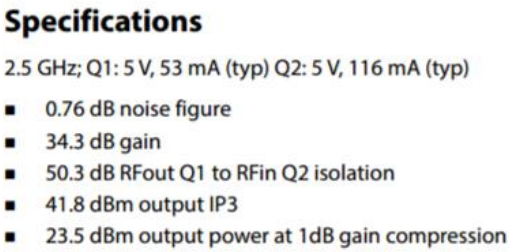
App Note about General Strategies for Winning and Allocation of Budget

Firstly, a winning strategy is to build the system so it only relies on a 5-volt input. The reason for this is due to the provided battery pack being able to provide 5 volts. Being able to power your system solely from the battery pack allows for the system to be mobile and allows for outdoor testing without the need for extension cords and power supplies. The battery pack can power the Teensy and from the Teensy's 5-volt DC output, the rest of the system should be powered from it. Therefore, all active components that are selected for the system should only need a 5-volt input. Below is an example of what you should be on the lookout for.



Specifications

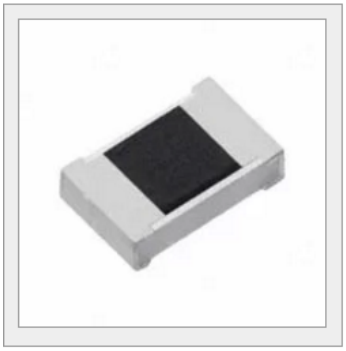
2.5 GHz; Q1: 5 V, 53 mA (typ) Q2: 5 V, 116 mA (typ)

- 0.76 dB noise figure
- 34.3 dB gain
- 50.3 dB RFout Q1 to RFin Q2 isolation
- 41.8 dBm output IP3
- 23.5 dBm output power at 1dB gain compression

Every team will eventually figure out how to calculate the overall characteristic of their system using ADIsim and each team will optimize for a reading between 10 to 50 meters but each team should do calculations with how the score is measured and do a cost-benefit analysis on making the system's range go further. The reason for this is due to the unspecified rule which came up before the week of the competition as a chunk of our score derives from the maximum distance which the system can measure. Since everyone followed the rules of going only up to 50 meters, the systems that we have built have not been optimized to detect too far. If a team wishes to win from the beginning, they need to keep this in mind when selecting components and calculate how much power will be consumed while getting better maximum distance readings.

The most valuable tip that I have figured out from building this system is to always choose to build the simplest circuits. From day one, our team set out to get the system to work and we agreed that the more complex the circuit diagram is, the more likely that it is going to lead to failure. The simplest circuits were what we thought to be the most elegant as it did what we wanted without having to spend extra time in the PCB layout stage and in the soldering stage. Therefore, do not select components where it is necessary to assemble around 30 SMD components to get the desired output unless it is the only option. A simple mistake during PCB design or soldering on the hot plate can ruin the entire system so try not to make it any more complicating.

In terms of budgeting, it is very important to fully utilize the allocated money on components as there is no reason to skimp out on them since they can easily be lost and mistakes can be made during the soldering process. After sending out the PCBs, teams will most likely receive three or more PCBs. Because of this, the minimal number of components you need is the number of boards multiplied by all the components on one board. One thing to note is that you do not need to purchase SMDs that are 0603 since those will be provided but double check the google document titled, "Inventory of Class Supplies" to make sure that it is in indeed in stock. Most likely, your team will make multiple boards which means multiple components will be necessary. Something that I learned after purchasing is the fact that it is always better to buy SMD components in bulk. Oftentimes, the price of buying 25 or even 50 of the same component is much more economical, especially when compared with buying just one. For example, shown below is the pricing for a 10k Ohm resistor.



Product Overview

Digi-Key Part Number	P10.0KHCT-ND
Quantity Available	**9,374,570** Can ship immediately
Manufacturer	Panasonic Electronic Components
Manufacturer Part Number	ERJ-3EKF1002V
Description	RES SMD 10K OHM 1% 1/10W 0603
Expanded Description	10k Ohm ±1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200 Thick Film
Lead Free Status / RoHS Status	Lead free / RoHS Compliant
Moisture Sensitivity Level (MSL)	1 (Unlimited)
Manufacturer Standard Lead Time	10 Weeks

Documents & Media

Price & Procurement

Quantity 25

P10.0KHCT-ND

Customer Reference

Update

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All prices are in USD.

Price Break	Unit Price	Extended Price
1	0.10000	0.10
10	0.01900	0.19
25	0.01360	0.34
50	0.01040	0.52
100	0.00770	0.77
250	0.00584	1.46
500	0.00468	2.34
1,000	0.00345	3.45

The cost of 10 resistors would be 19 cents but for just 33 more cents, you can get 50 resistors. It really does not hurt to have spares and it is especially annoying when you must deal with small strands of component packaging in the first place. Another reason for buying so many components also due to the fact that most team will be doing a PCB rerun. This will mean that a second iteration of PCBs will need to constructed and it will most likely reuse the same parts so having extras will be handy. In our final monetary calculation, we saw that we spent a grand total of barely under $100 and this seemed to be the case with many other teams. We made the mistake of not buying multiple components and this led us to having to beg other teams for parts and having to swap out intended components with

components that had similar values. Fortunately, the components we were missing were close to other components we had and the components we were missing were not used for any tuning purposes but it would have been ideal to not be in that situation in the first place. Also, read specification sheets closely and make sure to be following the circuit schematic for your operating frequency as the diagram can vary drastically when selecting SMD components.

Another aspect of items that need to be purchased are the antennas. I honestly believe that Hao's suggestion of purchasing a Yagi antenna is optimal for this competition due to its high directivity, low cost, and low weight. Other teams have tried building their own antenna, purchasing other types of antennas, or sticking with the cantennas. After evaluating these choices, I still believe that the Yagi performs the best and will be explained below. For formulating your own antenna, it is just too cumbersome and time-consuming to be worthwhile. It can be done but I believe that it is a better choice to not spend weeks on trying to simulate various antenna designs and then waiting for the antenna to be fabricated. Other popular antenna choices were patch antennas but this is not the best as these are highly omnidirectional. These are either sending or receiving signals from all directions but our competition is about max distance in a single direction and so the patch would not be well-suited. Lastly, cantennas are good for this competition and my recommendation is to use just the cantennas if the Yagi antennas do not work but the best result was having one Yagi and one cantenna as shown below.

It did not make too much of a difference between having the Yagi antenna on receive and cantenna on transmit or vice versa, just the combination of the Yagi antenna and the cantenna produced the best results. Because of this, my personal recommendation is to purchase the Yagi antenna but due to its fragility, purchasing two would be beneficial as the soldering can come loose during the competition and having a backup is always a good idea.

The last item for the complete system aside from the working radar system would be the structure which holds everything in place. As shown above, we opted to use just cardboard from leftover boxes and this is a lightweight and economical choice for this competition.