

# Low Power Radio Frequency Source for Inductively Coupled Plasma

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# Overview

1. Plasma Generation
2. Radio Frequency Source

# 1. Plasma Generation

# What is fire?

- Plasma, the fourth state of matter
- Charged are separated

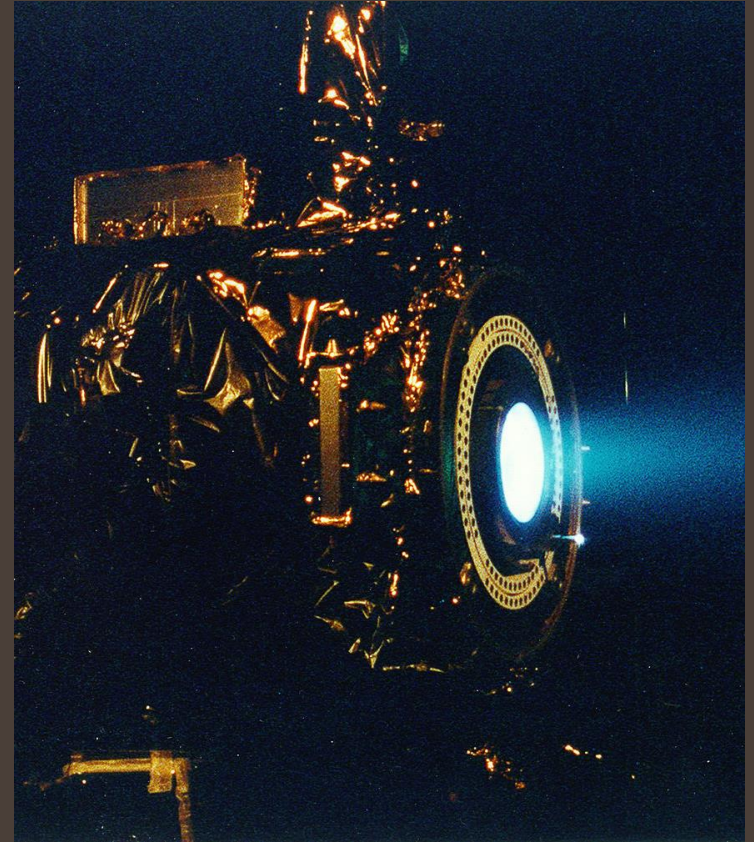
# Uses for Plasmas

## Microscopy



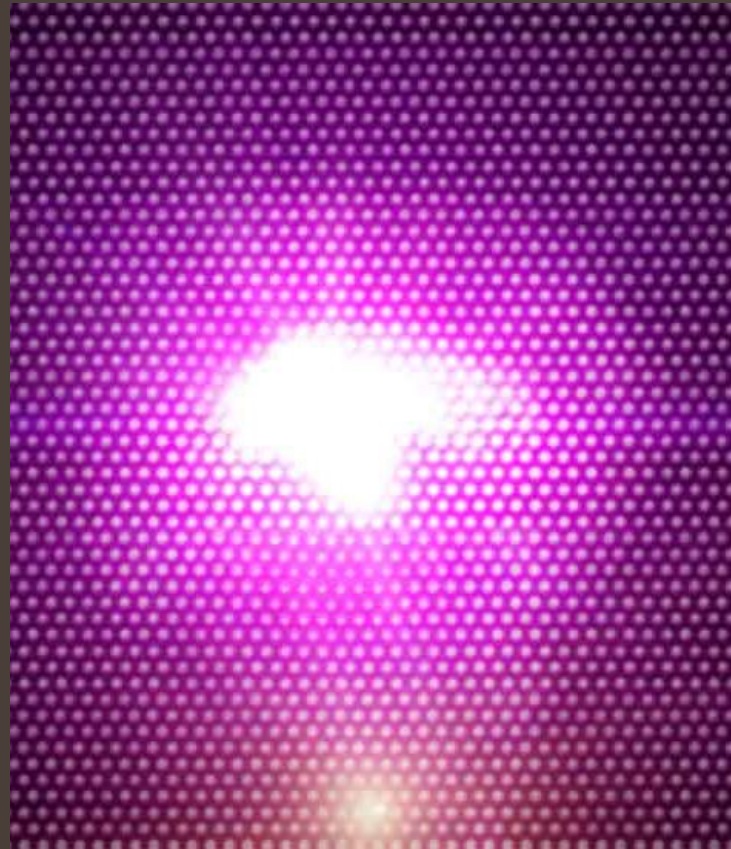
ZEISS, *Focused Ion Beam Scanning Electron Microscope* [photograph]

## Space Travel

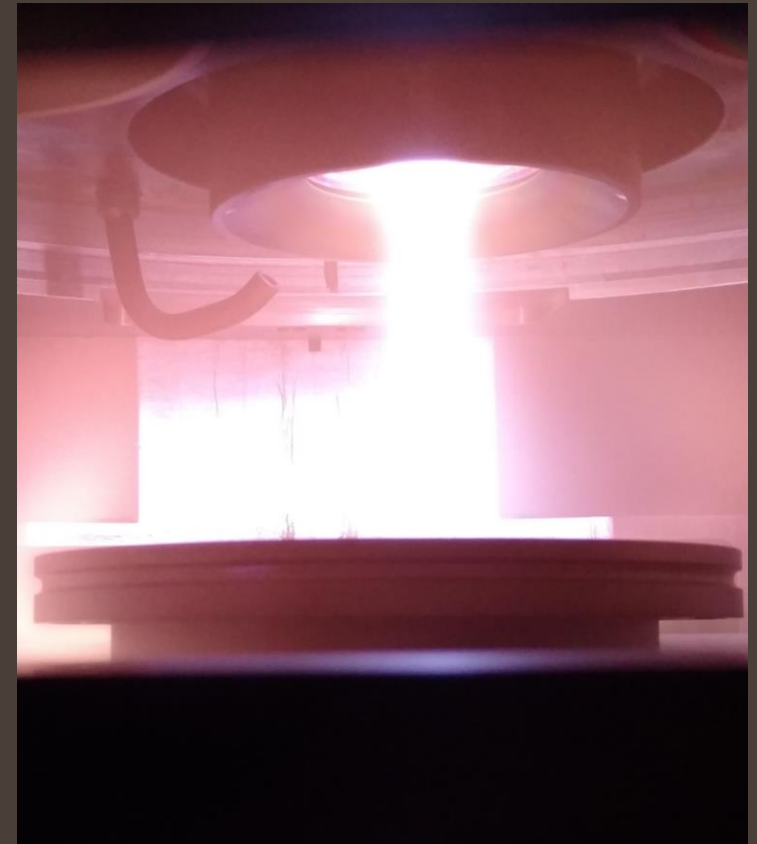


NASA (2017), *NEXT ion thruster* [photograph]

# Plasma Generation

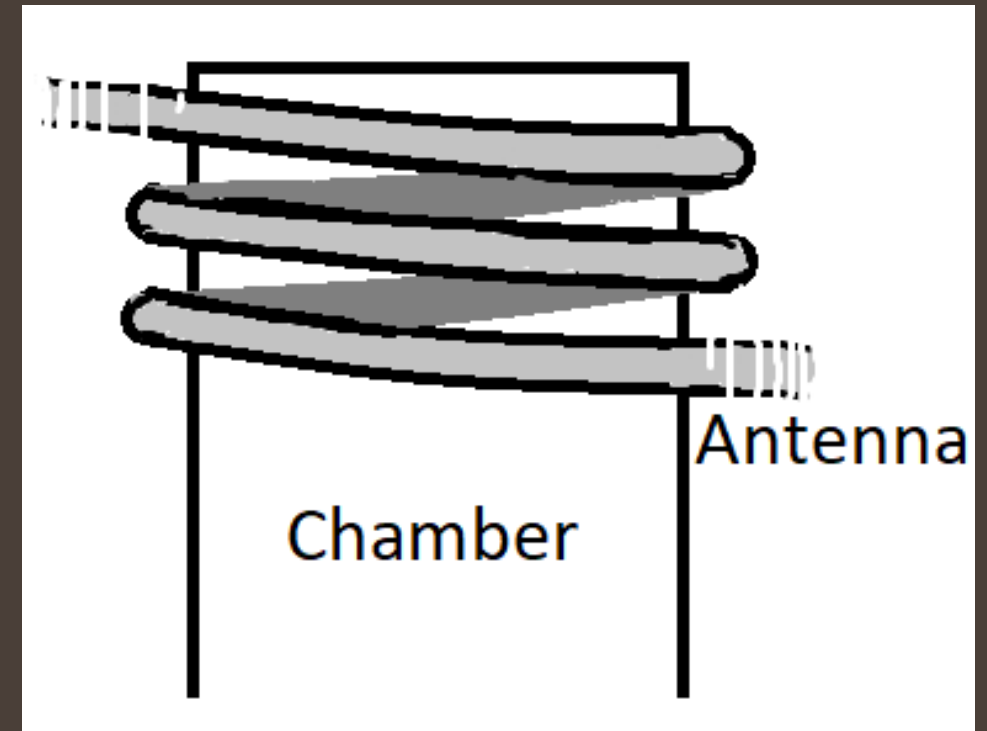
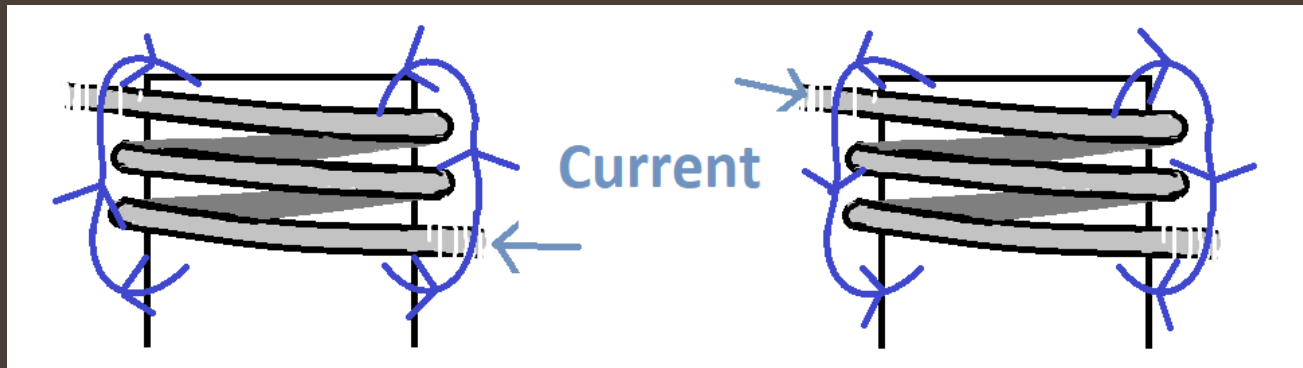


[Untitled image of plasma] [photograph]  
Retrieved from  
<https://geekswipe.net/science/physics/why-does-microwaving-a-grape-produce-plasma/>

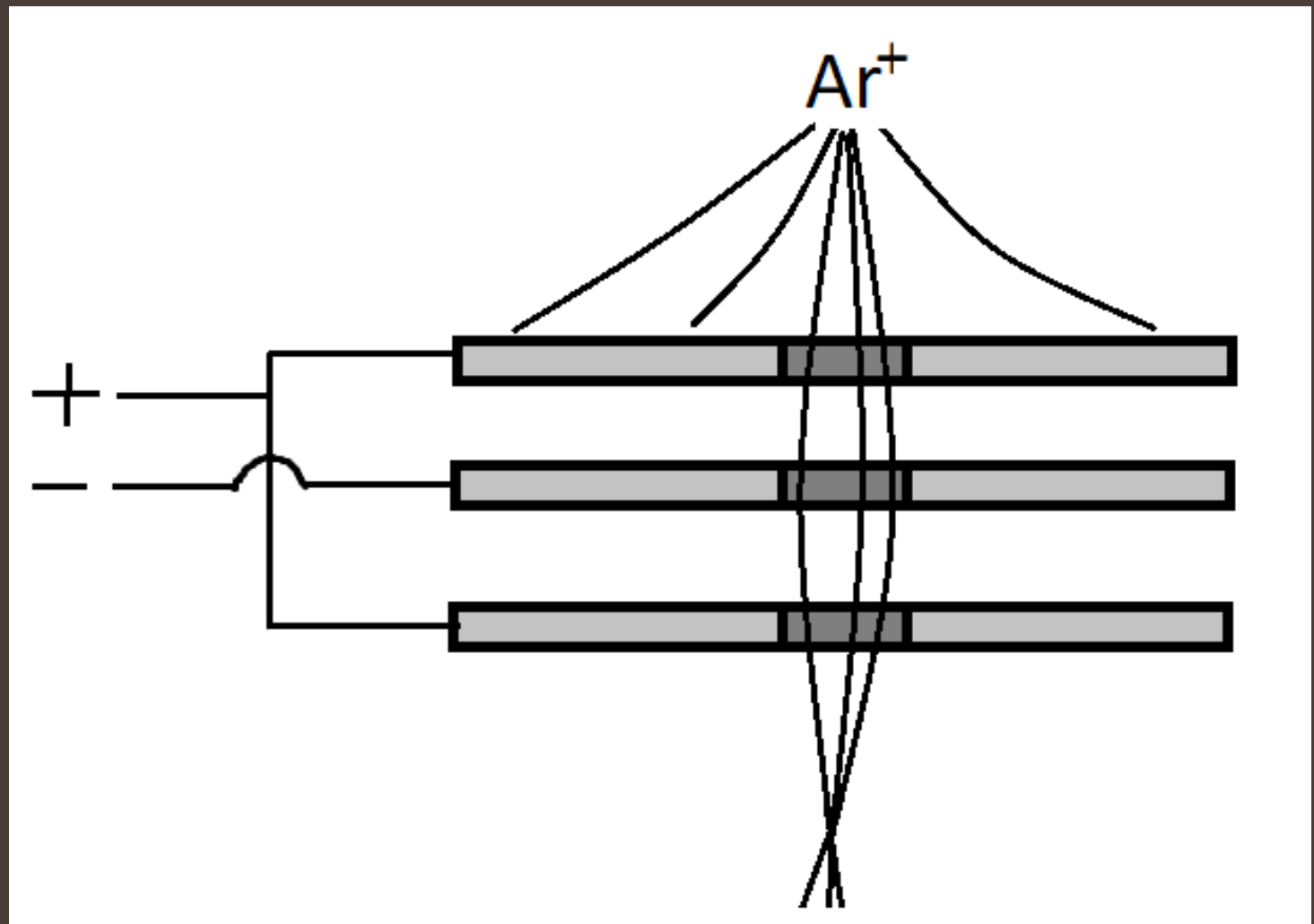


# Inductively Coupled Plasma (ICP)

- Typically consist of chamber, antenna, and extraction system
- Radio frequency (RF) signal passes through antenna



# Extraction System





# Ferrite ICP

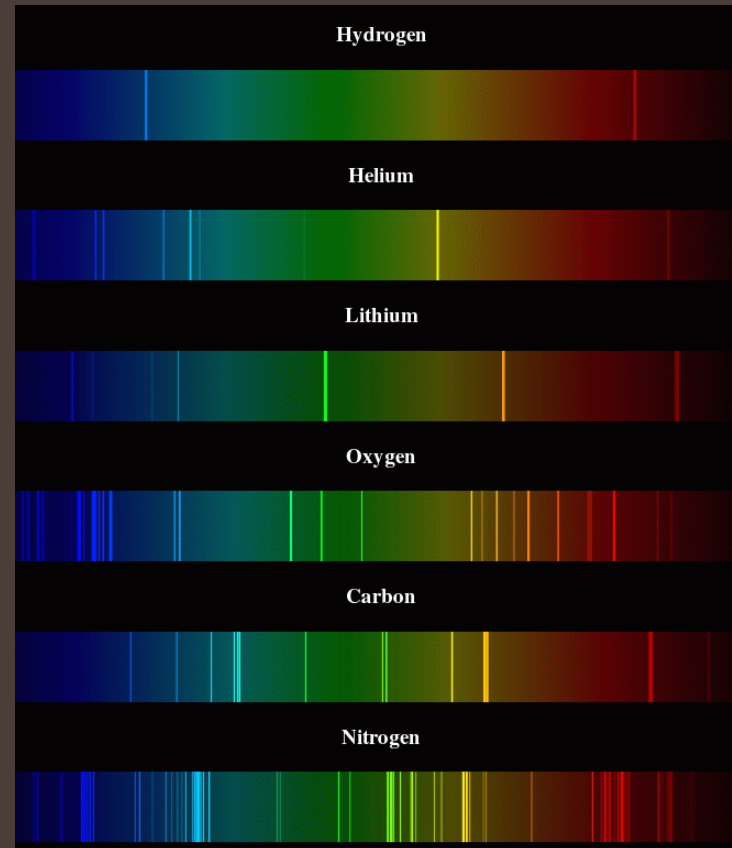


Ferrite ICP design by J. Bang and C. Chung, from *Development of Ferrite-Enhanced Side-Type Inductively Coupled Plasma*

## 2. Radio Frequency Source

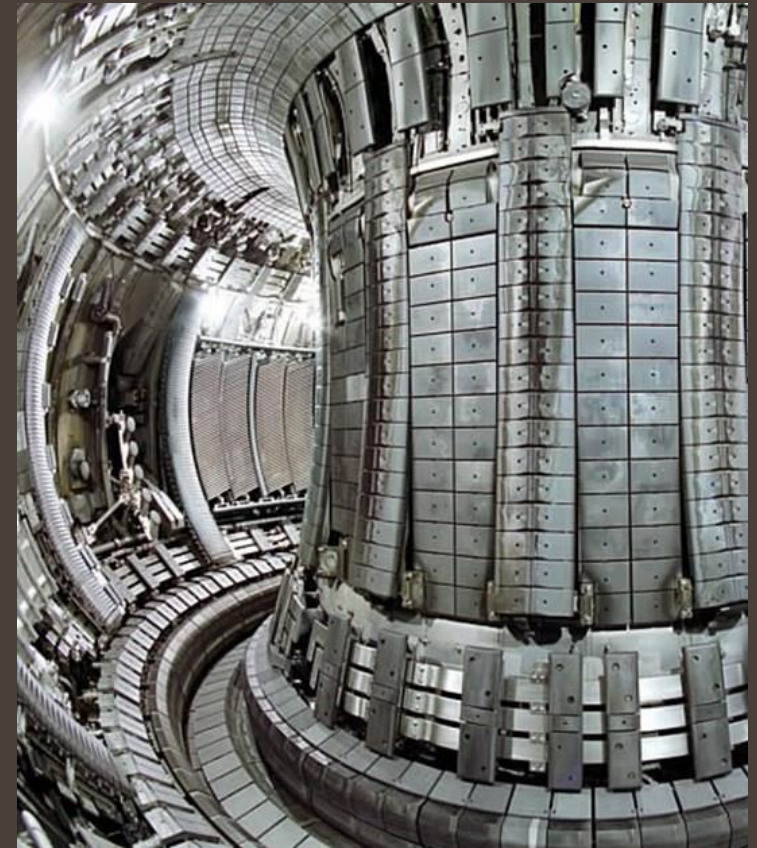
# Significance

## Spectroscopy



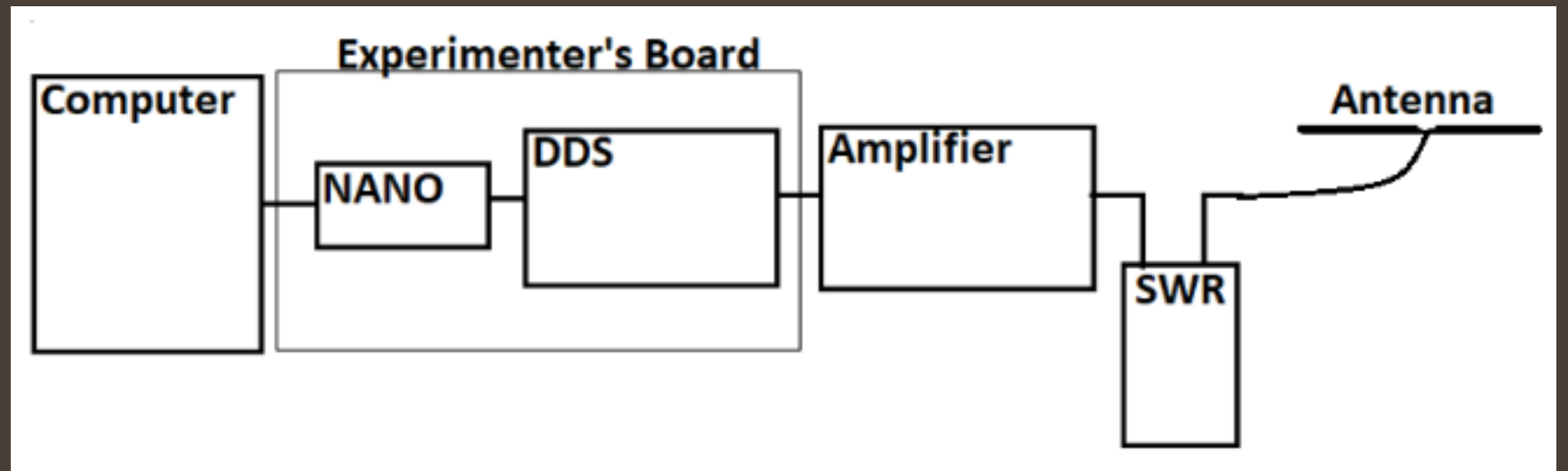
Retrieved from  
<https://www.astro.rug.nl/~ndouglas/teaching/ObservingTechniques/spectroscopy.html>

## Nuclear Reactors



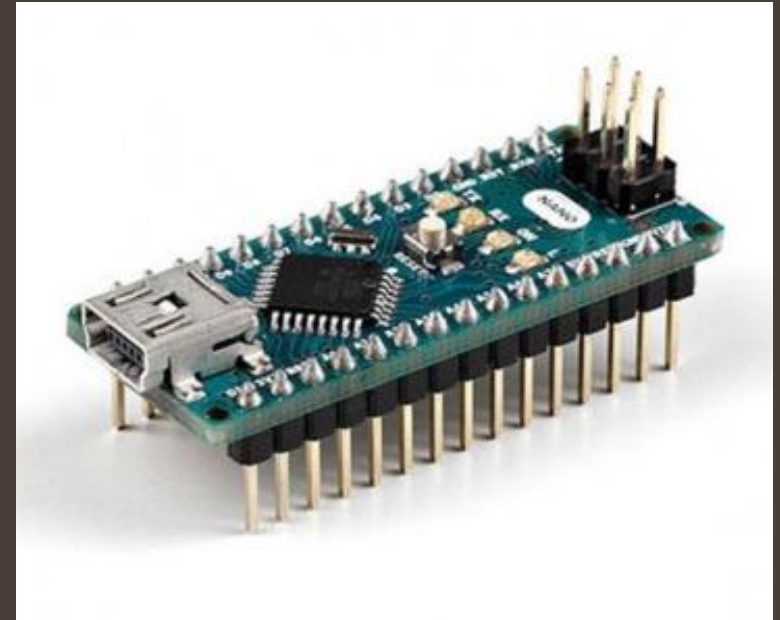
Retrieved from  
<https://www.iter.org/sci/MakingitWork>

# Components



# Arduino NANO

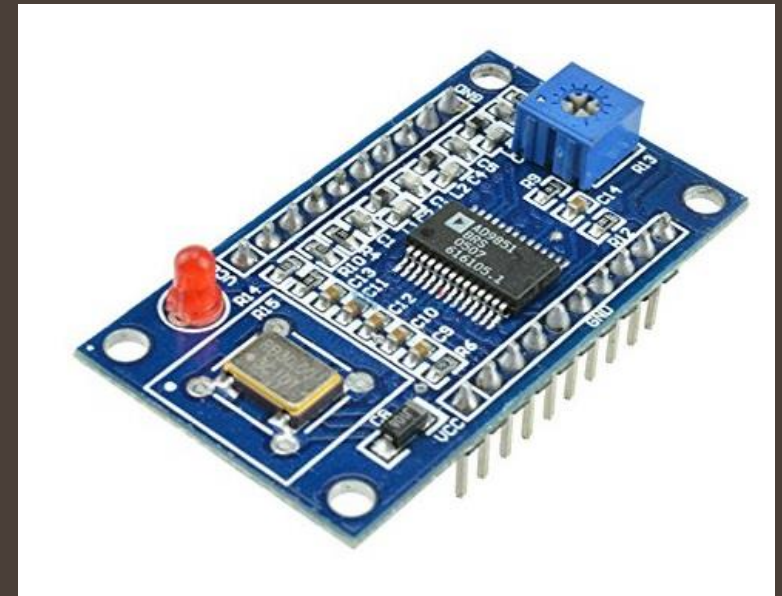
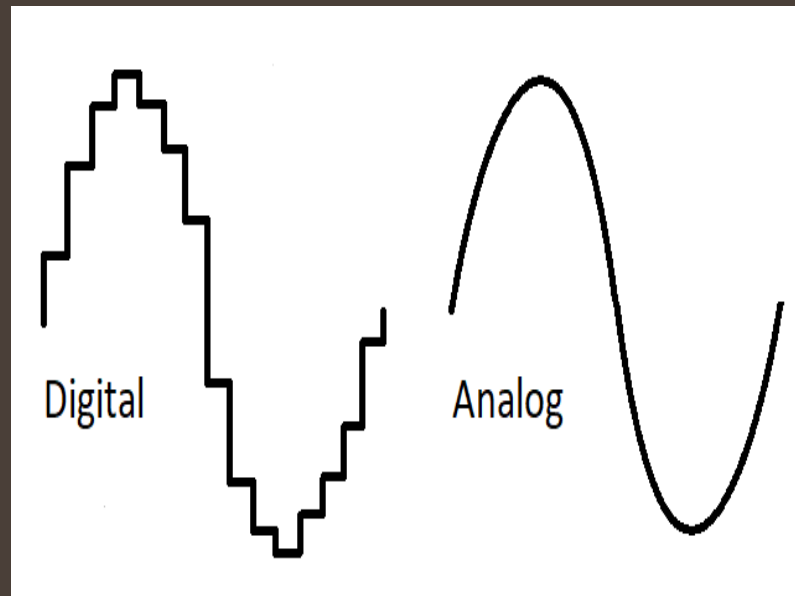
- A versatile microcontroller
- Programmable for read-world interaction



Retrieved from <https://store.arduino.cc/usa/>

# DDS AD9851

- Produces a signal in the form of a wave



Retrieved from  
<https://www.amazon.com/AD9851-Signal-Generator-0-70MHz-Low-Pass/dp/B076KPLTQF>



# Amplifier

- DDS's signal needed to be amplified



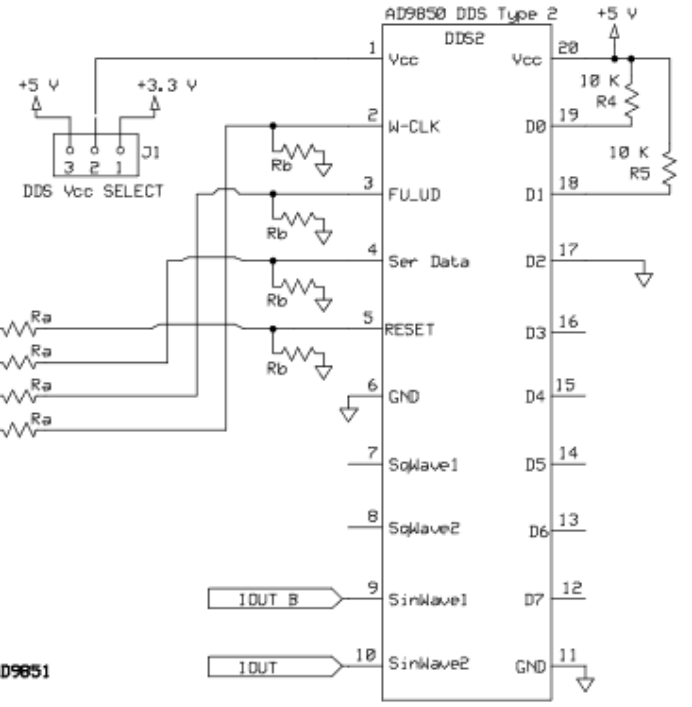
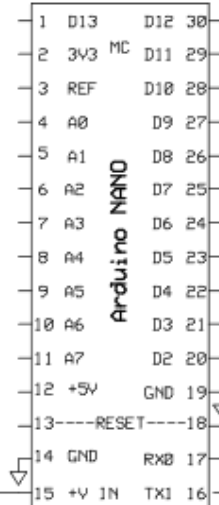
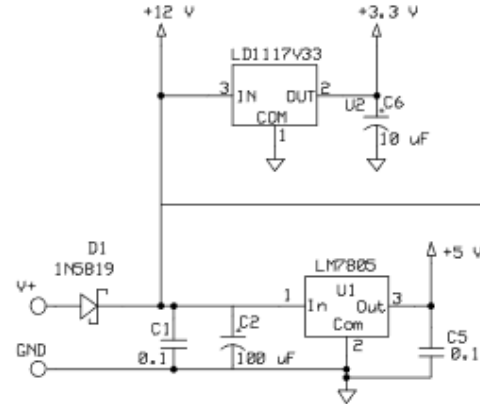
Retrieved from  
<https://www.aliexpress.com/item/1PC-1MHz-700MHz-3-2W-HF-VHF-UHF-FM-Transmitter-RF-Power-Amplifier-For-Ham-Radio/32823282228.html>

# Experimenter's Board

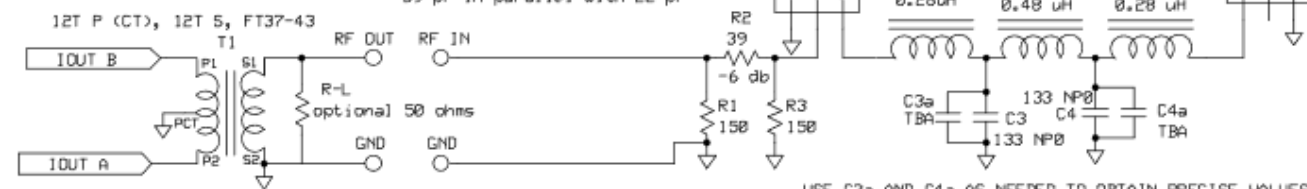
ONLY THE DEDICATED CONNECTIONS ARE SHOWN  
MANY OTHER PINS OF THE NANO  
AND SEVERAL OF THE DDS MODULE  
ARE BROKEN OUT TO PCB PADS

THE TWO PULLUP RESISTORS (R4, R5) ARE OTIONAL  
U2 IS OPTIONAL WHEN THE DDS REQUIRES A 3.3 V SUPPLY

IF DDS Vcc = +3.3 V :  
ALL Ra = 1 K, ALL Rb = 2 K



**Filter Components for use with AD9851**  
L1 & L3 0.13 uH 7T T37-10  
L2 0.22 uH 9T T37-10  
C3, C3a & C4, C4a 61 pF total  
39 pF in parallel with 22 pF

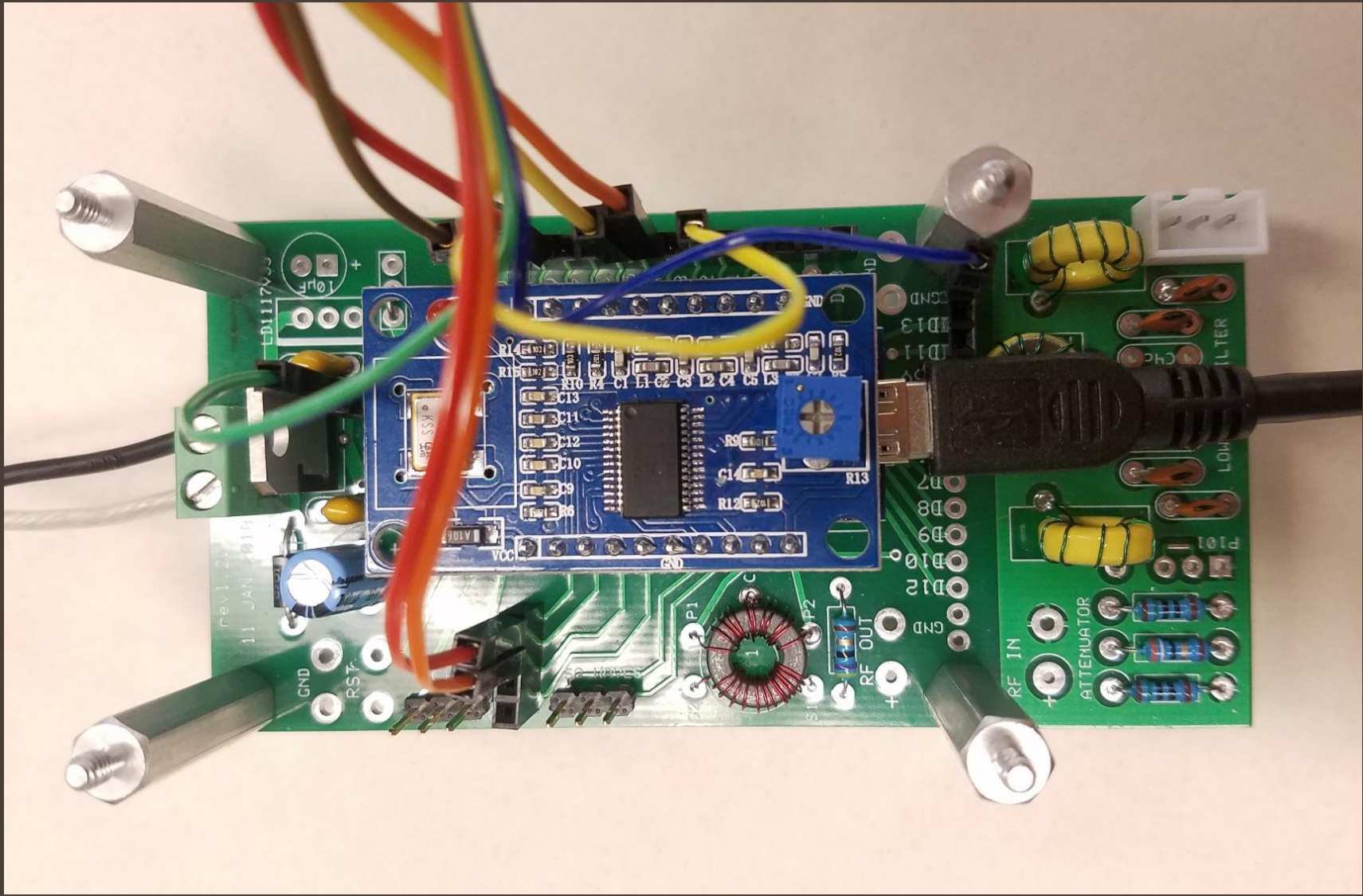


USE C3a AND C4a AS NEEDED TO OBTAIN PRECISE VALUES

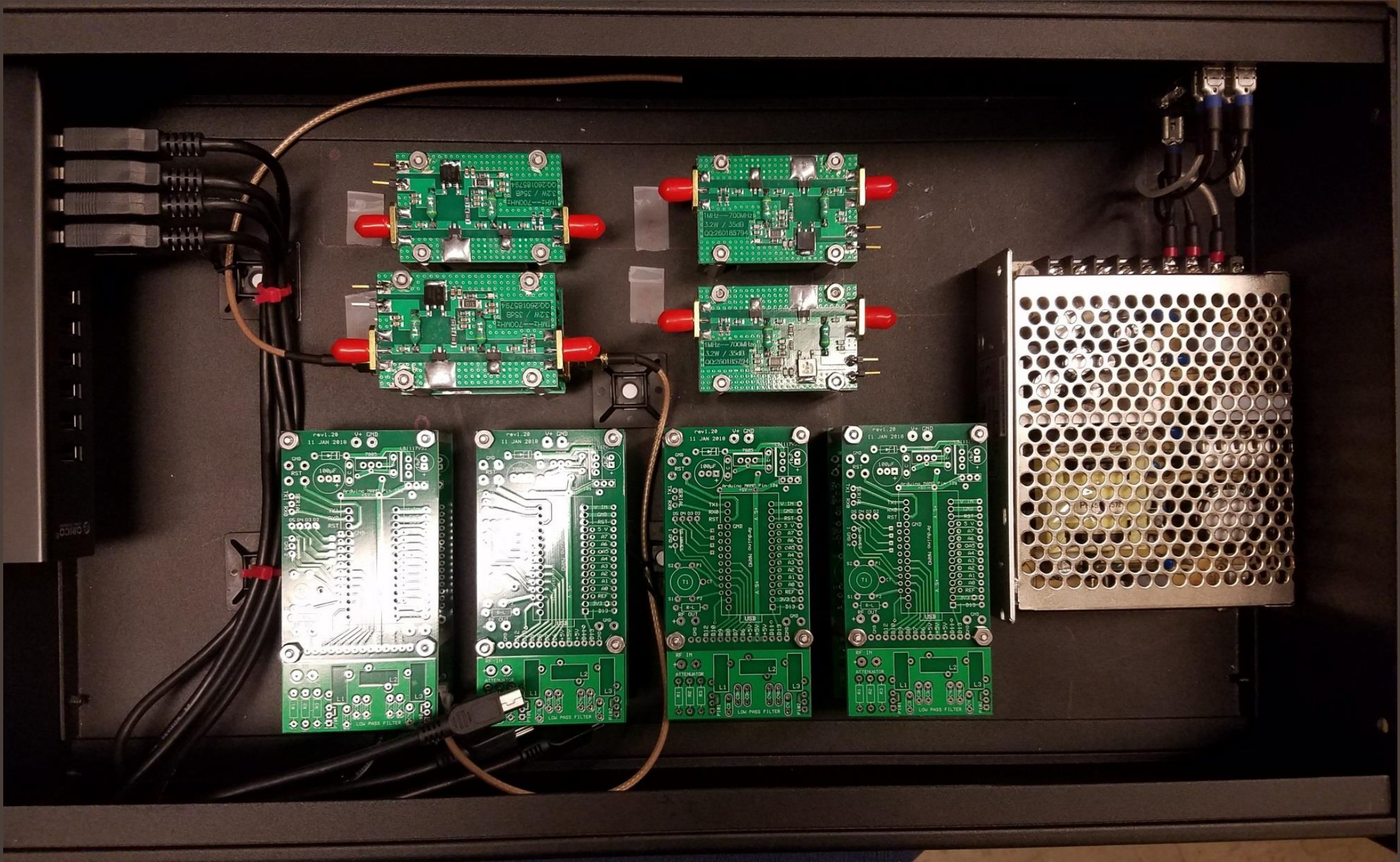
THIS IS THE SAME LPF CIRCUIT USED ON THE TYPE I AND TYPE II PHSNA  
VALUES SHOWN ARE FOR 32 MHz CUTOFF

E&M Solutions, LLC		
Type II DDS / NANO Experimenter Board		
Jim Giannacco NSLR	Rev 1.20	Page 1 of 3









# Acknowledgments

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