

SM 1446 DEFINITION AND MEASUREMENT OF INTERMODULATION

SM 1446 Definition and Measurement of Intermodulation

Understanding the SM 1446 standard and the measurement of intermodulation is critical for engineers and technicians working with RF and microwave systems. SM 1446 provides a comprehensive framework for evaluating and quantifying intermodulation distortion (IMD) in electronic components and systems. Accurate measurement of intermodulation is essential to ensure the performance, reliability, and compliance of devices such as amplifiers, filters, and transceivers. This article explores the definition of SM 1446, the significance of intermodulation measurement, and practical methods to perform these assessments effectively.

What is SM 1446?

SM 1446 is a standard developed by the Society of Microwave Engineers and related organizations, focusing on the procedures and methodologies for measuring intermodulation distortion in RF and microwave devices. It provides guidelines to ensure consistency, accuracy, and repeatability across different testing laboratories and manufacturers.

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Purpose and Scope of SM 1446

This standard aims to:

1. Define the parameters and conditions under which intermodulation should be measured.
2. Establish standardized test setups and procedures for reliable results.
3. Provide methods for calculating and reporting intermodulation levels.
4. Ensure devices meet specified linearity and distortion criteria for optimal performance.

SM 1446 is applicable to a wide range of RF components, including power amplifiers, mixers, and filters, and is instrumental in quality control and system design.

Understanding Intermodulation Distortion (IMD)

Before diving into measurement techniques, it's important to understand what intermodulation distortion entails.

Definition of Intermodulation

Intermodulation occurs when multiple signals at different frequencies pass through a nonlinear device, producing additional signals at new frequencies. These unwanted signals are the sum and difference frequencies of the original signals and are often referred to as intermodulation products.

Types of Intermodulation Products

1. **Second-Order Products:** Frequencies at sums and differences of two original signals (e.g., $f_1 + f_2$, $f_1 - f_2$). These are usually easier to filter out but can cause issues if they fall within the system bandwidth.
2. **Third-Order Products:** Frequencies at $2f_1 - f_2$ and $2f_2 - f_1$, which are particularly problematic as they tend to fall closer to the original signals and are harder to filter.
3. **Higher-Order Products:** Involving more complex combinations of original signals, often with diminishing amplitudes.

The level of intermodulation distortion is often characterized by the amplitude of these products relative to the fundamental signals.

Measurement of Intermodulation: Techniques and Procedures

Accurate measurement of intermodulation distortion is vital for assessing device linearity. SM 1446 outlines specific methods to perform these measurements consistently.

Test Setup and Equipment

Key components for intermodulation measurement include:

1. Two or more tone generators capable of producing stable RF signals at specified frequencies and power levels.
2. A device under test (DUT), such as an amplifier or filter.
3. A spectrum analyzer with sufficient dynamic range and resolution bandwidth.
4. Attenuators and combiners to accurately feed signals into the

DUT.
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5. Calibration equipment to ensure measurement accuracy.

Proper setup involves combining the test tones, filtering, and carefully controlling power levels to prevent device damage or nonlinear behavior not representative of normal operation.

Measurement Procedure as per SM 1446

The general steps include:

1. **Signal Source Calibration:** Ensure that all RF sources are calibrated, providing stable and known power levels.
2. **Combining Test Tones:** Use power combiners to feed two or more signals into the DUT at specified frequencies (f_1 , f_2 , etc.).
3. **Power Level Adjustment:** Set the input power levels to the DUT as per the standard's recommended test conditions, often expressed in dBm.
4. **Measurement of Fundamental Signals:** Use the spectrum analyzer to verify the output signals at f_1 and f_2 .
5. **Identification of Intermodulation Products:** Scan for signals at the intermodulation frequencies (e.g., $2f_1 - f_2$, $2f_2 - f_1$). Measure their amplitudes relative to the fundamental signals.
6. **Data Recording and Analysis:** Record the amplitudes, calculate the intermodulation distortion levels (often expressed in dBc — decibels relative to the carrier), and compare against specified limits.

Calculating Intermodulation Levels

Intermodulation distortion is typically quantified by the ratio of the intermodulation product power to the fundamental power, expressed in decibels:

1. **IMD Level (dBc):** $20 \log_{10}$ (intermodulation product amplitude / fundamental amplitude).
2. This measurement indicates how much the distortion products are suppressed relative to the main signals.

Lower IMD levels imply better linearity and higher device quality.

Importance of Standardized Measurement

Adhering to standards like SM 1446 ensures:

1. Consistency across different testing environments and laboratories.
2. Reliable comparison of device performance.
3. Compliance with industry regulations and specifications.
4. Optimization of system performance by minimizing distortion.

Furthermore, standardized measurement techniques help in identifying nonlinearities early in the design process, saving costs and improving device longevity.

Challenges and Best Practices in Intermodulation Measurement

While measuring intermodulation is straightforward in principle, practical challenges can arise.

Common Challenges

1. Leakage of test signals causing spurious readings.
2. Limited dynamic range of spectrum analyzers.

3. Power fluctuations in RF sources affecting repeatability.
4. Temperature variations influencing device behavior.

Best Practices

1. Calibrate all equipment regularly.
2. Use high-quality combiners and attenuators to minimize losses and reflections.
3. Perform measurements in controlled environments to reduce external noise.
4. Repeat tests to ensure consistency and accuracy.
5. Document all test conditions meticulously for reproducibility.

Conclusion

The SM 1446 standard provides essential guidelines for the measurement of intermodulation distortion, ensuring that RF components and systems meet industry performance criteria. Understanding the definition of intermodulation, its implications, and the proper measurement techniques is vital for engineers aiming to optimize device linearity and system reliability. By adhering to the procedures outlined in SM 1446, professionals can achieve accurate, repeatable results, enabling better device design, quality assurance, and regulatory compliance. As RF systems become increasingly complex and demanding, mastering intermodulation measurement remains a cornerstone of effective RF engineering.

SM 1446: Definition and Measurement of Intermodulation In the realm of RF and microwave engineering, the integrity of signal transmission is paramount. Whether designing communication systems, radar, or electronic warfare equipment, engineers must ensure that signals are transmitted cleanly, without unwanted

distortions or interference. One critical parameter that often determines the fidelity of these systems is intermodulation. Among the standards and methodologies used to quantify and analyze intermodulation, the SM 1446—a comprehensive guideline developed by the Society of Microwave Engineers—stands out as a cornerstone document. This article delves deeply into the definition and measurement of intermodulation as per SM 1446, providing an expert-level review suitable for engineers, researchers, and technical professionals.

Understanding Intermodulation: The Fundamentals

What Is Intermodulation?

Intermodulation (IM) refers to the phenomenon where nonlinearities within an electronic component or system generate new frequency components that are sums and differences of the original input signals. When two or more signals pass through a nonlinear device such as an amplifier, mixer, or antenna system, they interact in complex ways, producing additional signals at frequencies not present in the original input. Key Points: - Origin: Caused by nonlinear characteristics of components. - Manifestation: Produces unwanted signals at intermodulation frequencies. - Impact: Can cause signal distortion, interference, and reduced system performance. Types of Intermodulation: - Second-Order Intermodulation (IM2): Produces signals at frequencies like $2f_1 - f_2$ and $2f_2 - f_1$. - Third-Order Intermodulation (IM3): Produces signals at frequencies such as $2f_1 - f_2$ and $2f_2 - f_1$; typically more problematic due to proximity to the original signals. - Higher-Order IM: Fourth, fifth, and higher orders, increasingly complex but generally less significant.

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Why Is Intermodulation Measurement Important?

Intermodulation products can severely degrade system performance. For example:

- In communication systems, IM signals can fall within the bandwidth of desired signals, causing cross-talk and data corruption.
- In radar and electronic warfare, they can mask targets or create false signals.
- In satellite communications, IM products can cause interference with adjacent channels.

Hence, precise measurement and control of intermodulation are vital for compliance, quality assurance, and system optimization.

SM 1446: The Standard for Intermodulation Measurement

Overview of SM 1446

The SM 1446 document, published by the Society of Microwave Engineers, provides a detailed methodology for measuring and evaluating intermodulation distortion in RF components and systems. It sets standardized test procedures, measurement conditions, and reporting formats to ensure consistency, repeatability, and comparability across different laboratories and manufacturers. Core objectives of SM 1446:

- Define test setups for IM measurement.
- Specify signal levels, frequencies, and environmental conditions.
- Establish criteria for acceptable intermodulation levels.
- Provide guidelines for interpreting results.

Scope and Applicability

The standard applies primarily to active RF components such as: - Amplifiers - Mixers - Oscillators - Transmitters - Receivers and communication modules It also covers passive elements where nonlinearities are present.

Defining Intermodulation: Key Concepts per SM 1446

Fundamental Parameters

SM 1446 emphasizes the importance of understanding and accurately defining parameters such as: - Input Power Levels (P_{in}): The power fed into the device under test (DUT). - Carrier Frequencies (f_1, f_2): Typically two or more signals used to evaluate IM distortion. - Intermodulation Products (f_{IM}): Frequencies generated at sums and differences of input frequencies and their multiples.

Intermodulation Distortion (IMD) versus Total Harmonic Distortion (THD)

While THD measures the harmonic content relative to the fundamental signal, IMD focuses on the unwanted mixing products generated from multiple signals. SM 1446 specifically targets intermodulation because of its critical impact on multi-carrier systems.

Measurement Techniques for Intermodulation as per SM 1446

Test Setup and Equipment

A typical SM 1446-compliant measurement setup involves:

- Signal Generators: Two (or more) stable, low-noise RF sources tuned to the test frequencies.
- Power Amplifiers: To drive the DUT at specified input levels.
- Directional Couplers and Attenuators: For precise power control and measurement.
- Spectrum Analyzer: With high dynamic range to detect weak IM products.
- Calibration Devices: To ensure measurement accuracy and correct for system losses.

Diagrammatic overview:

- Two RF sources feed signals into the DUT.
- The spectrum analyzer captures output signals, including IM products.
- Calibration is performed to account for system response.

Measurement Procedure

Following SM 1446 guidelines, the measurement process involves:

1. Calibration: - Measure system response with known signals. - Correct for insertion loss, gain, and any system nonlinearities.
2. Input Signal Configuration: - Set two RF sources to frequencies f_1 and f_2 . - Adjust power levels to specified levels, often expressed in dBm or mW.
3. Device Under Test (DUT): - Connect the DUT in the measurement chain. - Ensure thermal stability and controlled environment.
4. Data Acquisition: - Sweep the spectrum analyzer to identify fundamental signals and IM products. - Record the amplitudes of fundamental and intermodulation signals.
5. Data Analysis: - Calculate the intermodulation distortion level relative to the fundamental signals, commonly expressed as intermodulation

intercept points (IP3) or intermodulation distortion levels (IMD) in dBc.

Measurement Parameters and Conditions

- Signal Power Levels: Typically in the range of -30 dBm to +10 dBm, depending on device linearity. - Frequency Spacing: Often 1 MHz to several hundred MHz, depending on application. - Number of Tones: Usually two-tone tests, but multi-tone tests are also possible. - Environment: Temperature-controlled and shielded to prevent external interference.

Quantifying Intermodulation: Metrics and Standards

Intermodulation Distortion Levels (IMD)

IMD levels are expressed as the relative amplitude of the intermodulation signals compared with the fundamental signals, usually in dBc (decibels relative to the carrier). Common measurement expressions: - IM3 (Third-Order Intercept Point): The hypothetical input power level where IM3 products would equal the fundamental output. - IMD3 in dBc: The ratio of the IM3 product amplitude to the fundamental signal amplitude. Example: > "An amplifier exhibits an IM3 level of -30 dBc at an input power of +10 dBm, indicating the IM products are 30 decibels below the fundamental."

Intermodulation Intercept Points (IP3)

- Definition: An extrapolated point where the power of fundamental and third-order IM products intersect. - Significance: Higher IP3 values indicate better linearity and lower IM distortion.

Acceptance Criteria

SM 1446 specifies acceptable IMD levels depending on system requirements, frequency bands, and application standards. For example: - Commercial communication systems: IM3 levels below -30 dBc. - Military or space systems: Stricter thresholds, often below -40 dBc.

Challenges and Best Practices in Intermodulation Measurement

Common Challenges

- Measurement Sensitivity: Weak IM products require high dynamic range spectrum analyzers. - System Nonlinearities: Calibration errors, component nonlinearities, or environmental factors can skew results. - Power Level Control: Precise control of input power is critical to avoid overdriving the DUT.

Best Practices for Accurate Measurements

- Calibration: Regular calibration of measurement setup with known standards. - Isolation: Using high-quality directional couplers and filters to prevent interference. - Thermal Stability:

Ensuring DUT and measurement equipment are thermally stabilized. - Multiple Measurements: Repeating tests at different power levels and frequencies to verify consistency. - Data Logging: Maintaining detailed records for traceability and analysis.

Conclusion: The Significance of SM 1446 in Intermodulation Analysis

The SM 1446 standard provides a rigorous, structured approach to measuring and understanding intermodulation distortion in RF components and systems. By defining clear procedures, measurement metrics, and acceptance criteria, it empowers engineers to produce systems with predictable, reliable performance. Mastery of intermodulation measurement as per SM 1446 not only facilitates compliance with industry standards but also enhances the overall quality and robustness of RF systems across defense, telecommunications, satellite, and emerging 5G and beyond applications. In an era where spectral efficiency and signal integrity are more critical than ever, understanding and controlling intermodulation through meticulous measurement practices remains a

For many readers, encountering *Sm 1446 Definition And Measurement Of Intermodulation* is not always a planned event. Sometimes it begins with a question, a task, or a moment of curiosity that appears unexpectedly. Having the ability to access the material immediately changes how that curiosity is handled.

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strengthens the connection between curiosity and understanding.

Reading no longer feels like a formal activity that requires preparation. It blends naturally into daily life—during quiet mornings, between responsibilities, or at the end of a long day. This flexibility encourages consistency without forcing rigid routines.

The structure of PDF books supports this rhythm well. Pages remain familiar each time they are opened. Headings guide attention, and visual elements help anchor ideas. Over time, readers develop an intuitive sense of where information is located.

Annotation tools turn reading into dialogue. Notes capture reactions, disagreements, and insights that emerge during reflection. These personal markers make returning to the text more meaningful, as the reader encounters their own evolving perspective.

Search functions simplify complex exploration. Instead of rereading entire sections, readers can locate specific ideas efficiently. This practical advantage makes the book useful beyond initial reading, especially for reference and revision.

Trustworthy sources matter. Platforms that prioritize legality and accuracy create confidence in the material. Readers can focus fully on understanding without questioning reliability or safety.

Access without excessive cost opens doors. When financial pressure is removed, exploration becomes more adventurous. Readers feel free to explore unfamiliar topics, knowing that curiosity does not come with unnecessary risk.

Students benefit from this freedom. Learning extends beyond classrooms and deadlines. Concepts can be revisited calmly, reinforced through repetition, and connected across subjects without urgency.

Professionals approach *Sm 1446 Definition And Measurement Of Intermodulation* with a different lens. They seek relevance, clarity, and applicability. Being able to return to specific sections when challenges arise turns reading into a practical resource rather than a one-time activity.

Personal growth often happens quietly. Reading becomes a companion rather than an obligation. Ideas settle gradually, influencing thinking and decision-making over time.

Accessibility features ensure broader participation. Adjustable displays and supportive reading tools help accommodate different needs, allowing more readers to engage comfortably.

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The global nature of access adds another layer. Readers across different cultures encounter the same material, often interpreting it through unique experiences. This shared access strengthens collective understanding.

Revisiting familiar passages often reveals new insights. What once felt complex may later feel clear. Growth becomes visible through repeated engagement rather than rushed completion.

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readily available, learning becomes less about finishing and more about returning. The book remains present, patient, and ready whenever attention shifts back.

This steady availability encourages a calmer relationship with knowledge. There is no pressure to absorb everything at once. Understanding unfolds naturally, shaped by time and reflection.

In this way, reading becomes less transactional and more personal. The value lies not only in information gained, but in the habit of thoughtful engagement that develops along the way.

Questions & Answers About sm 1446 definition and measurement of intermodulation

No	Question	Answer
1	What is SM 1446 in the context of intermodulation measurement?	SM 1446 is a standard guideline that defines the procedures and parameters for measuring and assessing intermodulation distortion in electronic communication systems.
2	How is intermodulation measured according to SM 1446?	Intermodulation is measured by inputting multiple signals into a device and analyzing the output spectrum to identify and quantify unwanted intermodulation products, following the specific methods outlined in SM 1446.

3	What are the key parameters involved in the measurement of intermodulation as per SM 1446?	Key parameters include the intermodulation distortion level (IMD), input signal levels, frequency spacing between carriers, and measurement bandwidth, all as specified in SM 1446 guidelines.
4	Why is the measurement of intermodulation important in telecommunications?	Measuring intermodulation is crucial because it helps identify non-linearities in components that can cause signal interference, degradation of communication quality, and regulation compliance issues.
5	What equipment is typically used to measure intermodulation according to SM 1446?	Equipment such as spectrum analyzers, signal generators, and intermodulation measurement systems are used, calibrated according to SM 1446 standards to ensure accurate assessment.
6	How does SM 1446 define the acceptable levels of intermodulation distortion?	SM 1446 sets specific thresholds for IMD levels based on application requirements and regulatory standards, which vary depending on the frequency and power levels involved.
7	Can SM 1446 be applied to both analog and digital communication systems for intermodulation measurement?	Yes, SM 1446 provides guidelines applicable to both analog and digital systems, ensuring consistent measurement and assessment of intermodulation distortion across different technologies.
8	What are the recent trends in intermodulation measurement related to SM 1446?	Recent trends include the adoption of advanced digital measurement techniques, real-time analysis, and automation to improve accuracy and efficiency in intermodulation testing as per SM 1446 standards.

SM 1446, intermodulation distortion, IMD, measurement techniques, signal processing, nonlinear systems, RF testing,

intermodulation products, test standards, measurement accuracy

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The strength of PDF lies in its adaptability. Over the years, the format has expanded beyond static pages to support interactivity, accessibility, and enhanced security. As digital ecosystems grow more complex, PDFs continue to serve as a stable bridge between content creation, distribution, and long-term preservation.

The evolving role of PDFs in a digital-first world

As organizations and individuals move toward digital-first workflows, PDFs increasingly function as official records and reference materials. While web-based platforms excel at dynamic content, PDFs provide permanence and consistency. For materials such as Sm 1446 Definition And Measurement Of Intermodulation, this reliability ensures that information remains unchanged and authoritative over time.

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Integration with cloud-based ecosystems

Cloud technology has transformed how PDFs are stored, accessed, and shared. Integration with cloud platforms allows seamless synchronization across devices, enabling users to access Sm 1446 Definition And Measurement Of Intermodulation anytime and anywhere. Cloud-based workflows also support collaboration, version history, and automated backups.

Future PDF usage will likely emphasize deeper cloud integration, making documents more connected while preserving their standalone nature. This balance supports flexibility without sacrificing document integrity.

Advancements in accessibility standards

Accessibility is becoming a central requirement rather than an optional feature. Future PDF standards increasingly emphasize compatibility with assistive technologies. Structured tagging, logical reading order, and improved screen reader support ensure that Sm 1446 Definition And Measurement Of Intermodulation remains usable by a diverse audience.

Accessible documents benefit all users by improving clarity and navigation. As regulations and expectations evolve, accessible PDFs will become a baseline standard for responsible digital publishing.

Artificial intelligence and PDF interaction

Artificial intelligence is reshaping how users interact with digital documents. AI-powered search, summarization, and content analysis tools are beginning to enhance PDF usability. For large documents like Sm 1446 Definition And Measurement Of Intermodulation, these technologies allow users to extract insights more efficiently.

Future PDF readers may offer intelligent navigation, automated highlights, and contextual recommendations. These features enhance productivity while maintaining the original structure and reliability of PDF documents.

Enhanced interactivity and smart documents

PDFs are no longer limited to static text and images. Interactive forms, embedded media, and dynamic elements continue to evolve. Smart PDFs can guide users through content, collect input, and adapt based on user interaction. When applied thoughtfully, these features add value to Sm 1446 Definition And Measurement Of Intermodulation without overwhelming readers.

The future of PDF interactivity focuses on usability and compatibility. Interactive features must remain accessible across devices and platforms to ensure consistent user experiences.

Long-term archiving and digital preservation

One of the most important roles of PDFs is long-term preservation. Libraries, institutions, and organizations rely on PDFs to archive knowledge and records. Using standardized PDF formats and maintaining multiple backups ensures that Sm 1446 Definition And Measurement Of Intermodulation remains accessible for years or even decades.

Digital preservation strategies increasingly emphasize format stability, metadata accuracy, and redundancy. PDFs continue to meet these requirements better than many alternative formats.

Balancing PDFs with emerging formats

While new formats and platforms continue to emerge, PDFs coexist rather than compete directly. HTML, interactive web apps, and multimedia platforms offer flexibility, while PDFs provide consistency and permanence. Using PDFs like Sm 1446 Definition And Measurement Of Intermodulation alongside other formats creates a balanced digital content strategy.

This hybrid approach allows users to choose how they consume information while ensuring that authoritative versions remain available in a stable format.

Security advancements and trust models

As digital threats evolve, PDF security features continue to improve. Enhanced encryption, stronger authentication, and improved digital signatures help protect document integrity. For sensitive materials such as Sm 1446 Definition And Measurement

Of Intermodulation, these advancements reinforce trust and authenticity.

Future security models will likely focus on transparency and verification rather than restrictive controls, allowing users to trust documents without sacrificing usability.

Regulatory and compliance-driven documentation

Regulatory requirements increasingly shape digital documentation practices. PDFs remain a preferred format for compliance due to their stability and auditability. Maintaining clear version history, digital signatures, and secure storage ensures that Sm 1446 Definition And Measurement Of Intermodulation meets regulatory expectations across industries.

As regulations evolve, PDFs adapt by supporting new standards for authenticity, traceability, and accessibility.

Sustainability and efficient digital practices

Digital documentation contributes to sustainability by reducing paper usage. Optimized PDFs minimize storage and bandwidth consumption, supporting environmentally responsible practices. Efficient handling of Sm 1446 Definition And Measurement Of Intermodulation reduces duplication and unnecessary data storage.

Sustainable digital practices also include long-term planning, reducing the need for frequent format migration and minimizing digital waste.

User behavior and reading habits

User expectations continue to influence PDF development. Readers increasingly expect intuitive navigation, responsive performance, and customizable viewing options. Future PDFs will likely prioritize

user comfort while preserving document consistency. When Sm 1446 Definition And Measurement Of Intermodulation aligns with modern reading habits, engagement and satisfaction increase.

Understanding how users interact with digital documents helps creators design PDFs that remain effective and relevant over time.

Maintaining relevance through regular updates

Long-term value depends on relevance. Periodically reviewing and updating PDFs ensures accuracy and usefulness. When updates are required, clear versioning helps users identify the most current edition of Sm 1446 Definition And Measurement Of Intermodulation.

Maintaining editable source files alongside PDFs simplifies updates and supports long-term adaptability as standards evolve.

Preparing for technological change

Technology will continue to evolve, but documents that follow open standards are more resilient. Using widely supported features, avoiding proprietary dependencies, and maintaining clean structure help future-proof Sm 1446 Definition And Measurement Of Intermodulation.

Preparedness reduces the risk of obsolescence and ensures smooth transitions as tools and platforms change over time.

The enduring value of PDF documentation

Despite rapid technological change, PDFs remain one of the most reliable formats for structured information. Their balance of stability, flexibility, and compatibility ensures continued relevance. Resources like Sm 1446 Definition And Measurement Of Intermodulation benefit from this durability, maintaining value long

after initial publication.

PDFs are not a temporary solution but a long-term foundation for digital knowledge sharing and preservation.

Final thoughts on the future of PDFs

The future of digital documentation is shaped by accessibility, security, intelligence, and sustainability. PDFs continue to evolve while preserving their core strengths. By adopting best practices and staying informed about emerging trends, users can ensure that Sm 1446 Definition And Measurement Of Intermodulation remains accessible, trustworthy, and effective for years to come. Thoughtful preparation today creates lasting digital resources that stand the test of time.