

**Wireless Power Specifications Document**

Aaron Pettit

Trevor Welch

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**How to Use This Document**

This document is divided into five major sections. While specification document formats vary from group to group the format presented here is a good representation of what you will encounter in industrial specifications. The sections of the document are:

1. Scope
2. Applicable Documents
3. Stakeholder Requirements
4. Engineering Requirements
5. Verification of Requirements

This document is not only intended to explain engineering specification documents and show the development of a specification through the use of a running example. It also aims to help you produce a specification for your project. In order to achieve this goal each section will be presented in three levels. I will:

1. Attempt to explain the reasons that the section exists and what data goes into that section.
2. Complete that section for the running example and annotate the example to make it more understandable.
3. Strongly suggest that you complete the section for your project. When you see the symbol  it means you are going to get to produce something.

A skeleton template will be available in the same place that you found this document. Fill out that skeleton template as you follow through this document. You will quickly produce a specification in the least painful way I can think of. Note that I didn’t say pain free. Sometimes thinking as hard as you need to think in engineering design just makes your head hurt.

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Revision History

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| **Revision** | **Description** | **Author** | **Date** | **Approval** |
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A simple hardware example will be used throughout this guide to illustrate the writing of a specification document. The USU ECE Controls Lab needs a new power amplifier. The requirements for its design follow the narrative in this document.

From experience I know that I will not get it all right the first time. If you find what you believe to be a mistake or omission, and can make a good case for why you feel that this is so, then I will revise the document and immortalize your name in the revision table.

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# SCOPE

This section is a very top level, simple verbal description of what the item is and where it is used. See the amplifier example under the **General** heading.

1. **General: This document describes the design and verification requirements for a wireless power system using a tesla coil. This will also specify a receiver that is to be installed on sites which use this power.**
2. Additional short descriptive paragraphs can be added only if needed for special classification, designation of alternate versions or other material that is part of a top-level description.



Take time to write this section for your project. Being able to write a simple description of even complex things is a good indicator of how well you understand what you are planning.

# APPLICABLE DOCUMENTS

This section is often poorly understood and poorly implemented. It is a list of documents that are a critical part of understanding the item or requirements imposed on the item. Every document listed must have a text reference in the body of the spec further describing and limiting how it is to be applied. Conversely, no document is to be referenced in the spec unless it is listed here. Don’t put items here that are background information or of general interest.

Always obtain and review all items listed here. This section often has the following statement:

The following documents shown shall form part of the specifications for this project. In the event of a conflict between requirements, priority shall first go to the contract, second to this document, and lastly to these reference documents.

There are lots of MIL-STD(standards) and MIL-HDBK(handbooks) that cover an amazing range of subjects. Here is a website that has them plus NASA documents and others all available ([every government specification and handbook you can imagine](http://everyspec.com/)) for free. Other groups publishing standards include Institute of Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME), Society of Automotive Engineers (SAE), American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM) and Aeronautical Radio, Incorporated (ARINC) to name more than a few.

Another thing to note is that referencing documents will often save you time (and money). For example, a referenced document can contain a complete set of environmental tests. Stating that your system has to be tested to the requirements of MIL-STD xxx is a lot easier than making up the series of tests yourself. The process is akin to what you do when you use a library in C programming: someone has provided software that meets your needs. Why reinvent the wheel? Particularly in something as difficult to get right as environmental testing.

Another benefit to using standards documents is that it connects your project to what is typically done in industry. While this should be obvious it is sometimes forgotten. The designers that you hand the spec over to may already know the standard that you have specified and know how to meet these standards. The simple adherence to standard could save you a lot of money.

1. **Government Documents** This is where to put MIL-Specs, MIL-STDs, NASA specs and so forth. Be sure to include the revision level and date.
2. **Industry Documents** This is where to put ANSI, ASTM, ASME, IEEE, Company specifications and so forth. Both this section and government documents can be divided up into logical subcategories.

My project is pretty simple and I don’t have any applicable documents, but your project might. Did you know that in order to use USB on a commercial device that you have to pay a licensing fee? I know, your development board has a USB port on it. You can use it because the board manufacturer paid the fee. The USB spec is about 1500 pages. Saying that your device must comply with this spec (or a part of it) is a lot easier than writing it all out.



Research and write down the external specifications that you want your system to meet. Think about standards (like USB) and MIL-Specs that cover things like environmental testing and electromagnetic compatibility.

# STAKEHOLDER REQUIREMENTS

This section is fundamentally a list of characteristics and features requested by the stakeholders. Stakeholders are anyone that has part in the system whether in designing it, packaging it, using it, maintaining it, etc. Forgetting or ignoring a stakeholder often means change at a project phase when change is expensive.

As an example, you are tasked to design a large temperature display for a bank. The typical ‘customer’ only passively interacts with the device through its display therefore having no input to the system. However, the designers and maintainers of the system must have the ability to modify the system and evaluate their modifications through the display. These users access the system both through input and output and their needs must be met by the design.

I have identified the stakeholders in the power amplifier module project listed and they are listed in the specification as follows.

#### The stakeholders for the Tesla Coil Power System are:

#### Anyone living near the implemented system.

#### The company designing the system.

#### The customer who purchases the system.

#### Any personnel who build and maintain the system.

## Stakeholders User Stories

#### The primary stakeholders needs are described below.

* + - **People living in the community around the system will be the daily consumer.**

#### The system must have no adverse health effect or safety concerns to the community.

#### User Story

#### As a community member, I am concerned about the safety of this system. I do not want the electromagnetic field to affect the health of a family and the electronic devices in the vicinity. I do not want to be randomly shocked or have my electronics fried.

#### System does not interfere with commercial and residential signal traffic.

#### User Story

#### As a community member, I do not want the system to interfere with any signals such as Wi-Fi, radio, and cellular signals.

* **The company that makes the system:**

#### System must comply with all legal standards.

#### User Story

#### As the designers of this system, law suits are a thing that should be avoided whenever possible. The design of the system needs to apply to all the rules and regulations that apply to each part.

#### Utilize existing technology whenever possible

#### User Story

#### Due to cost and time restraints, existing technology must be researched and implemented when possible to preserve resources. Don’t reinvent the wheel.

* **The customer is the one who will be purchasing and installing the system.**

#### Must be easy to setup.

#### User Story

#### When our company installs the system, there must be clear instruction on how to set up the system. Whenever possible, use diagrams and images to explain complex mechanisms. The people who will be on site to install the system may not have an engineering background so the process should be made easier to understand.

#### Must be reliable.

#### User Story

#### The system must be able to operate on its own for 35 years without any need for major part replacement and maintenance. Only common inspections and minor maintenance should be required.

#### The system must continue to operate unless there is a blackout. This includes hot summer days over 110 F and winter nights below -20 F. The system must also operate in all weather conditions such as rain, snow, and at any humidity. A backup generator must be installed in case of a blackout for emergency shutdown. The system must also be able to survive an earthquake.

#### The system must be within the following size, cost restrictions, and operating field.

#### User Story

#### Space is limited so the system must fit on a 2,000 sq. ft property with a height restriction of 100 ft. All of the part must be transportable by semi-trucks. The total system weight is not crucial, but the system weight should be close to 40 tons or below.

#### The total system cost needs to be below $100 million with a monthly maintenance and operational cost below $60k.

#### The system will be obtaining its power from another source such as dams and this system will convert this power into wireless energy. The effective radius of power distribution must be 20 miles.

* **Any personnel who build and maintain the system.**

#### Must be a computer on site to interface with the system.

#### User Story

#### There must be a computer module on the site that allows technicians to monitor the current status of the system. The interface must use a keyboard, mouse, and monitor for the user to interact with. The interface must be easy to navigate and understand using easy to read formatting and menus. Alerts must be implemented into the system to alert the technician of any system changes.

#### A manual must be created and easily available for technical training purposes and on site reference. Technicians must undergo technical training before being authorized to work on the system.

# 4 ENGINEERING REQUIREMENTS

1. The system will broadcast wireless electricity in a ten mile radius.
   1. Receivers must be able to obtain electricity from the source anywhere within a ten mile radius.
2. The system must be set up and maintained. Users will need a receiver on premise to hook into the building's wiring.
   1. The system must be set up on test site.
   2. A working receiver must be able to convert the wireless electricity to 120 V AC usable in homes
3. System must operate indefinitely unless an outage occurs.
   1. The system is running while maintenance tasks are performed.
   2. The system is running with no outages, without range decreasing, and with no unexpected problems for two months.
4. No health concerns caused by the system
   1. Research of wireless electromagnetic waves on the human body conducted by top researchers.
5. No large magnets or uncertified electrical equipment within 100 yards of the coils while operating.
   1. Determine the materials that equipment can be made of to be within a 100 yard radius of the coils while operating.
6. The equipment must fit on a 2,000 sq. ft property. Height restriction up to 100 ft. Parts must be able to fit on an 18 wheel semi.
   1. Transport equipment on 18 wheel semi
   2. Equipment set up on test site of 2,000 sq ft.
   3. System height when fully assembled must be below 100 feet.
7. After installation, system will weigh 8-10 tons
   1. Weigh individual parts and verify the total is less than 10 tons
8. System must run without need of complete major part replacement for 35 years.
   1. All materials in the system must be certified for use of at least 35 years by testing part functionality and predicting the effect of the load on materials after 35 years.
9. Existing infrastructure in homes that will need only slight modification. (Receivers)
   1. Test system by installing a receiver, connected to a grid of 10 homes and compare data with a current hardwired infrastructure.
10. Existing concept
    1. Implement research already done in system design.

# 5 VERIFICATION OF REQUIREMENTS

We have to know that we designed what we were required to design by this document. This process is called ‘verifi and it answers the fundamental question: “Did we build what we said we would build?”. We verify requirements by testing to see if the requirements are met.

Design teams must test every requirement in order to prove that the requirement is met. Testing each requirement means that each requirement must cast in some quantifiable way. In this section you specify how you will test each requirement to show that it has been met.

Don’t worry! It is not as bad as it sounds. Sometimes (not always!) you can verify or test a requirement simply by looking at the completed system to make sure some required thing is present.

Testing often ‘takes it on the chin’ in terms of project schedule. Since integrated system testing typically occurs near the end of a project, the time for testing is compressed against the deadline. People start short-cutting tests to stay on schedule. Sometimes you may get away with it but it is never a good idea either technically or ethically. Epic failures have occurred because of truncated testing. One such failure occurred during the testing of the Hubble Space Telescope. The following is an excerpt from the official report detailing the failure.

Reliance on a single test method was a process which was clearly vulnerable to simple error. Such errors had been seen in other telescope programs, yet no independent tests were planned, although some simple tests to protect against major error were considered and rejected. During the critical time period, there was great concern about cost and schedule, which further inhibited consideration of independent tests.

The Hubble Space Telescope Optical Systems Failure Report-NASA November 1990

If you are interested the whole report is available at ([https:// www. ssl. berkeley. edu/~ mlampton/ AllenReportHST. pdf](https://www.ssl.berkeley.edu/%7Emlampton/AllenReportHST.pdf)).

The Hubble error wasn’t caught until the telescope was deployed in space. Can you imagine the cost of fixing this problem? It is not simply a case of bundling you off with your instruments and putting you up in a fancy hotel for a week or two. Some estimates set the price at about $1 billion.

The Dilbert comic strip has a similar, and darkly amusing, view of testing truncation. ([http:// dilbert. com/ strip/ 2010-08-21](http://dilbert.com/strip/2010-08-21) )

([http:// dilbert. com/ strip/ 2009-07-01](http://dilbert.com/strip/2009-07-01) )

The key to completing this section is that every requirement has an associated test. The best practice in this section is to match the sub-paragraph numbers in the previous section to the sub-paragraph numbers in this section, e.g the requirement in 4.3.1.6 is covered by the test described in 5.3.1.6.

Possible verifi methods include:

1. Inspection:

Inspection is a method of verifi consisting of investigation, without the use of special laboratory appliances or procedures, to determine compliance with requirements. Inspection is generally nondestructive and includes (but is not limited to) visual examination, manipulation, gauging, and measurement.

1. Demonstration:

Demonstration is a method of verifi that is limited to readily observable functional operation to determine compliance with requirements. This method shall not require the use of special equipment or sophisticated instrumentation.

1. Analysis:

Analysis is a method of verifi taking the form of the processing of accumulated results and conclusions, intended to provide proof that verifi of a requirement has been accomplished. The analytical results may be based on engineering study, compilation or interpretation of existing information, similarity to previously verifi requirements, or derived from lower level examinations, tests, demonstrations, or analyses.

1. Direct Test:

Test is a method of verification that employs technical means, including (but not limited to) the evaluation of functional characteristics by use of special equipment or instrumentation, simulation techniques, and the application of established principles and procedures to determine compliance with requirements.

## Verify Coverage of Stakeholder Requirements

The tester verifi that everything that the stakeholders have asked for are covered by one or more requirements. It is a good idea for the requirements author(s) to perform a similar check at this point. The tester is likely to do his own analysis or disagree on points in yours, but the exercise itself is valuable. And if you do the analysis you might as well write it down here.

## Interface

### Functional Interface Constraints

### Functional Interface Requirements

### Support Interface Constraints

### Support Interface Requirements

## Functional Requirements

### Functional Method Constraints

### Functional Design Requirements

## Support Requirements

### Support Method Constraints

### Support Requirements

A tabulation of all the requirements and the testing method with a blank space for results is useful for whomever is doing the testing.

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| **Paragraph Number** | **Test Type** | **Tester’s Name** | **Pass/Fail** | **Date** |
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Now read over your completed specification and make additions and corrections. Find others who will be willing to read and comment on the specification (hopefully they will still like you when they are done). The more eyes the better. Ask yourself if you handed this spec to a competent classmate what would they build?



Congratulations! You have written an engineering specification and that is no mean feat.