IC Measurements with the Analog Discovery 3

First Class Handbook

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Contents

1 Introduction: A Lab in Your Hand **2**

2 Chapter 1: What is the Analog Discovery 3? **2**
- 2.1 High-Level Description . . . 2
- 2.2 Key Hardware Capabilities (Summary) . . . 2
- 2.3 Practical Implications . . . 2

3 Chapter 2: WaveForms Software **2**
- 3.1 Overview . . . 2
- 3.2 Starting in Demo Mode . . . 3
- 3.3 Core Instruments — Overview and Key Controls . . . 3
  - 3.3.1 Oscilloscope . . . 3
  - 3.3.2 Waveform Generator . . . 3
  - 3.3.3 Power Supplies . . . 3
  - 3.3.4 Logic Analyzer . . . 3
  - 3.3.5 Spectrum Analyzer / FFT . . . 4

4 Chapter 3: Logic Analyzer and Protocol Decoding **4**
- 4.1 Logic Analyzer: Timing Analysis . . . 4
- 4.2 Protocol Decoding: UART, SPI, I²C . . . 4

5 Chapter 4: WaveForms SDK — Conceptual Overview **5**
- 5.1 Why Scripting Matters . . . 5
- 5.2 Common Use Cases . . . 5

6 Appendix A: Quick Reference Tables and Safety Notes **5**
- 6.1 Demo-Mode Settings Reference . . . 5
- 6.2 Safety Guidelines . . . 5

7 Appendix B: Pre-Class Instructions for Students **5**

8 Closing Remarks **5**

1 Introduction: A Lab in Your Hand

Modern electronics education must balance deep instrumentation knowledge with practicality and accessibility. The Analog Discovery 3 (AD3) is a compact, USB-powered instrument that consolidates many bench instruments into a single, portable device. This first class introduces how to navigate the software, understand the primary instruments, and visualize typical IC measurement workflows — all using WaveForms in demo mode.

The Analog Discovery 3 (AD3) is not a toy, nor a simplified approximation. It redefines accessibility by offering professional measurement capabilities in a form factor ideal for teaching, prototyping, and field work.

2 Chapter 1: What is the Analog Discovery 3?

2.1 High-Level Description

The Analog Discovery 3 (AD3) is a multifunction measurement device developed by Digilent. It integrates multiple instruments — oscilloscope, waveform generator, power supplies, logic analyzer, spectrum analyzer, and more — into a single USB-powered unit. It operates through the WaveForms application, which provides intuitive control, visualization, and data export capabilities.

2.2 Key Hardware Capabilities (Summary)

Instrument	**Representative Capability**
Oscilloscope	2 analog channels, 14-bit ADC, up to 125 MS/s (aggregate limits apply)
Waveform Generator	2 channels, arbitrary waveforms, amplitude up to ±5 V
Power Supplies	Programmable rails (±5 V), on/off control, current monitoring
Logic Analyzer	Up to 16 digital channels, timing capture, pattern generator
Spectrum / Bode Analyzer	FFT-based spectral analysis; Bode plot tool for frequency response
General I/O	Static digital I/O, trigger lines, ground/reference points

Table 1: Representative capabilities of the AD3 (refer to the official datasheet for detailed specifications).

2.3 Practical Implications

- **Portability:** Professional instrumentation in a compact, portable form.
- **Cost-effectiveness:** Enables broader access to hands-on measurement experiences.
- **Versatility:** Supports analog, digital, and frequency-domain measurements — ideal for IC-focused labs.

3 Chapter 2: WaveForms Software

3.1 Overview

WaveForms is the official software interface for the Analog Discovery 3 (AD3). It is cross-platform (Windows, macOS, Linux) and provides virtualized instruments through a unified GUI. For instructional use, WaveForms includes a *Demo Mode* that simulates realistic signals, allowing experimentation without physical hardware.

3.2 Starting in Demo Mode

1. Download and install WaveForms from the official Digilent website.
2. Launch the application and select **Demo Mode** from the devices list.
3. Choose a configuration suited for your lesson (default profiles include typical signals).

3.3 Core Instruments — Overview and Key Controls

3.3.1 Oscilloscope

Purpose: Visualize voltage as a function of time.

Key Controls:

- Vertical scale (volts/div), coupling (AC/DC)
- Horizontal timebase (s/div)
- Trigger level and type (edge, rising/falling)
- Auto measurements: frequency, Vpp, RMS
- Cursors for amplitude/period analysis

Demonstration: Measuring Op-Amp Gain

$$G = \frac{V_{\text{out,pp}}}{V_{\text{in,pp}}}$$

- WaveGen: 1 kHz sine, 100 mVpp
- Scope CH1: Op-amp input, CH2: Op-amp output
- Supplies: ±5 V

3.3.2 Waveform Generator

Purpose: Generate test signals for IC excitation.

Key Controls:

- Waveform type, frequency, amplitude, offset
- Duty cycle (for square/triangle)
- Enable/disable output

3.3.3 Power Supplies

Purpose: Provide programmable DC voltages.

Key Controls:

- Voltage setting, enable/disable
- Current monitoring
- Ground referencing

3.3.4 Logic Analyzer

Purpose: Capture and decode digital signals.

Key Controls:

- Channel selection (D0–D15)
- Sample rate and acquisition mode
- Trigger settings
- Display format: binary, hex, decoded

3.3.5 Spectrum Analyzer / FFT

Purpose: View signals in frequency domain.

Key Controls:

- FFT window, span, resolution
- Peak markers

Demonstration: Show square wave harmonics using FFT mode.

4 Chapter 3: Logic Analyzer and Protocol Decoding

4.1 Logic Analyzer: Timing Analysis

The Logic Analyzer allows you to capture, visualize, and analyze digital signals over time — ideal for buses, clocks, and state transitions. It is particularly useful for debugging digital ICs, microcontrollers, and timing-sensitive logic.

Key Concepts

- Time-correlated capture of multiple digital lines.
- Trigger-based acquisition — detect rising/falling edges, patterns.
- Manual or auto decoding for common buses.

Demonstration: 555 Timer Waveform

- Connect 555 output to D0.
- Sample rate 10× expected frequency (e.g., 1 MHz).
- Measure period, duty cycle from digital trace.
- Compare with theoretical timing:

$$T = \ln(2) \cdot C(R_A + 2R_B), \quad f = \frac{1}{T}$$

Tip: Use cursors to measure pulse width and interval accurately.

4.2 Protocol Decoding: UART, SPI, I²C

WaveForms includes protocol analysis tools to decode digital communication protocols in real time.

Supported Protocols (Common)

- **UART (Serial):** TX/RX, baud rate selection, decoded ASCII/hex
- **SPI:** MOSI, MISO, CLK, CS; clock polarity and phase settings
- **I²C:** SDA, SCL lines; start/stop detection, address/data display

Usage Steps

1. Launch Logic Analyzer.
2. Select relevant digital lines (e.g., D0–D3).
3. Enable protocol decoder (via “Add Decoder”).
4. Set communication parameters: baud rate, mode, addressing, etc.
5. Observe live decoded data alongside signal traces.

Educational Value

- Reveals hidden layers of digital communication.
- Helps students understand clocked vs. asynchronous protocols.
- Useful in debugging embedded systems and sensor interfaces.

5 Chapter 4: WaveForms SDK — Conceptual Overview

5.1 Why Scripting Matters

Automation enables repeatable, controlled, and large-scale measurements. The SDK is ideal for research and advanced testing.

5.2 Common Use Cases

- Frequency sweeps for Bode plots
- Scheduled time-domain logging
- Regression testing of hardware

6 Appendix A: Quick Reference Tables and Safety Notes

6.1 Demo-Mode Settings Reference

Task	Suggested Settings
Observe sine wave	1 kHz, 100 mVpp; Scope: 2 V/div, 200 µs/div
Square wave FFT	1 kHz; FFT span: 0–10 kHz
Logic timing capture	Sample rate 10× signal frequency
Op-amp gain measurement	CH1: input, CH2: output; Vpp compare
555 timer waveform	Square wave 100–1 kHz; measure duty cycle

Table 2: Recommended demo settings for common tasks.

6.2 Safety Guidelines

- Always verify supply voltages before connecting ICs.
- Confirm ground/common connections.
- Use current limits when working with real hardware.
- Demo mode is safe — but real circuits require caution.

7 Appendix B: Pre-Class Instructions for Students

1. Install WaveForms before class from the official Digilent website.
2. Launch in Demo Mode and explore the Oscilloscope and WaveGen tabs.
3. Review a one-page oscilloscope primer covering timebase, triggering, and scaling.

8 Closing Remarks

This handbook focuses on clarity and effective visual demonstration. It positions the Analog Discovery 3 (AD3) as a professional-grade tool and introduces WaveForms as a complete environment for electronics instruction. Future sessions will add hands-on wiring and scripting for a complete learning experience.

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