WHITE PAPER

Six Product Development Activities to Unlock Test Insights

KEYSIGHT

Introduction

Testing plays a central role in the product development process, ensuring that products meet functionality, performance, and safety requirements. Within this broader process, six focus areas — component selection, functional block validation, block integration, incremental design optimization, manufacturing preparation, and regulatory and safety verification — are essential. These activities span various phases of the product development life cycle, as shown in Figure 1.

While engineers conduct testing throughout every stage of product development, this white paper focuses on the six areas that offer the greatest potential to unlock critical test insights. These activities can help you transform your ideas into tangible, manufacturable products designed to specifications.

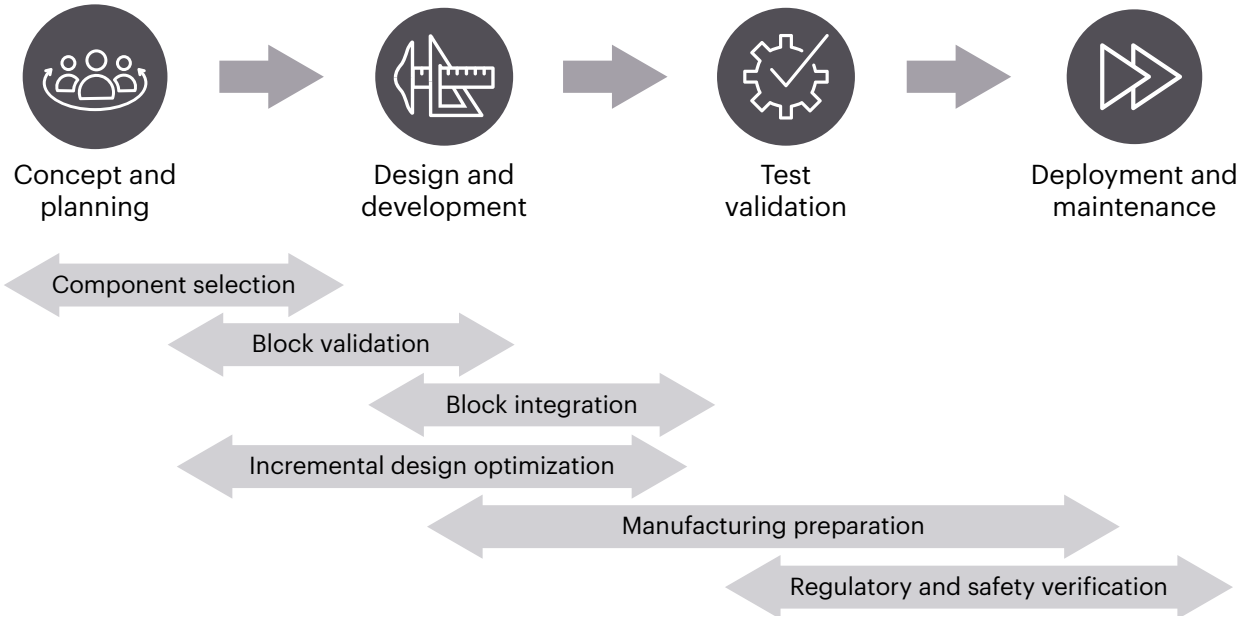

Figure 1. Six critical activities in the product development life cycle

Optimizing Test Coverage at Every Stage

The following sections break down each of the six activities, outlining common challenges, practical solutions, and proven methods for improving test coverage, accuracy, and efficiency. At each stage, you will see how the test instruments can help you design with confidence, minimize costly iterations, and accelerate the delivery of high-quality products.

Activity 1: Component testing and selection

Every product begins with individual components, and the quality of those components has a direct impact on the final design. This section examines the critical role of component characterization during early design, outlines common challenges engineers face, and presents strategies to streamline the selection process using automated testing.

Challenge

During the initial design phase, component selection is central to achieving product development goals while adhering to project constraints and requirements. Engineers must evaluate competing vendor components and ensure that they meet technical design requirements for form, fit, functionality, performance, power consumption, and more. This work can be tedious, requiring large amounts of data to evaluate multiple competing components.

Solution

Automate your test sequences and the recording of test results to simplify the component characterization process. You want to surround your device under test (DUT) with the essential test instruments shown in Figure 2. These basic instruments are the backbone of your test bench, playing a pivotal role in the quality and performance of your products. Keysight Smart Bench Essentials Plus can help you gain critical test insights you can trust.

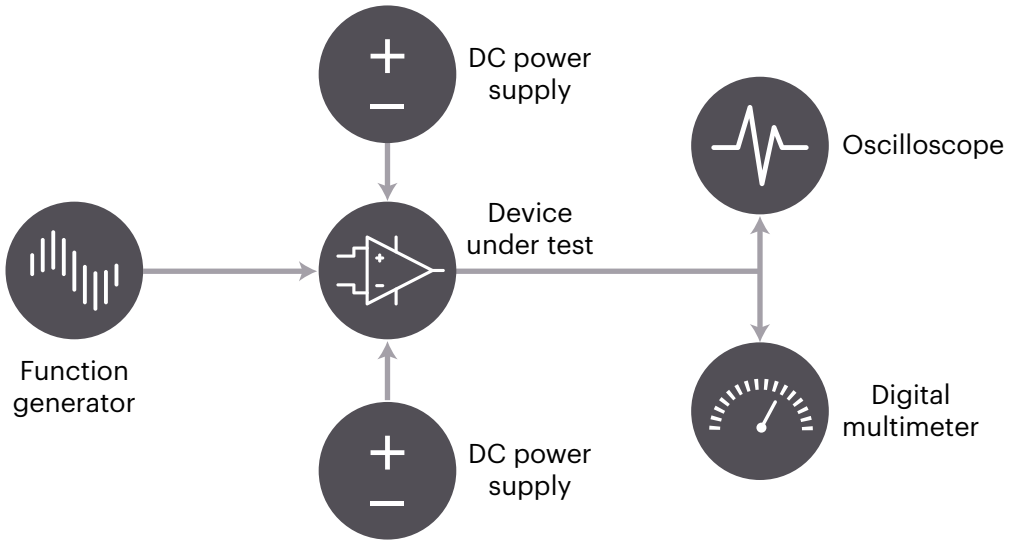

Figure 2. Surround your DUT with instruments for component characterization

When each instrument performs as intended and follows the correct sequences, measurements are captured with the proper test signals and power biasing. Depending on the output signal you are measuring, you may want to use a DMM with high linearity and precision for accurate test results. By capturing data across all test sequences and configurations, you gain deeper insights into your DUT's behavior. Understanding the limitations of your DUT during component testing and selection can help you avoid issues later in the design process.

Smart Bench Essentials Plus 6.5-digit DMMs feature built-in technology that eliminates extraneous noise from the true measurement. This approach ensures reliable measurements every time and a good balance of resolution, linearity, and accuracy. Uncover critical test insights fast so you can make better design decisions.

Tips and methods

- Use a set of instruments with a compatible interface and programmability, each serving a distinct function:
  - DC power supply to provide controlled biasing to the DUT
  - waveform generator to provide controlled input test signals
  - DMM to measure RMS voltage or current output signals
  - oscilloscope to measure dynamic output signals
- Activate instrument-triggering features to aid communication.
- Use programming software or graphical instrument control software to automate your tests and record all the results easily.
- Repeat the same, unbiased characterization process for all components to ensure a fair and accurate comparison.
- Give higher priority to specifications that are imperative to your design during the component selection process.

Activity 2: Functional block validation

Once you have selected the components, you need to ensure that each functional block behaves as intended. This section explores the challenges of functional block validation and how precision instruments and test automation can help ensure complete coverage and trustworthy results.

Challenge

Each functional block has its inputs and outputs according to the expected design specifications. Functional design block validation can be challenging when test results are ambiguous. The situation gets worse when you have numerous input and output combinations to test.

For example, if the inputs are digital, the number of combinations to test is 2^n, where n is the number of inputs. If there are eight digital inputs, where n is eight, as shown in Figure 3, that means there are 256 combinations to test. The sheer number of tests, combined with uncertainties in the test results caused by factors such as a lack of system-level references or calibration, increases the risk of incomplete tests or incorrect data representation.

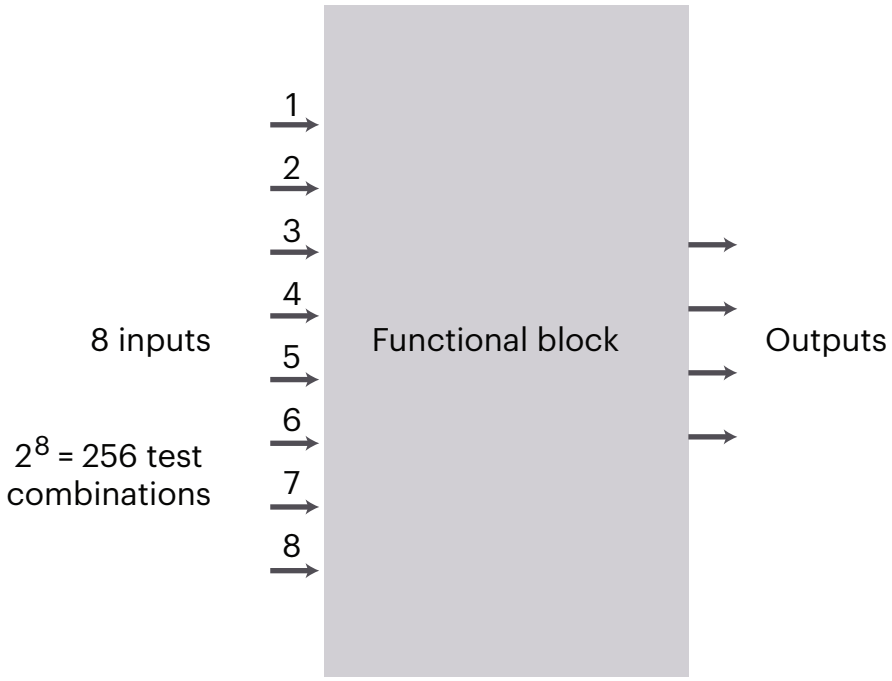

Figure 3. The number of test inputs corresponds to the test combinations of a functional block

Solution

To ensure reliable results, test instruments must provide precision, accuracy, and reliability. Some instruments promise impressive specifications, but these are often based on narrow test guardbands — and performance can quickly degrade outside of ideal conditions.

Look for test instruments that are rigorously evaluated to meet industry standards for test performance and calibration. Make sure they are compatible in usage and programmability. Use test automation software to cover all test combinations for quick and comprehensive results. Pairing test automation with reliable test instruments helps ensure proper test coverage, providing the accurate and precise results you need to unlock insights during function block validation.

Smart Bench Essentials Plus waveform / function generators come equipped with pro-level technology that employs a virtual variable clock with advanced filtering techniques to track the waveform's sample rate. You get predictable low jitter, low harmonic distortion, and high signal integrity for a true representation of your programmed waveform. Simulate reliable input signals that reveal true functional block performance for accurate test results.

Tips and methods

- Reduce test result uncertainty with instruments that are reliable and accurate. For example, use high-quality test signals as sources to test your functional block. Use clean DC power sources to bias your functional block so that no external noise mixes with your test results.
- Automate comprehensive testing using programming software or graphical instrument control software. The combination of input signals grows exponentially with each input added to the functional block. Hence, performing tests without automation becomes overwhelmingly complex.

Activity 3: Block integration and testing

Once you have validated individual blocks, you need to confirm that they work together seamlessly. This section explores how precise, high-resolution instrumentation can help detect subtle integration issues early, ensuring a smoother path to full system functionality.

Challenge

Modern products often involve complex designs with multiple intricate and interdependent, interconnected functional blocks. When turning on a fully integrated design for the first time, verifying that the functional blocks handle data correctly (for example, inputs, outputs, data transformations) is complex, especially when dealing with large datasets or real-time data with sensitive time-synchronization requirements. The product may run several hundred or thousand steps during the first turn-on to perform self-checks. The interactions between the functional blocks may fail because of compatibility issues, performance problems, incorrect communications, or data corruption.

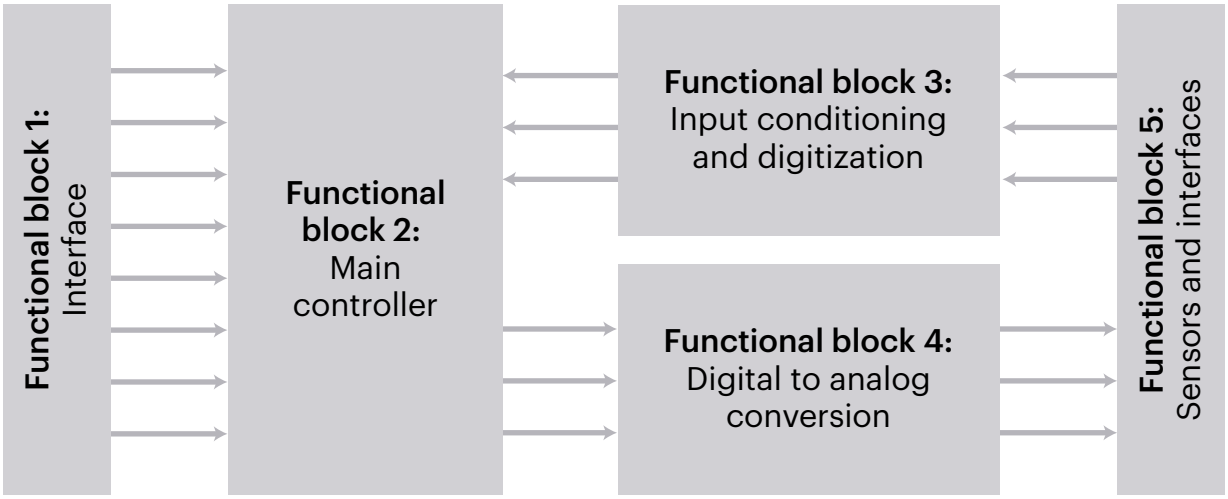

Figure 4. Integration of functional blocks

Solution

Test instruments must have advanced triggering mechanisms to capture the interactions between the functional blocks. Potentially, unwanted signals or transients may occur, and the test instruments must have the speed and resolution to catch them. Use an oscilloscope with high vertical resolution accuracy to capture fast transient signals.

The Smart Bench Essentials Plus HD3 portable oscilloscope features a custom ASIC and 14-bit ADC, providing four times the vertical resolution of a 12-bit ADC and half the noise floor of other general-purpose oscilloscopes. It enables you to debug your DUT by detecting small signals beyond the noise, capturing the slightest and most infrequent signal glitches.

Tips and methods

- Create power-up sequence test cases that run in conjunction with your DUT's embedded software power-up sequence. It is important to iron out the fundamental communication and compatibility issues between the functional blocks before proceeding with the performance and functionality testing.
- To automate your tests and record all results efficiently, it's often essential to use programming software or graphical instrument control tools.
- Analyze the results, identify any bugs, and make necessary fixes until you achieve your objectives for the block integration tests.

Activity 4: Iteration and incremental design optimization

Design rarely succeeds in a single pass. Most products evolve through multiple refinements, with each cycle adding greater complexity. This section looks at how combining physical test instruments with simulation tools, emulators, and digital twins can help engineering teams streamline design optimization, reduce iteration cycles, and bring products to market faster.

Challenge

The product development process typically includes multiple hardware and software iterations to fix bugs and optimize designs. Ensuring sufficient test coverage is always challenging because of the increasing number of variables and functionalities in each incremental test cycle. The goal is to minimize design iterations while meeting cost, quality, performance, and time-to-market imperatives.

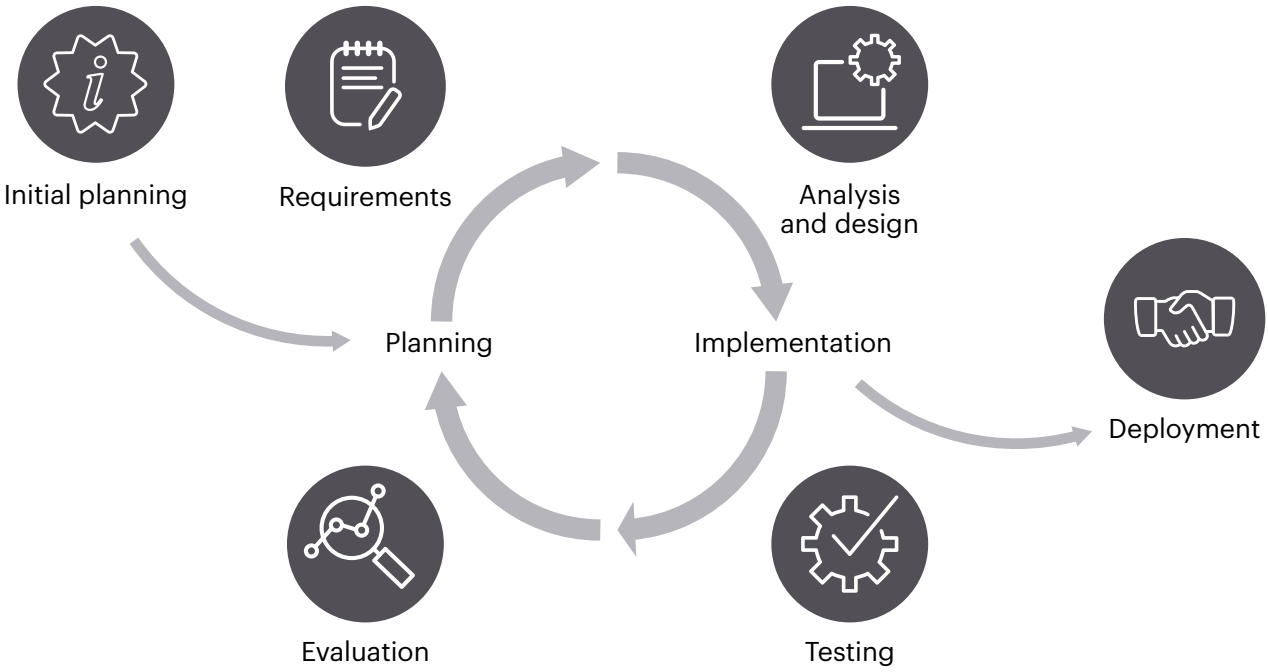

Figure 5. Iterative and incremental process model

Solution

Incorporating computer-aided design (CAD) modeling tools, such as Keysight electronic design automation software, early in the design stages and using programmable hardware emulators will increase the predictability of results during each hardware build and test. For projects involving many test cases and external variables, creating a digital twin enables engineering teams to predict, analyze, and validate real-world performance entirely in a virtual environment. When combined with CAD tools and emulators, digital twins offer powerful insights before physical prototypes are built. Physical test instruments remain essential. However, without accurate simulation, emulation, and analysis, it's difficult to produce prototypes that function as expected under test — causing lengthy design, test, and retest cycles until the team achieves the desired outcome.

Tips and methods

- As shown in Figure 5, every iteration of the product design process requires planning, design, development, testing, and evaluation. CAD modeling tools accelerate virtual design optimization and provide predictable results with fewer physical iterations. As a result, the final design aligns more closely with requirements and is achieved in less time than without these tools.
- Use emulators to help simulate parts of your design. For example, you can use software and a DC power supply to emulate your battery source. While testing your product design, you can analyze power consumption in real time and subsequently optimize your design.
- If possible, incorporate digital twins into your testing and analysis to help cover more comprehensive test cases in real-world situations.
- Automate and streamline all your tests and analysis.

Activity 5: Manufacturing preparation

Even the most innovative product design can fall short if it isn't optimized for manufacturing. This section explores how early integration of design for manufacturing (DFM) principles — supported by accurate, traceable test instrumentation — helps ensure that your design is ready for smooth, high-yield manufacturing from the start.

Challenge

A key aspect of product development is design for manufacturing. DFM is the practice of designing products in a way that makes them easier, more cost-effective, and more efficient to manufacture. It also aligns with a broader manufacturing methodology, Lean Six Sigma, which aims to reduce product defects and enhance product quality. Refer to Figure 6 for an overview of the various design principles, including those beyond DFM.

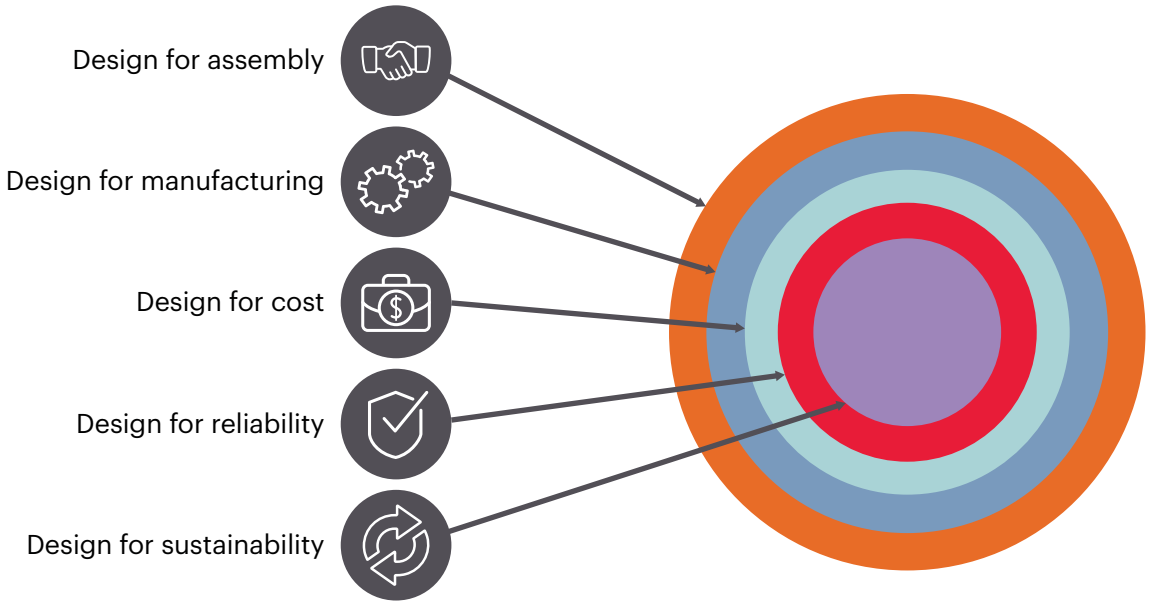

Figure 6. DFM is one of the design principles of the Lean Six Sigma methodology

Ignoring this area can lead to costly setbacks and production inefficiencies. For example, if the total production test yield is less than 50%, the product may be unprofitable. Additionally, if the product is too complicated to build, extra build processes may be required, leading to higher-than-expected production costs.

Solution

DFM follows a set of guidelines, including rules, checks, and tolerances. The goal is to ensure that the product design ultimately helps manufacturers save time and money and deliver better-quality products to customers faster.

Instruments with well-defined error tolerances enable engineers to design and test with confidence and deliver high-quality, manufacturable products with strong test yields.

The Smart Bench Essentials Plus 400 W, four-channel DC power supply provides capabilities such as output sequencing and adjustable slew rates for application-specific tasks. Featuring four channels that are flexible in configuration and can be expanded to 128 V in series or 40 A in parallel, it provides a reliable source of power with low output noise, low ripples, and fast load transient response.

Tips and methods

- Consider DFM rules and guidelines early in the design process. For example, simplify the assembly of parts as much as possible.
- Ensure that all the test instruments used for characterizing your product are calibrated and traceable to the metrology laboratory.
- Test instruments are one source of measurement uncertainty. If you are using an instrument with poor measurement uncertainty, this uncertainty will be used to calculate the test guardband for your product, which in turn determines pass / fail decisions during testing. Select instruments that are accurate and will enhance your test guardband to establish accurate pass / fail criteria in your product tests.

Activity 6: Regulatory and safety verification

Before any product reaches the market, it must meet strict regulatory and safety standards. This section looks at the importance of early-stage regulatory and safety testing and how certified, high-performance instruments can help you uncover issues early, validate compliance efficiently, and keep your product roadmap on track.

Challenge

All products need to undergo regulatory and safety verification. However, catching non-compliance issues later in the product development cycle, as shown in Figure 7, can set back product launch time by months or even more than a year.

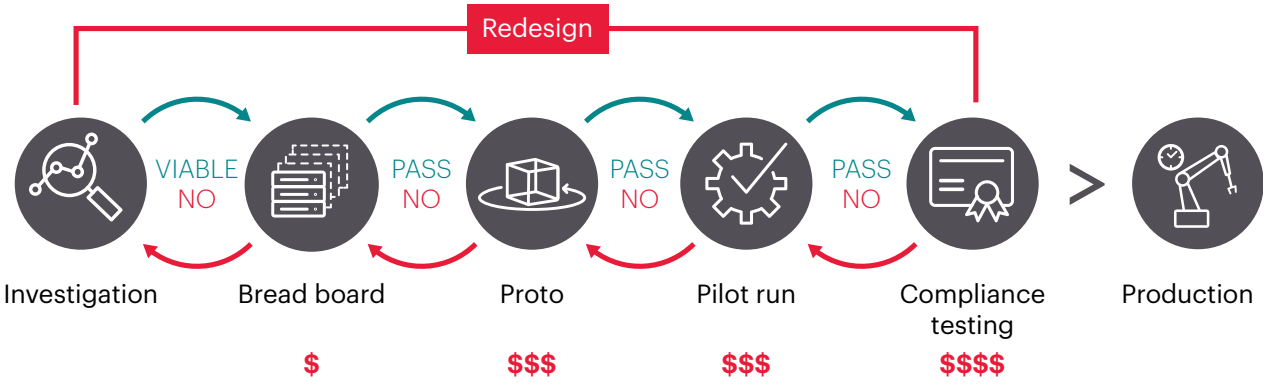

Figure 7. Cost of solving compliance testing during the product development cycle

Solution

Conduct pre-regulatory safety tests to catch problems early. A wide range of pre-regulatory test services are available, including tests for electromagnetic compatibility emissions and immunity, radio frequency, wireless protocols, environmental conditions, and safety compliance. Selecting test instruments that are certified to industry standards ensures the accuracy and reliability of your test results. Poorly performing test instruments may miss critical test insights or failures, potentially resulting in costly delays if the issue is not detected until later stages of the product development cycle.

Tips and methods

- Use test equipment that has undergone comprehensive regulatory and compliance testing to ensure that it does not contribute to measurement errors.
- Conduct as many pre-regulatory or pre-compliance tests as possible during the development and prototyping stages. Early failures corrected upfront will help avoid costly rework at the later stages of the product development cycle.
- Pairing your test instruments with software that can perform remote control and test automation enables data logging over time, storage, and detailed post-analysis.

Summary

For each of the six critical product development activities discussed, engineers face unique challenges. However, these challenges are also opportunities to unlock critical design insights. With the right test instruments and procedures, you can do the following:

- Test and identify component limitations with precision to select the best components for your design.
- Catch defects early through comprehensive test coverage, thus speeding up the validation process.
- Capture functional block interactions and transient signals accurately.
- Improve design predictability to reduce test cycles.
- Improve the manufacturability of your products.
- Identify hidden defects early to avoid costly rework during regulatory and safety verifications.

Gaining insights you can trust starts with accurate, reliable test instruments and performance. If your bench instruments are holding you back — introducing errors, slowing down test cycles, or failing to meet evolving standards — it may be time to advance your test bench. Keysight Smart Bench Essentials Plus delivers an elevated set of basic instruments — power supply, function / waveform generator, DMM, and oscilloscope — equipped with proven pro-level measurement technologies, certified to industry and safety standards.