



Tektronix[®]

KEITHLEY

A Tektronix Company

Own the future.

We may not know the future,
but we know the people who
will get us there.

Give them every advantage
with Tektronix and Keithley
world-class test and
measurement solutions.

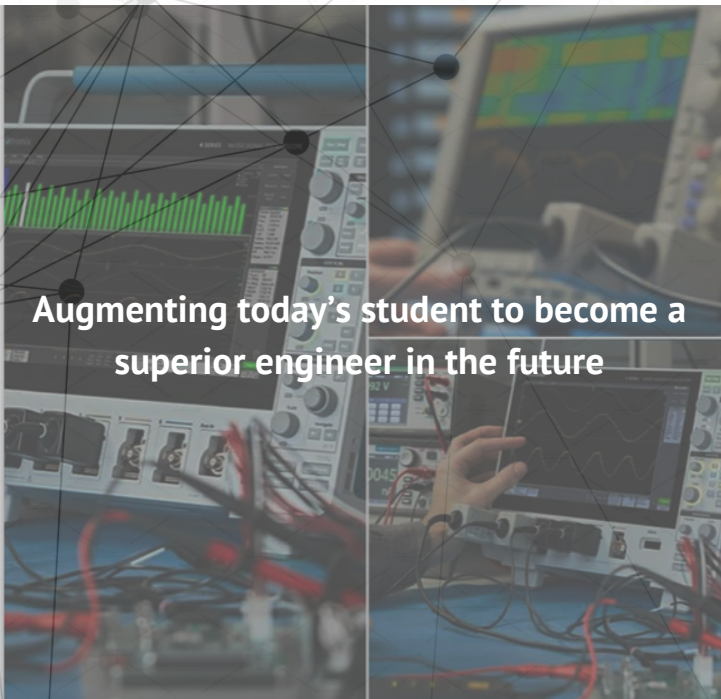
SAN INSTRUMENTS

Measurement Solutions to Accelerate Innovations

**Recommended Bench Configuration from San Instruments to Establish
State of the Art Laboratories**

www.saninstruments.com

Preparing Engineering students to turn ideas into reality

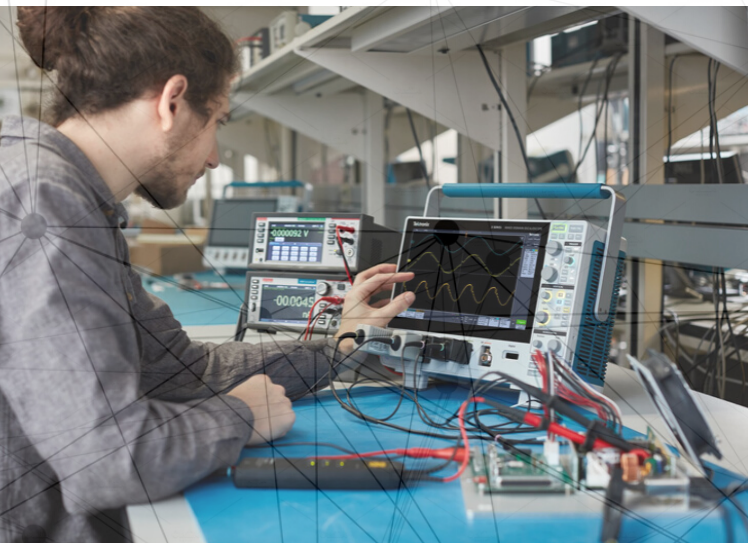


Augmenting today's student to become a superior engineer in the future

Design your labs with the precision of Tektronix and Keithley's Test & Measurement Instruments , Weller soldering equipment, Power Supplies, electric workstations, accessories and software.

To quickly turn your classrooms into an electronics lab, we offer electronics study trainers to transform your classroom into an electronics measurement lab

Recommended Bench Configuration from San Instruments to Establish State of the Art Laboratories



Prepare future engineers for tomorrow's exciting challenges

A comprehensive line of quality bench instruments from high performance oscilloscopes to precision source measure units that help train future engineers

Efficient instrument management solution with classroom content delivery via network-based TekSmartLab™ Software Solution, designed to make teaching and learning easier and more immersive

GET SMARTER WITH SAN INSTRUMENTS

We provides engineering equipment, software, and resources to turn ideas like yours into a successful venture, whether it's for a first year or final year project or extensive research to remediate global climate issues. That's our legacy, and it drives our vision to empower academic researchers, educators, and students with the cutting-edge tools, knowledge, and skills necessary to stand out above the rest — in the lab or in the classroom.



Basic Electronic Test Bench

Prepare future Engineers for tomorrows exciting challenges with an affordable yet powerful suite of entry level test equipments. This bench Configuration includes the hardware, software and service components you will need to give your students the engineering fundamentals they need.



- TBS1000/2000B Series Oscilloscopes
- DMM6500/2100 series Digital Multimeter
- Keithley 2231-30-3 Multiple power Supply
- AFG 1000 series Arbitrary Function Generator
- Weller Soldering/Desoldering station
- Tek Smart Lab For Remote operations of lab

Advanced Electronic Test Bench

With the advantages of Electronic design, and Implementation skills have particular emphasis on analog and Mixed-signal circuits, Serial Bus decoding, Power Management, wireless communications and rapid prototyping. This configuration provides students with the instruments to help them learn real world applications.

- MDO3 series Mixed Domain Oscilloscopes
 - MSO with 16 Digital Channel
 - Spectrum Analyser 1Ghz/3GHZ options
- DMM 6500/2100 series Digital Multimeter
- Keithley 2231-30-3 Multiple power Supply
- AFG 1000 series Arbitrary Function Generator
- Weller Soldering/Desoldering station



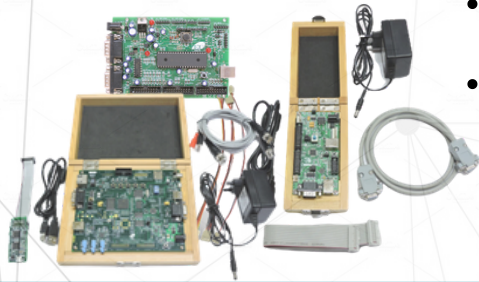
Basic & Advanced Embedded Lab Setup

The Basic Microcontroller Lab program is specially designed keeping in mind the curriculum as well as the basic skills needed for working with microcontrollers. This lab offers variety of 8 bit platforms thus enabling the students to have a complete experience to work with different microcontroller targets.

The target boards included are for 8051, PIC and AVR. This lab also includes different development tools in the form of compilers, IDE, etc. The pluggable interfacing kits offered can be interfaced with different target CPU boards thus mastering the art of programming and interfacing. The documentation provided includes lesson plans, manuals and workbooks with complete procedures of operations and experimentation.

Basic Embedded Lab Setup -

- Educational Practice Board for 8051/ PIC18F4455/ ATmega32
- Raspberry Pi3 & Accessories
- Arduino Boards
- All in One General Purpose Peripherals Board
- IDE Configured for 8051/PIC/AVR Platform



Advanced Embedded Lab Setup -

- Educational Practice Board for ARM Cortex-M4/Cortex M3/ ARM 7 LPC2148
- All in One General Purpose Peripheral Board
- TFT/Touch Screen Interfacing Kit
- Graphic LCD 128x64, GSM Module
- FingerPrint / RFID Module
- Zigbee/Xbee_Module Set (Set includes 2 Qty)
- IDE Configured for ARM7/Cortex Platform



- TBS1000/2000B Series Digital Oscilloscopes.
- MDO3 SERIES with protocol Analysis.
- DMM 6500/2100 series Digital Multimeter.
- Keithley 2231-30-3 Multiple Power Supply.
- AFG 1000 series Arbitrary Function Generator.
- Weller Soldering/Desoldering station.
- Tek Smart Lab For Remote operations of lab.

Basic Embedded Lab Experiments

The experiments include the cases studies on the various features of the micro controllers including on-chip and off-chip peripherals. These cases enable the learner to learn the art of writing the interfacing drivers, initialization routines, reusable functions, etc. The case studies provided with the lab includes the following peripherals:

- GPIO Interface
- Timer/Counter
- Interrupts
- UART study & analysis
- SPI Protocol Study & Decoding
- I2C Protocol Study & Decoding
- Interfacing Switch
- LED interfacing
- Interfacing 7-Segment LED
- Interfacing LCD
- Interfacing Matrix Keyboard
- Interfacing Stepper Motor
- Relay Interfacing

Advanced Embedded Lab Experiments

We offers advance embedded lab for ARM Cortex M4/M3/ ARM 7 LPC2148 Platform to explore peripherals like USB, Ethernet, TFT,SD CARD, Audio, CMOS Camera, sensor interface etc. in addition to the conventional microcontroller peripherals. This lab introduces the use of Micro Python programming language in addition to the C programming language for various experiments.

- GPIO interface (LED, Relay, Switch, LCD(16x2), Matrix Keyboard, 7- Segment, Stepper Motor, DC motor)
- I2C and SPI Interface (EEPROM)
- UART interface using (polling, Interrupt and DMA mode)
- Timer (Capture/Compare)
- Watchdog Timer , Real Time Clock
- Exploring Cortex M4/M3 Features like Deep sleep, sleep wake up mode, Thread Mode, Bit banding
- Wi-Fi interface / USB interface (HID and MSC)
- Accelerometer/ Audio (Record and play)
- Camera Interface , Ethernet
- GSM Modem ,Thermal Printer Interface
- Interfacing of project specific modules viz. Finger print kit, RFID and Zigbee kit, TFT touch Screen
- RTOS LAB - ucosII and Free RTOS based Experimentation

Basic & Advanced DSP Lab Setup

The Basic & Advanced DSP lab offers a complete solution to learn the basic concepts of Signal Processing. The lab offers set of DSP CPU board along with the emulator and accessories which can be used to perform hands-on experiments to justify the concepts involved in the signal processing. The easy integration with the Code Composer Studio tool and the debug features enable the user to easily implement and test the code. With the advantages of Electronic design, and Implementation skills have particular emphasis on analog and Mixed-signal DSP circuits, Serial Bus decoding, Power Management and rapid prototyping. This configuration provides students with the instruments to help them learn real world applications

Basic DSP Lab

- Educational Practice Board for EPB_C5515
- JTAG Emulator XDS100_V2
- Voltage Protection Kit
- Power supply
- Cable Accessory Set
- Workbook



Advanced DSP Lab

- Educational Practice Board for EPB_C6748
- JTAG Emulator XDS100_V2
- Power supply & Cable Accessory Set
- CCD Camera
- All in One General Purpose Board
- Daughter board for All in one General Purpose Board
- GSM / FingerPrint/Rfid Module
- Workbook

Test & Measurement instruments



TBS1000/2000B DSO

Tektronix AFG1022



Keithley 2231-30-3 PS

Basic DSP Lab Experimentations

The lab consists of experiments covering Basic DSP operation and audio processing.

- Write a "Hello World" program and execute on EPB_C5515 target board using CCSv5 or later.
- Write a program to blink single XF LED on EPB_C5515 target board.
- Import a program to blink 4 user LED's on EPB_C5515 target board.
- write a program for Basic file I/O for CCS5.3 using EPB_C5515 target board (i.e reading/writing data from/to a file stored in your system into code composer studio)
- Generate sine wave signals to the CCS Graph window using data file from the PC.
- Generate square wave signals to the CCS Graph window using data file from the PC.
- Write a program for basic signal generation for CCS5.3 using EPB_C5515 target board.
- Write a program for re-generation of sine wave for CCS5.3 using EPB_C5515 target board.
- Write a program to control gain of AIC3204 coded for EPB_C5515 target board.
- FIR Filter implementation using Linear Buffering (C Coding).
- FIR Filter implementation using Linear Buffering (Assembly Coding)
- implement linear buffering using EPB_C5515 target board using assembly language function for "linearbuff()"
- Fixed-Point Implementation
- FFT and Spectrum Analysis On Oscilloscopes
- Overlap Save method for Filtering using FFT,.

Advanced DSP Lab Experimentations

Signal & Audio Processing Experiments

- generate Audio loopback using pooling method.
- generate Audio loopback using interrupt method.
- generate loop back method by EDMA(Enhanced direct memory access) controller.
- generate delay interrupt.
- generate Echo effect(L138_echo_intr).
- generate flanging Effect .
- Input Data Stored in a Buffer.
- generate sine wave using look up table/Using Function
- generate sine wave using DIP Switches for Amplitude and Frequency Control.
- generate Sweep sinusoid using Table with 8000 Points.
- generation of DTMF Tones using a Lookup Table.
- generate Square wave using look up Table
- generate Impulse response of reconstruction Filter.
- generate Frequency Response of DAC
- Reconstruction Filter using a Pseudorandom Binary Sequence.
- generate Step Response of AIC3106 Codec using Pseudorandom Noise.
- Step Response of AIC3106 Codec Anti aliasing Filter..
- generate to Identification of AIC3106 Codec bandwidth using an Adaptive Filter.
- generate Ramp wave.
- generate Amplitude Modulation by polling.

Infinite Impulse Response Filter Experiments

- implementation of an IIR filter Using cascade second order filter.
- implementation of an IIR filter Using cascade second order Transposed.
- Estimating the Frequency Response of an IIR filter using Pseudorandom Noise as Input.
- Estimating the Frequency Response of an IIR filter using Sequence of Impulses as Input.
- Fourth order Elliptic Low pass IIR Filter Designed Using fdatool.
- Band Pass Filter Design using fdatool.
- implementation of an IIR filter Using DSPLIB Function DSPF_sp_biquad().
- Fixed Point Implementation of an IIR Filter.
- implementation of a Fourth Order IIR Filter Using AIC3106 Digital Effects Filter.
- generation of a Sine Wave Using a Difference Equation.
- generation of DTMF Signal using Difference Equations.
- generation of a Swept Sinusoidal Using a Difference Equation.
- Sine wave generation using a Difference Equation with C Calling an ASM Function.

Finite Impulse Response Filter Experiments

- generate Moving average Filter.
- generate Moving Filter with Internally Generated Pseudo random noise.
- generate Identification of the moving Average filter frequency Response Using a Second CPU Board.
- generate FIR filter implementation with a Pseudo random Noise Sequence as Input.
- generate FIR filter with Moving Average, Low Pass, Band Stop, and Band Pass characteristics defined in separate coefficient files.
- generate FIR filter implementation with internally generated a Pseudo random Noise Sequence as Input and output stored in memory.
- generate Effects on Voice or music using three FIR low pass filters.
- generate Implementation of four different filters: Low pass, High Pass, Band Pass and Band Stop..
- generate Voice Scrambling using Filtering and Modulation.
- FIR Filter implemented using DMA based I/O.
- FIR Filter implemented using DSPLIB function.
- FIR Filter implemented using C Calling an ASM Function.
- FIR Filter implemented using C Calling a Faster ASM Function.

Image Processing Experiments

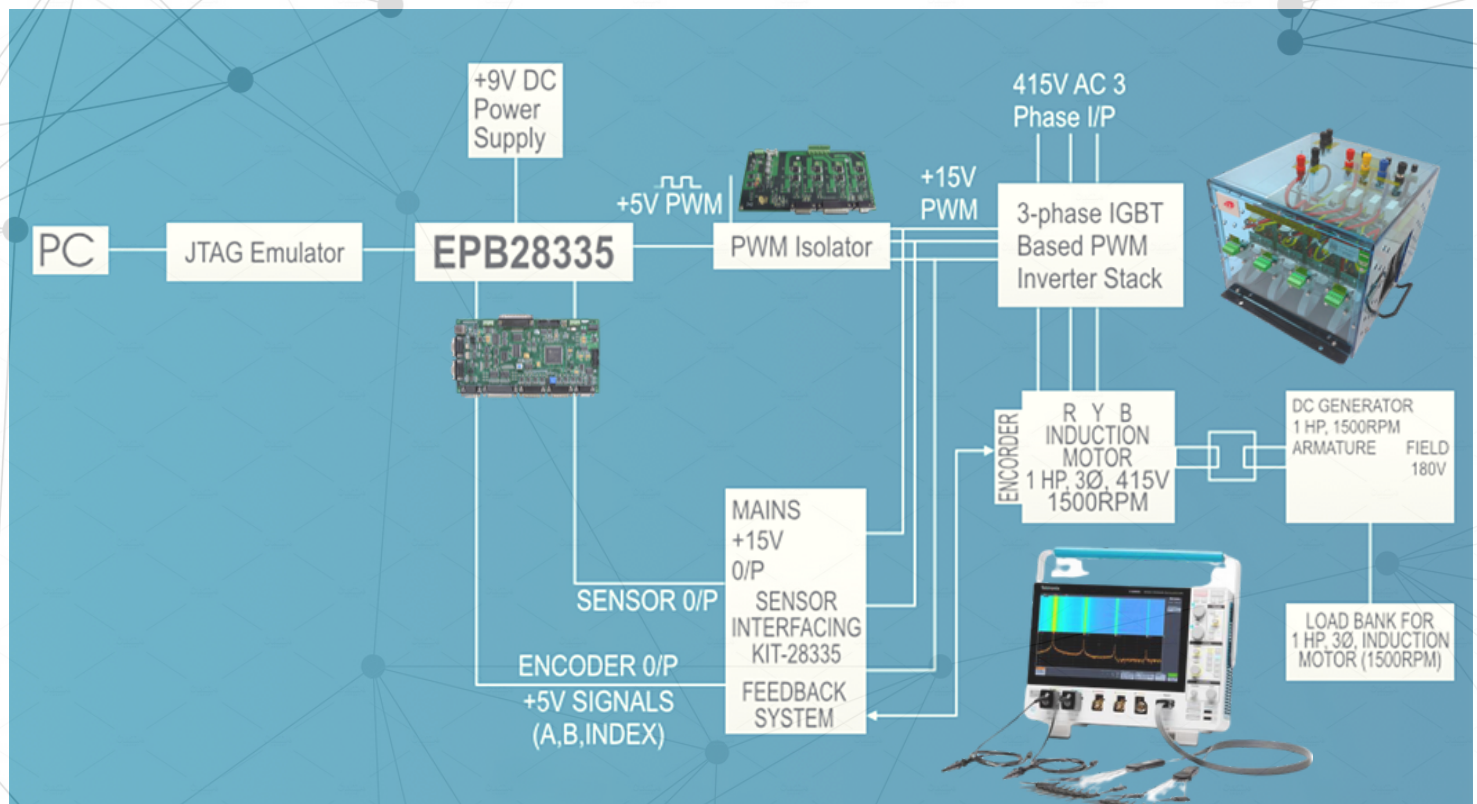
- Edge detection of the image using Sobel algorithm.
- Image Smoothing and Image Sharpening using convolution functions.
- Image Restoration using Median filtering.
- Image Thresholding using Image clipping.
- Image Thresholding using len2min/grt2max different function.
- Image Thresholding using negative function.
- Image Thresholding using black and white image generation.
- Image quantization.

Fast Fourier Transform Experiments

- DFT of Sequence of Real Numbers with Outputs in the CCS Graphical Display Window and in MATLAB And on Scope.
- Estimating Execution Times for DFT and FFT Functions.
- demonstrate the EDMA3 Memory Move.
- DFT of a signal in Real Time using a DFT Function with Pre calculated Twiddle Factors.
- FFT of a Real Time Input Signal using an FFT Function in C.
- FFT of a Real Time Input Signal using TI's C-Callable Optimized DSPLIB FFT Function.
- demonstration of Fast Convolution.
- Write a program for Real Time Fast Convolution.
- demonstration of Graphic Equalizer.

DSP Based Induction & BLDC Motor Training Lab Setup

The DSP Lab for Motor Control and Drives is specially designed for the research activities in addition to the general curriculum study. It contains the standard DSP target board featuring the latest TMS320F28335 32-bit floating DSP controller from Texas Instrument. The lab offers other resources like the inverter stack along with the pluggable isolation board. The lab allows the experimentation using conventional C programming method which helps in optimisation of the results. This lab offers experimentation on motion control, power electronics, electrical and instrumentation engineering.



Lab Details

- Educational Practice Board for TMS320F28335
- USB JTAG Emulator for EPB28335
- PWM Isolator Module
- SMPS Power Supply for PWM Isolator Kit
- 3phase (1 HP) Inverter Stack Module
- 1HP 3 Phase, 415V, 1500 RPM Induction Motor with +5V Encoder with 1024 PPR resolution
- DC generator (1HP 1500 RPM) with Load Panel
- Sensor Interfacing Kit - 28335 (With 3 Current Sensor)
- Sensor Interfacing Kit - 28335 (With 3 Voltage Sensor)

Experiments performed

This lab can be best utilized for research activities based on drives and motor control. Following are some of the experiments that can be performed to get acquainted with the DSP based motor control system.

- Basic experiments to explore GPIO
- Exploring different communication protocols like UART, CAN and I2C based devices like EEPROM, RTC
- Experiments to explore data converters like ADC and DAC
- Writing code to generate PWM signals
- Generating a dead band on EPWM 1A/1B
- Generating HRPWM for PWM-A and PWM-B
- Capturing signal using pooling and interrupt methods
- Exploring timer peripheral writing and reading data on external and internal RAM
- Interface inverter stack module with DSP target board with variable frequency and variable band taking care for error signal as well as thermal trip
- Practical Based on three phase Bridge Inverter
- Harmonic And Power analysis of three phase Inverter, induction Motor, BLDC motor

Basic Power Electronics Bench

As an industrial power designer or Engineers, you must perform a range of power-specific measurements to develop, test, and race products to market & to optimise your productivity by reducing your development and test time with a broad range of power-specific measurements, such as switching loss (including turn-on, turn-off, and conduction losses), harmonic distortion measurements and dv/dt and di/dt measurements. Use a single instrument to make an array of measurements – from measuring high voltages and high currents to debugging control circuits.

Start making reliable power measurements on day one with a collection of tools chosen by Tek experts for power applications including electronic component testing, power converters, inverters, and motor-drives.

TPS2000 series Isolated Scope

- TPS- PWR for power measurements applications
- A622 Current probe 2 no
- P5122 1 KV High Voltage Probe



3 /4 Series MDO Oscilloscope

- TCP0030A (30A; 120 MHz current probe for testing AC input, DC load (IL) and fast switching drain (Id) currents)
- THDP0200 (1500V; 200 MHz differential probe to safely and accurately making floating measurements)
- Power Measurement software PWR (automates line, switching device, and output measurements)



Advanced Power Electronics Sic & Gan Based Testing Bench

Ultra-fast power semiconductor switching technology such as SiC or GaN that make up some of today's power electronics topologies, are extremely difficult to optimise. The SiC MOSFET and GaN FET Switching Power Converter Analysis Kit is the only solution in the market that can accurately characterise all the critical parameters for optimising Power Electronics topologies that use technology like SiC and GaN, including:

- Gate charge and gate-drive performance on high-side low-side
- Dead-time optimisation including accurate turn-on, turn-off and gate-drive timing
- VGS, VDS and ID measurements on high-side and low-side switches
- Switching loss, conduction loss and magnetic loss analysis



- 5 Series MSO Oscilloscope - High resolution (12 bit) for testing Vgs, RDS_ON and conduction losses under real conditions.
- 5-PWR software – Automated, accurate and repeatable power measurements for calculating switching losses, conduction losses, RDS_ON, magnetic losses, SOA and much more under real operating conditions.
- GaN Half-bridge Demo Board – Two independent GaN-based half-bridge circuits.
- TIVH05 IsoVu isolated differential voltage probe – 2.5 KV differential voltage rating for testing VDS signals on high voltage SiC and GaN power converters. Also has 500 MHz bandwidth for extremely fast dv/dt common to SiC and GaN power devices.
- TPP1000 high bandwidth passive probe (Standard Accessory) -

Next Generation 6-GHZ RF Test Bench

With the rapid evolution of wireless technologies and the complexity of RF wireless signals and designs , your students need modern bench equipment that will prepare them to succeed in the real world. This bench would be for beginner to learn RF testing concept and for certain specialized applications of interest like Antenna Measurement, EMI/EMC , Real time RF testing , Wireless standards, etc.



The benches would be a mix of the following:

- RSA306B/600 – 6.2 GHz USB powered Real-Time Spectrum Analyzer
- TTR506A : USB Vector Network Analyzer, 100 KHz to 6 GHz
- TSG 4106A : 6 GHz RF Vector signal Generator
- TTR500-DEMO-KIT : Demo kit for TTR 500 VNA (case, cal kit, filter, 2 cables)
- RSA 3 DKIT : RF Trainer Board with 6 GHz Whip Antenna .

Experiments :

- GSM/EDGE signals – OBW (occupied Bandwidth measurements)
- GSM/EDGE Signals – ACPR (Adjacent Channel Power Measurement)
- Phase Noise measurement of CW signals.
- How to Capture very low powered signals – Understanding RBW /sensitivity measurements.
- CCDF (Peak to Avg Ratio) measurement of Digitally Modulated signals .
- Understanding of Time and Frequency domain behavior of Pulse signals.
- ASK Modulation – Learning how to decode the Bit pattern and understanding its impact in Frequency domain .
- ASK Modulation- Measurement of Bit patterns width, rise time, Fall time etc.
- FSK modulation- Multi Level FSK demodulation and understanding the Impact Frequency Transition
- QPSK/QAM Modulation- Eye diagram, Constellation , EVM measurements.
- Impact of different Modulation schemes on EVM.
- Impact of AWGN Additive white Gaussian Noise on Digital signals .
- Impact of Filters like Gaussian, Raised cosine ,Root Raise cosine on Digital Signals spectrum.
- Impact of Antenna vs RF Cable path between Tx and Rx .
- Understanding the Difference between Harmonics and Spurious signals .
- W-CDMA pilot signal Test .
- AM/FM /PM Signals demodulation.
- AM/FM/PM – Audio Quality Measurements -SINAD, Modulation Distortion, S/N,THD,NTHD etc.
- OTA (Off the Air) Capture using Antenna
 - Bluetooth signal analysis using Mobile Phone .
 - WLAN signal analysis using WI-FI router /Mobile Phone .
 - Remote less Car Key (ASK/FSK) signal analysis .
 - Real time Capturing of short duration signals .
 - Hop rate measurement of Frequency hopping signals .
 - Capture and Playback(Recording) for deeper analysis.

Recommended Bench Product Descriptions

These products were chosen to meet the unique needs of the education lab.

Oscilloscopes

3 Series MDO Oscilloscope > **NEW!**

With a touchscreen interface and built-in spectrum analyzer option, this scope is perfect for the student RF analysis lab.

Compatible passive probes included (one per channel).

TBS2000B Oscilloscope >

Featuring bandwidths up to 200 MHz and 4-channels, familiar, easy to use controls, context sensitive help system and a standard 5-year warranty. Perfect for the beginning engineering lab.

Compatible passive probes included (one per channel).

Probes

TCP0030A Current Probe >

You can use the TCP0030A current probe to make accurate measurements from DC to 120 MHz. The probe combines proven Hall-effect technology with the Tektronix TekVPI® oscilloscope interface.

Digital Multimeters

DMM6500 Digital Multimeter >

Leading touchscreen bench DMM with built-in premium features for the education lab.

Power Supplies

2231A-30-3 Power Supply >

Multi-channel programmable DC power supply ideal for testing a wide range of devices in the education lab.

2280S Power Supply >

Delivers up to 192W of low output noise power and superior load current measurement sensitivity. Built-in plotting functions offers plenty of versatility for your education bench.

Arbitrary Function Generator

AFG1062 Arbitrary Function Generator >

A building block for an education bench solution, this AFG generates all of the waveforms needed for a teaching lab.

AFG31000 Arbitrary Function Generator >

A high-performance AFG with built-in arbitrary waveform generation, real-time waveform monitoring, and the largest touchscreen on the market. Perfect for the modern teaching lab.

Source Measure Units

2450 Source Measure Unit >

Simultaneously sources and measures current. The touchscreen interface minimizes the learning curve and enables students and to learn faster, work smarter, and invent easier.

USB Signal Analyzers

RSA306B USB Signal Analyzer >

This affordable RSA enables students to capture results of experiments, perform analysis, and generate lab reports on their laptops, saving time and optimizing learning opportunities.

USB Vector Network Analyzer

TTR500 USB Vector Network Analyzer >

A full-featured 2-port, 2-path VNA at a breakthrough price. Now students can validate S-parameters of real-world RF designs for comparisons against simulations.

Vector Signal Generators

TSG4100 Vector Signal Generator >

Generates a variety of RF signals starting from true DC up to 6 GHz, with up to 200 MHz modulation bandwidth, the TSG4100 offers mid-range RF performance, ideally suited for the engineering student.

Software and Service

TekSmartLab™ >

Manage your lab with ease using TekSmartLab, a network-based lab instrument management solution for quickly setting up and efficiently managing basic electronics in engineering laboratories at colleges and universities.

SignalVu-PC Software >

Used with Tektronix spectrum analyzers and oscilloscopes to help students and professors validate RF/Wireless designs directly from their own computer.

Kickstart Software >

KickStart simplifies what you need to know about the instrument so that in just minutes you can take the instrument out of the box and get real data on your device.

Total Product Protection >

Protect your investment with a complete service plan providing coverage for all of your test and measurement lab equipment.



To learn more about recommended bench configuration & details of trainers kit visit :
saninstruments.com/education

TekSmartLab™ - Network Connected Remote Lab

TekSmartLab is the industry's first network-based instrument management solution for teaching labs, enabling a more efficient lab experience. With the TekSmartLab, instructors, students, and lab managers all benefit from improved connectivity, workflow, and automation.

Key features

- Easy to setup with industrial reliability
- Intuitive instructor - course - exercise organization
- Centralized monitoring and remote assistance
- Online editing and submission of test reports
- Automatic instrument asset information recording

Key benefits

- Lab managers can efficiently manage lab instruments:
 - Setup configurations of large fleets of instruments with one click
 - Capture instrument asset information automatically
- Instructors can manage teaching workflow more efficiently:
 - Instrument configuration can be saved and distributed to all the instruments when required
 - Monitor and control the lab instruments remotely to assist the students
 - Define report templates and have them load automatically when students are using smart devices
- Students can interact with their lessons seamlessly:
 - Retrieve and save test results wirelessly via smart devices
 - Edit and submit test reports electronically
 - Download materials that are on the lab server (lab procedures, videos, and more)



Easy to setup with industrial reliability

TekSmart Lab can be easily setup via WIFI without laying LAN cables. Without any configuration, instruments are recognized automatically by the system when they are connected to the system.

Centralized configuration

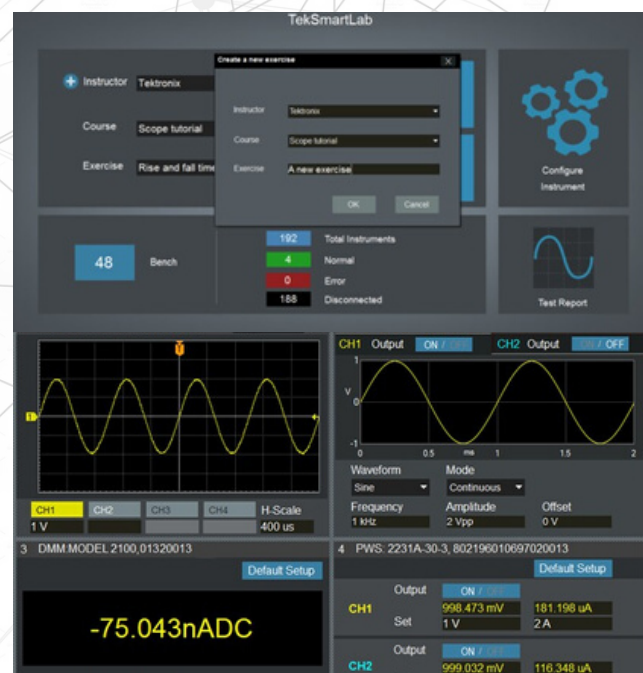
Instructors can setup the configurations of the instruments and distribute them to over 100 instruments with a single click. Instrument configuration changes can be made and delivered anytime;

Course and exercise based applications

TekSmartLab uses an instructor - course - exercise oriented hierarchy, an organization familiar to instructors at most universities: Instructors have different courses, and within each course there are different exercises. New exercises are easily created using the instructor name and course name, and easily selected with the same information.

Centralized monitoring and remote

assistance With TekSmartLab, the physical bench layout and lab layout is easily emulated: The number and type of the instruments on the bench can be setup, and the location of each bench within the lab can be customized.



A high-quality photograph of an astronaut in a white spacesuit floating in space, with the Earth's horizon and blue atmosphere visible in the background. The astronaut's helmet is reflective, showing some light.

Own the future.

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SAN INSTRUMENTS

Measurement Solutions To Accelerate Innovations



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