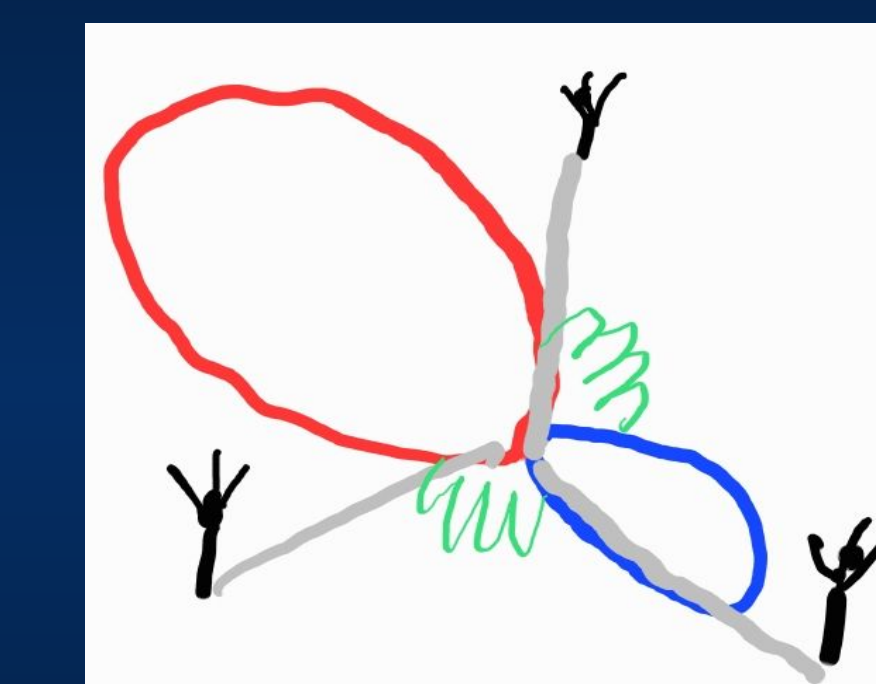


Phased Array for Duplex Communications on the 2m and 70cm Bands

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Introduction

Goal: Design and build a three-element phased array antenna system capable of duplex operation on amateur radio repeaters.

Constraints

- 70cm (~435 MHz) for reception
- 2m (~146 MHz) for transmission
- 0°, 90° and 180° phase shift delay lengths
- Easy control using microcontroller and relays
- Affordable for amateur radio hobbyists

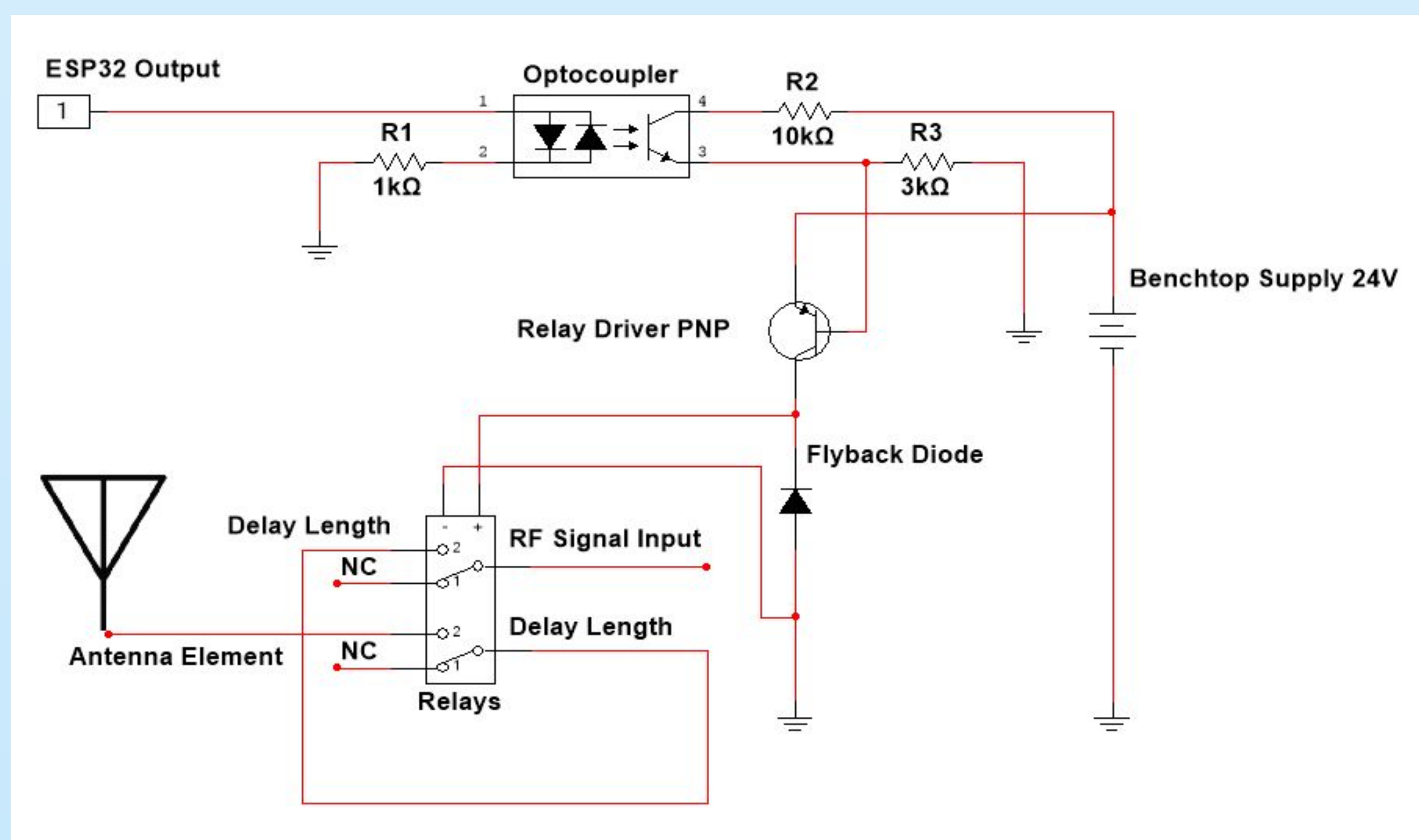
Methods

Programmable relay switchboard

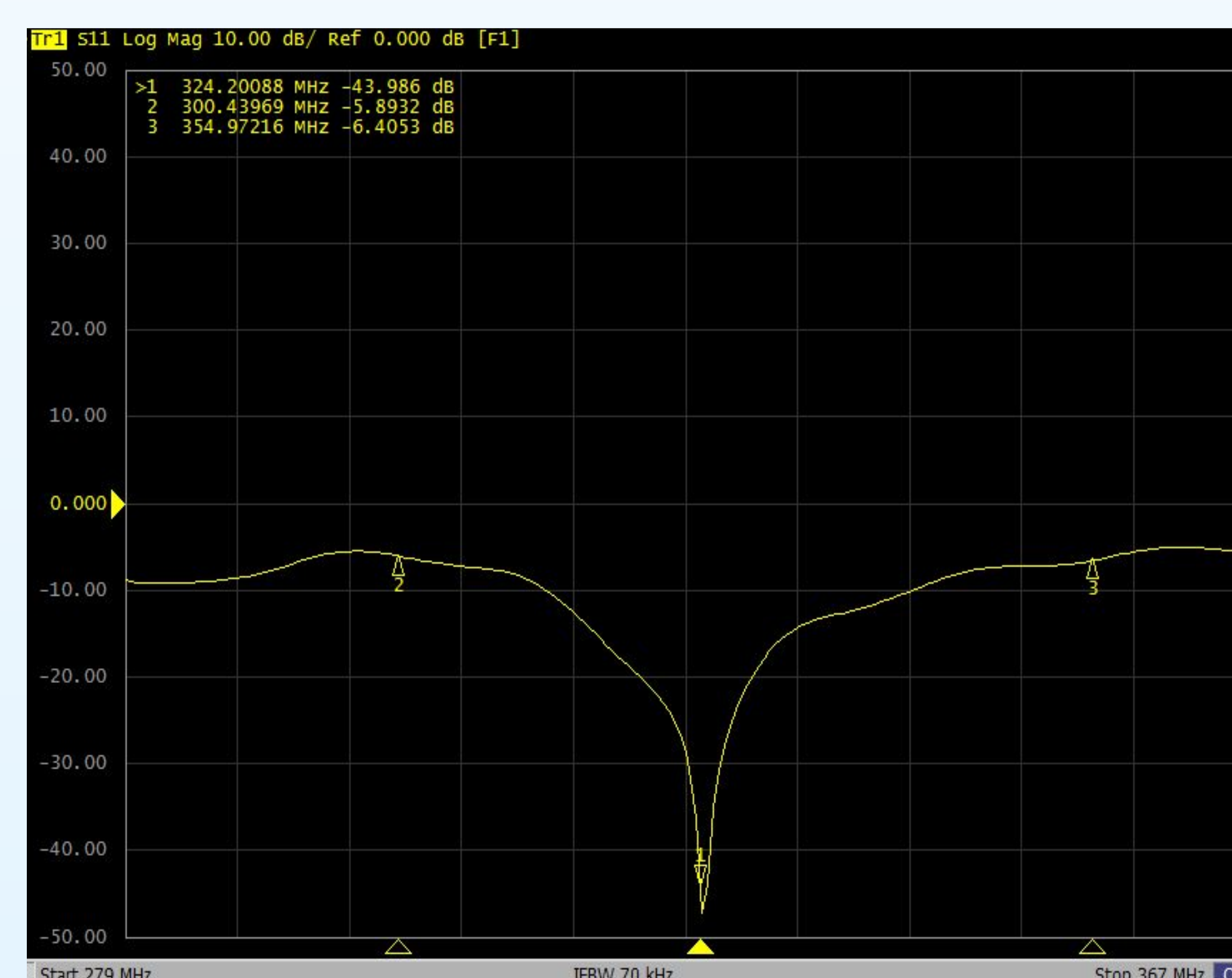
- Written in C, executed on ESP32
- Implements optocoupler for DC-DC isolation
 - Voltage divider from output drives relay transistor
- Flyback diode across relay for voltage protection

Antenna array

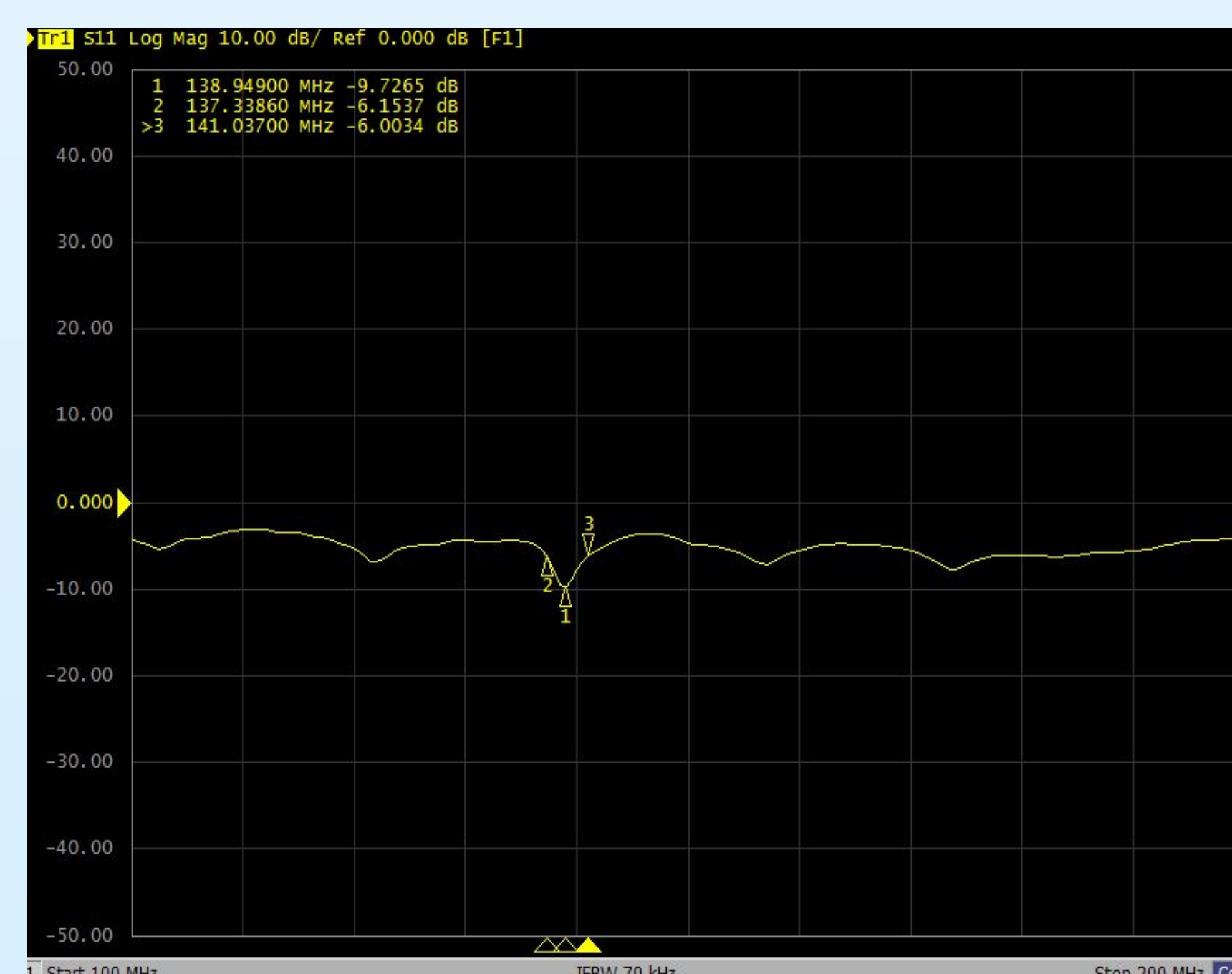
- PVC pipe structure to hold elements
- Custom 3D printed fitting to hold PVC segments
- Copper pipe half-wave vertical elements
- Relays to switch between delay lengths to implement phase shift before transmission



Results



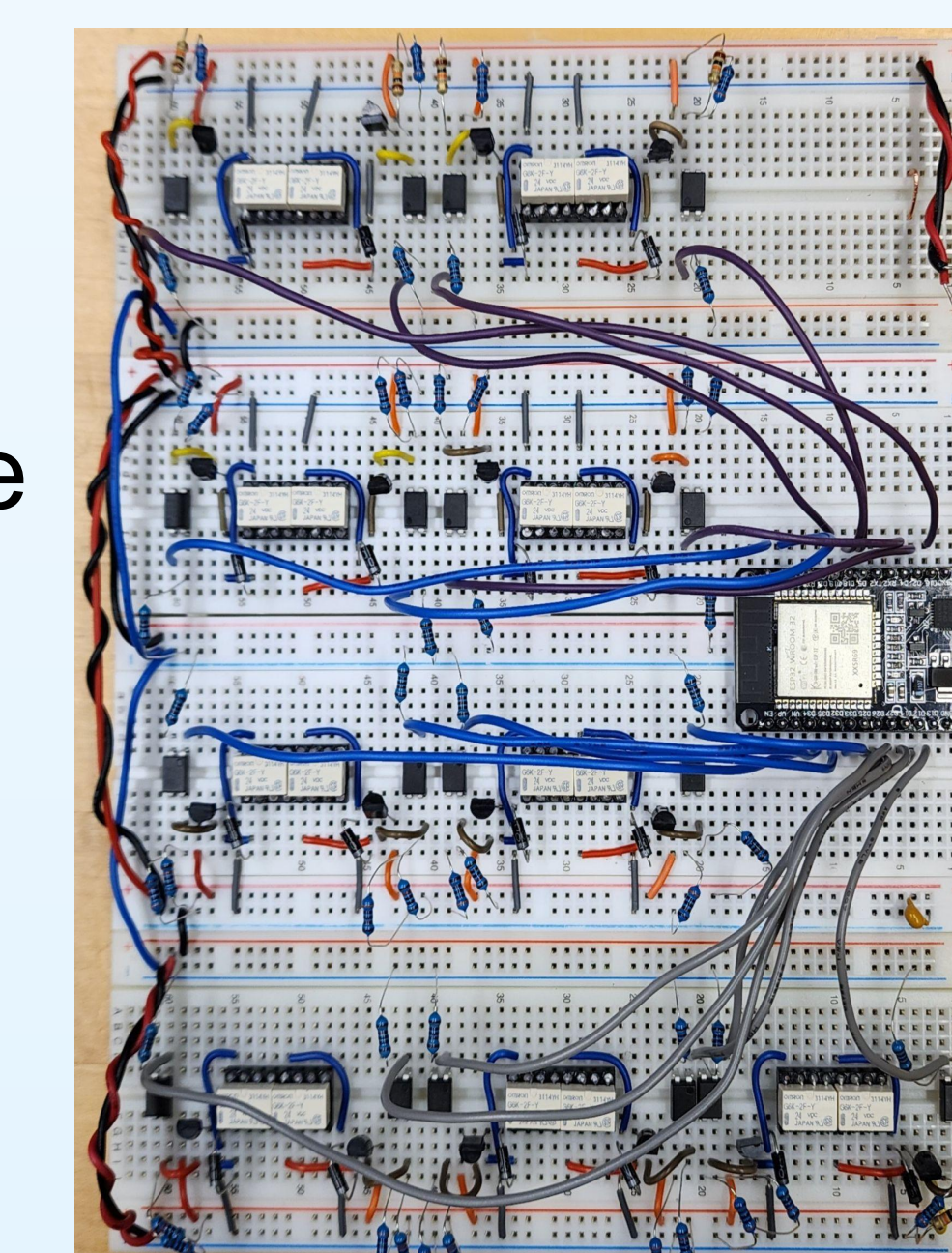
- 70cm single element with 0° phase shift
- 30.77 MHz bandwidth for 70cm in-phase



- 2m active configuration using in-phase, 90° and 180° delay lengths
- 11.98 MHz bandwidth for 2m in-phase

Discussion

- Return loss for all delay lengths is below -9dB
- Relay board connects the input signal to antenna transmission lines for all 18 delay lengths
- Design adjusted from J-pole to dipole elements to achieve more effective directionality
- 50Ω coaxial cable used to implement delay lengths
- Effective element length is longer than expected
 - Shortening element lengths would increase center frequency



Future Improvements

Programmable relay switchboard

- Wireless control functionality
- PCB to replace breadboard for relays and control circuitry
- SMA connections for delay lengths



Antenna array

- Replace element mounts with custom 3D prints
- More robust connections between coax lengths and elements
 - Replace breadboard with PCB and SMA connectors
- Explore matching techniques for decreasing reflections on the desired frequency bands
- Utilize VHF/UHF antenna tuner to match array to 50Ω radio output
- Weatherproofing for outdoor applications
- Shielding against electromagnetic interference

Phased Array Frequency Response

	Return Loss (dB)	Center Frequency (MHz)	Bandwidth (MHz)
2m In-Phase	-38.69	164.48	11.98
2m 90° Shift	-34.44	131.99	7.64
2m 180° Shift	-25.86	136.93	7.35
2m Active Configuration	-9.72	138.95	3.64
70cm In-Phase	-43.99	324.2	30.77
70cm 90° Shift	-29.82	363.25	33.67
70cm 180° Shift	-32.68	309.98	51.26
70cm Active Configuration	-12.17	304.96	19.6