

Senior Design Project
T307
25 September 2020
Customer Needs

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SECTION I: Description of Customer Needs Document

The purpose of the following sections is to address all specified needs by the customer (Dr. William Brey, National High Magnetic Field Laboratory) and sponsor (Paul Holcomb, Keysight). The needs were identified during several virtual meetings with the parties mentioned above. The Team carefully assessed all needs and constructed a list of requirements to satisfy said needs. In *Section II*, customer statements are presented and documented from the meetings. Based on those statements, in *Section III*, a complete list of all needs given to by the customer and the sponsor are presented. In *Section IV*, the requirements are stated. Ultimately, in *Section V*, a more in-depth explanation, definitions, and meaning of the needs from *Section III* are presented.

SECTION II: Customer Statements

Question 1: Will the final prototype be addressing multiple users?

Answer: The final prototype doesn't have to address all users.

Question 2: Which kind of information will this device be extracting?

Answer: Users would like to know when the probe fails and how to adjust it (this incorporates the idea that a reversed signal has to be displayed, so that the user may make appropriate decisions during an experiment).

Question 3: What does the displayed signal have to be?

Answer: The displayed signal has to be an envelope.

Question 4: What suggestion was made to decrease the cost of the prototype?

Answer: The use of an SDR was suggested to decrease the cost.

Question 5: What should the output of the SDR display?

Answer: The output of the SDR needs to display the alternation of the Radio Frequency (RF) pulses and the phase.

Question 6: What does the end user want to observe on the display and measure?

Answer: The prototype has to display length of sweep, control frequency, and have enough bandwidth for the spectroposit's experiment (600MHz to 800MHz). In addition, it must aim for one frequency and a clean system that works well.

Question 7: What is the target cost for every channel?

Answer: Target cost per channel needs to be around one thousand dollars.

Question 8: What kind of software is required alongside the SDR hardware?

Answer: The implemented SDR device needs to have appropriate software to be used alongside it such as C++ or MATLAB.

Question 9: What does the prototype need to look like and what is an essential ability it should have?

Answer: The prototype needs to be essentially a "box" (doesn't need a display) but should have the ability to connect to one (such as a computer).

Question 10: How should the prototype operate? Should it read the data continuously?

Answer: The SDR based prototype will run (sample) continuously for a period of time as long as several days. When an external trigger occurs, the recorded data will be saved (the customer can supply a trigger in the form of a Transistor-Transistor Logic (TTL) trigger that goes through Power Amp 100us before the pulse).

Question 11: How long is the pulse width?

Answer: The pulse width is short but can get up to a pulse-train that is 100ms long.

Question 12: How many channels does the prototype need?

Answer: It is a need for the prototype to have at least one channel.

Question 13: What range does the device need to be capable of analyzing?

Answer: The device has to be able to analyze signals with frequencies in a range from 600MHz to 800MHz.

Question 14: What is a sufficient resolution for the SDR's Analog-Digital Converter (ADC) for proper analysis of the signal?

Answer: The resolution must be equal to or more than 8-bits. This would be sufficient, but the scopes used by the customer are 8-bits. Hence, it is a requirement for the need to have a clear image to display on the computer.

Question 15: What is the function of the SDR in the prototype?

Answer: The SDR used in the prototype only needs to receive a signal. Later additional functionality could be to add the capability to compare the input with said received signal (output) from the source.

Question 16: How is it preferable to display the plot of received signal?

Answer: A connected computer needs to display the results from the SDR plotted. Show plot of butterfly (and potentially the ratio of reflected power)

Question 17: Are there any preferences in regard to a particular SDR device?

Answer: The customer would prefer if the implemented SDR device would be HackRF One, so that instructions can be made to use it in the labs.

Question 18: Are there any additional features in mind to potentially be included after completion of the basic prototype?

Answer: As another optional implementation, the customer suggested implementing an alarm when the reflected power ratio is higher than a certain threshold.

SECTION III: Needs of the project

Table I: Needs

No.	Need/Statement	Source
1	Prototype of a single unit (a "box")	Customer
2	Fast receipt of reverse signal	Customer
3	Needs to be repairable in case of failure	Customer
4	Needs to show the envelope of the signal at high frequencies	Customer
5	Software code/application needs to be appropriately chosen and configured for SDR connection to PC	Customer
6	Needs to have ability to start and stop readings (externally triggered)	Customer
7	The cost of the prototype needs to be under \$1000	Customer
8	Needs to have at least one channel	Customer
9	Needs to be able to run for many days/hours	Customer
10	Oscilloscope needs to work on 600MHz to 800MHz frequencies for 1H channel	Customer
11	No use of NI products	Sponsor

Table 1: Need parameters contained in this table

SECTION IV: Requirements of the project

Table II: Requirements

No.	Need	Requirement/Interpretation
1	1	All devices will be assembled in a single prototype unit, no devices lying around
2	4	SDR will have enough bandwidth to demonstrate the envelope
3	6	Prototype will be connected to an external trigger
4	2	Sampling rate of the SDR will be higher than minimum value for correct scan
5	4	Will capture the entire sample (pulse train)
6	5, 9	Will transmit the digital data of received signal to PC for review, analysis, and storage
7	7	Performs the software and hardware capabilities necessary while staying under budget
8	8	Must receive experiment output for analysis
9	9	Will have external storage of received data
10	4, 10	Prototype will record, analyze and plot 600MHz to 800MHz received signals and reflected power
11	11	Will not incorporate any National Instruments components nor software
12	4	Output digital signal from prototype will have at least 8-bit resolution
13	4	Prototype will have several times the bandwidth of the carrier frequency of the pulse
14	3	Quick access to hardware or code in software to run diagnostics on the system in case of failure

Table 2: Requirement parameters contained in this table

SECTION V: Explanation of Customer Needs

All the customer needs were gathered during direct communication with National High Magnetic Field Laboratory representative Dr. William Brey. There were two meetings in total from the start of the project until September 24, 2020. Dr. Brey provided a proposal of the project in which several technical specifications of the expected product were mentioned. These and additional needs are documented above in *Section II* as interpreted needs. Major needs expressed by the customer were abilities of the prototype to do as follows: accurately receive high frequency signals, display the received signals on the computer and use an SDR as a tool to behave such as the functionality of an oscilloscope. In addition, the cost of the product was asked to be under one thousand dollars. Both portability and repairability were pointed out as a need as well. Further clarifications on the need of portability, led the customer to declare that the final product needs to be a single unit prototype with at least one channel for signal receipt. Furthermore, after careful explanation of the environment in which the proposed prototype will be used, the customer brought up the need for the ability to work for a long period of time, potentially even several days. The need to accurately receive high frequency signals was broken down into three specific needs: a fast receipt of the incoming signal from the probe, a clear display of the envelope of the signal at high frequencies, and the need to contain a trigger to start or end a recording. To complete the research of total needs for the project, the team contacted sponsor representative Paul Holcomb. On the side of the sponsor there was only one direct need, which was to exclude any use of National Instruments (NI) products. This meant that neither the software nor the hardware made by NI can be implemented or used for the design of the prototype.

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