testing with the fastest scanning technology for wide spans and narrow resolution bandwidths



RSA5000/6000 Series Real-Time Spectrum Analyzers

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Safety and Infotainment

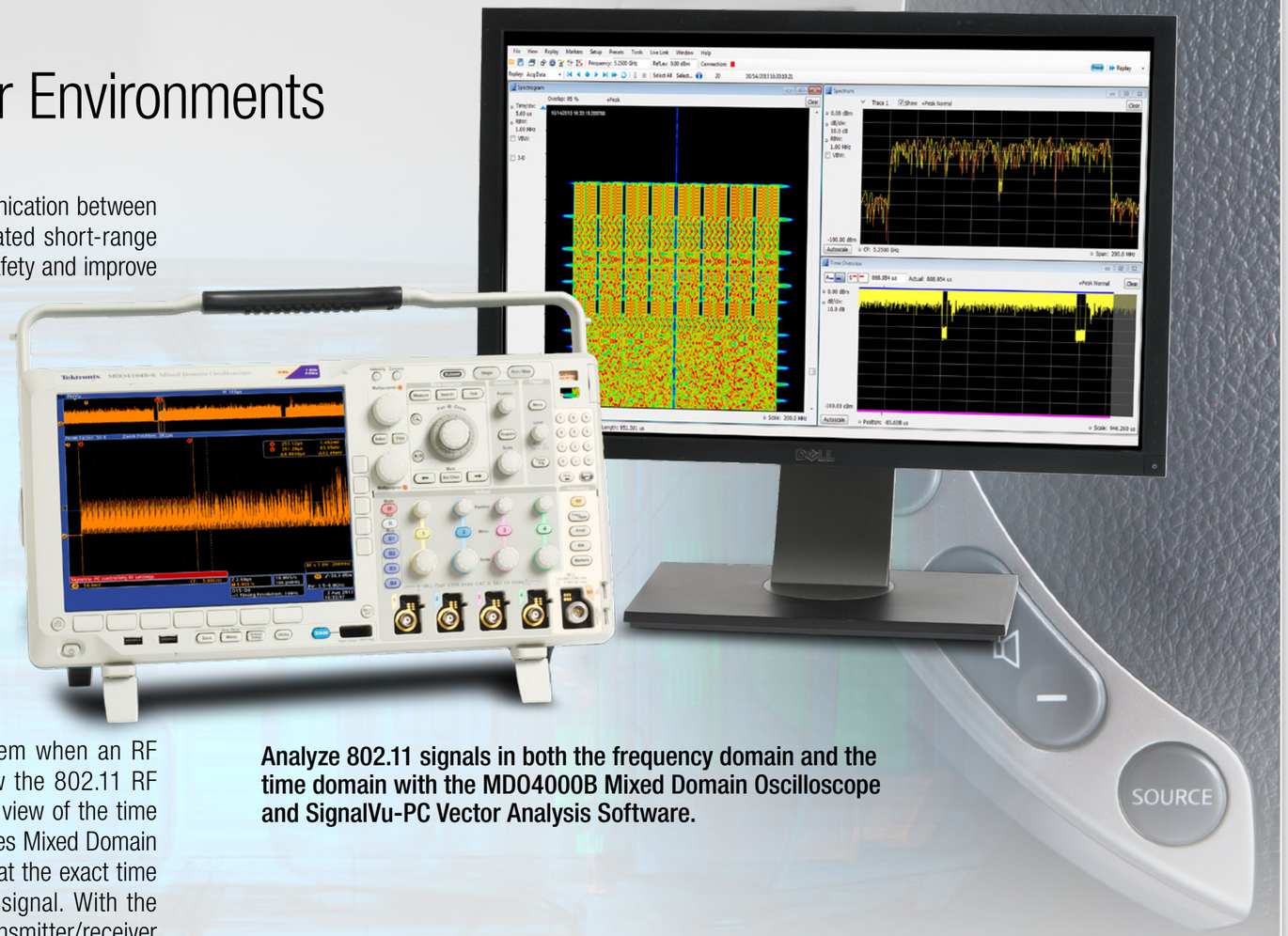
Incorporating Wireless Access in Vehicular Environments

The world's highways will soon support intelligent transportation systems that will permit communication between vehicles, as well as between vehicles and roadside infrastructure. The technology is a dedicated short-range communication link based on the 802.11p WiFi standard. This communication link will enhance safety and improve flow on major highways.

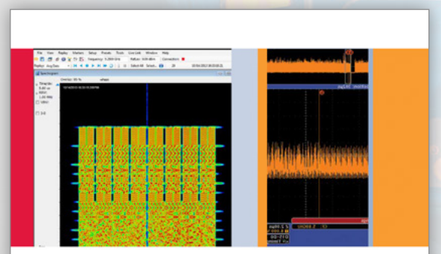
Other 802.11 communication protocols will be utilized in vehicles so passengers can use their WiFi-enabled devices to make their travel more enjoyable.

Design and performance verification of 802.11-based communication systems built into the automobile involves a wide range of RF measurements such as:

- Carrier frequency error
- Symbol timing error
- Average and peak burst power
- I-Q origin offset
- Error vector magnitude
- Constellation analysis
- Symbol extraction



Analyze 802.11 signals in both the frequency domain and the time domain with the MDO4000B Mixed Domain Oscilloscope and SignalVu-PC Vector Analysis Software.



The problem is determining the root cause of a problem when an RF parameter is not within the required specification. View the 802.11 RF transmission simultaneously with both a time-correlated view of the time domain and the control signals using an MDO4000B-series Mixed Domain Oscilloscope. See what is happening in the time domain at the exact time an anomaly occurs in the frequency domain of the RF signal. With the MDO4000B series oscilloscopes, problems in the RF transmitter/receiver chain can be quickly and efficiently identified.

Learn more about 802.11 testing with the primer:
WiFi: Overview of the 802.11 Physical Layer and Transmission Measurements

Get advice for your application.

Send us your question or join the discussion in our **application forum**.

Safety and Infotainment

Designing and Testing High Quality Audio Systems for the Automotive Environment

Drivers expect excellent audio quality from their in-vehicle audio system. Designs need to incorporate high resolution, high speed components to reproduce high fidelity music. In addition, good reception of transmitted music requires circuitry that is stable and injects low noise into the receiver chain. Finally, the system must have low distortion speakers so the quality designed into the circuitry is not compromised by poor-performing speakers.

The challenge is in designing good, low-distortion, low-noise systems with a flat frequency response over the 20Hz – 20kHz audio spectrum. Test tools are needed to:

- Generate a wide range of signals
  - AM, FM
  - Sine wave and noise signals
- Capture DUT signals
  - Acquiring the full characteristics of the signal with high speed sampling and wide analog bandwidths
  - Identifying anomalies that need to be eliminated
- Analyze signal quality with FFT-based analysis tools

Get advice for your application.

Send us your question or join the discussion in our **application forum**.

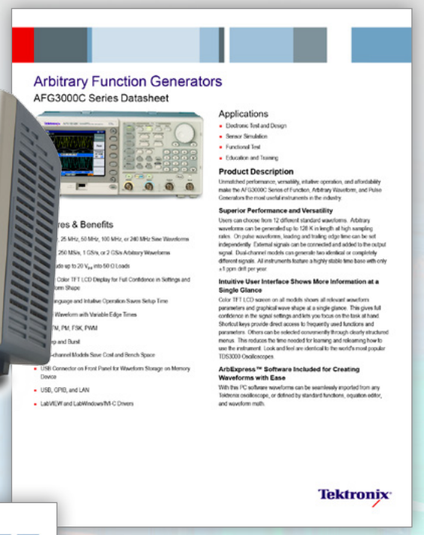
Infotainment

Efficient, Easy-to-Use, and Cost-effective Tools to Ensure Audio Quality

Tektronix offers a variety of cost-effective general purpose test instrumentation to make audio system testing and debugging both efficient and easy.

AFG3000C Series Arbitrary Function Generators - Create Any Type of Stimulus Signal

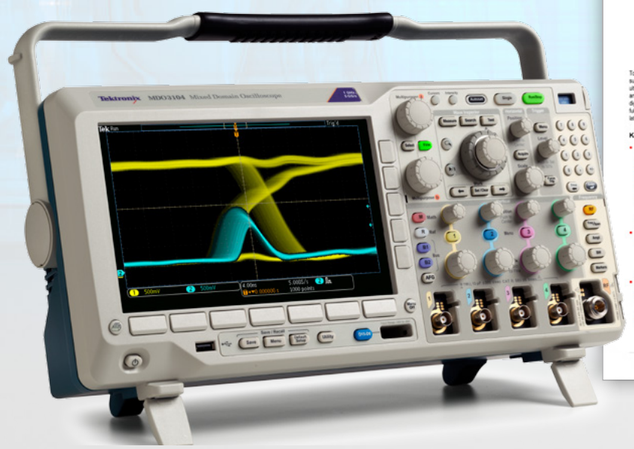
- Two channel versions for stereo system test
- AM, FM, sine wave, and noise signals for audio testing
- Models with bandwidths from 10MHz to 240MHz
- Arbitrary waveforms up to 128ksamples long with sample rates up to 2Gsample/s

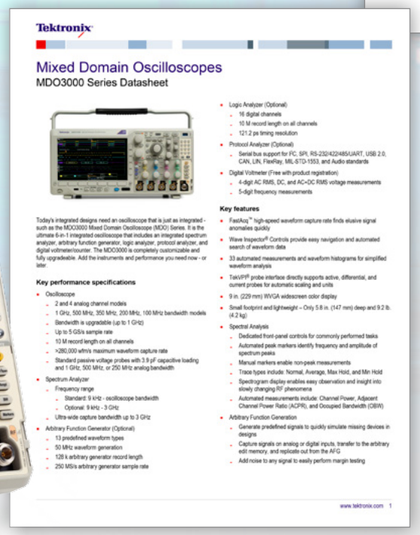


See the AFG3000C Data Sheet to learn more.

MDO3000 Series Oscilloscopes - Capture Any Audio Signal and Detect Spurious Signals or Unstable/Oscillating Waveforms

- Two or four analog channels for stereo signal acquisitions and for determining channel timing relationships
- Spectrum analyzer with up to 1GHz bandwidth
- Optional arbitrary function generator for audio signal generation
- Optional logic analyzer, protocol analyzer, and DMM
- 125 trigger combinations





Learn more about the MDO3000 Series. Read the data sheet.

Get advice for your application.

Send us your question or join the discussion in our **application forum**.

Safety and Infotainment

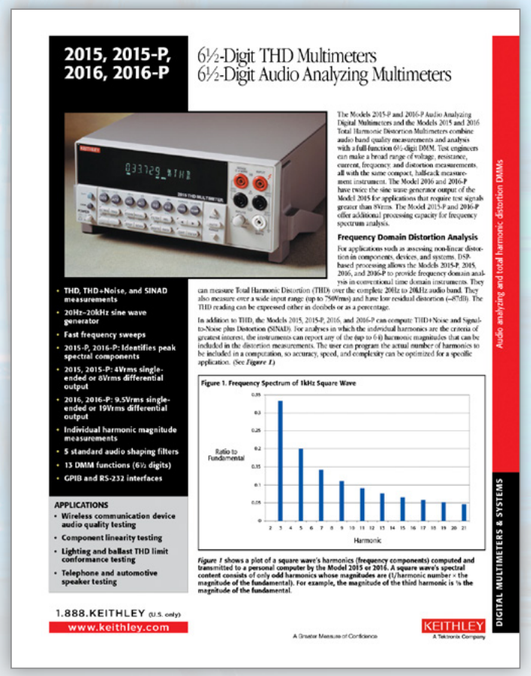
Production Testing for Automobile Speakers

Before speakers are installed in the automobile's interior, these verification tests must be performed:

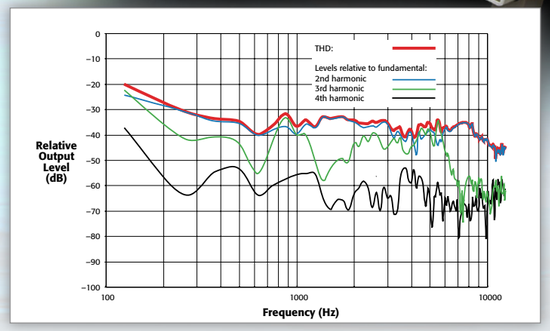
- Distortion
- Frequency response
- Power output
- Rub and buzz analysis

During production, test speed is critical to minimize test costs. For cost-effective and fast production testing of audio speakers, Keithley's Model 2015 and Model 2015-P Audio Analyzing Multimeters combine a digital multimeter (DMM) and an audio analyzer into one compact, half-rack measurement instrument solution. Well-equipped for testing automobile audio speakers, these instruments feature:

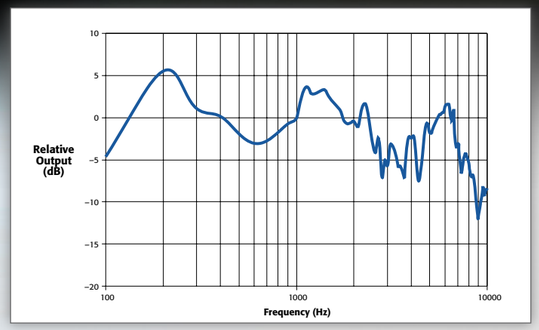
- THD, THD+noise, SINAD measurements
- 20Hz – 20kHz sine wave generator
- Fast frequency sweeps for fast production testing
- Identification of peak spectral components (Model 2015-P)
- A comprehensive set of 13 DMM functions
  - DCV, ACV, DCI, ACI, 2WΩ, 4WΩ, temperature, frequency, period, dB, dBm, and continuity measurements, and diode testing
  - Multi-functional design minimizes added equipment costs when configuring test setups



Download the data sheet to learn more about the Model 2015 and Model 2015-P.



THD and 2nd, 3rd, and 4th Harmonics as a Function of Frequency



Frequency Response

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