Automatic Calibration for Improved Suppression of Interference Signals in Wireless Receivers

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Abstract

With the increasing number of wireless devices in our surroundings, it becomes increasingly important to design radio frequency receivers for wireless communications with enhanced capabilities to suppress unwanted interference signals. The ongoing research efforts involve the development of new devices, circuits, and digital algorithms to improve the robustness of wireless receivers. As part of this goal, this research project focuses on the prototyping of an automatic calibration approach with an Arduino microcontroller, which is done dynamically on signal power detection and the use of digital control circuits. In the experiments, an attenuator is used to optimize the suppression of interference in analog radio frequency front-ends of wireless receivers.

Background

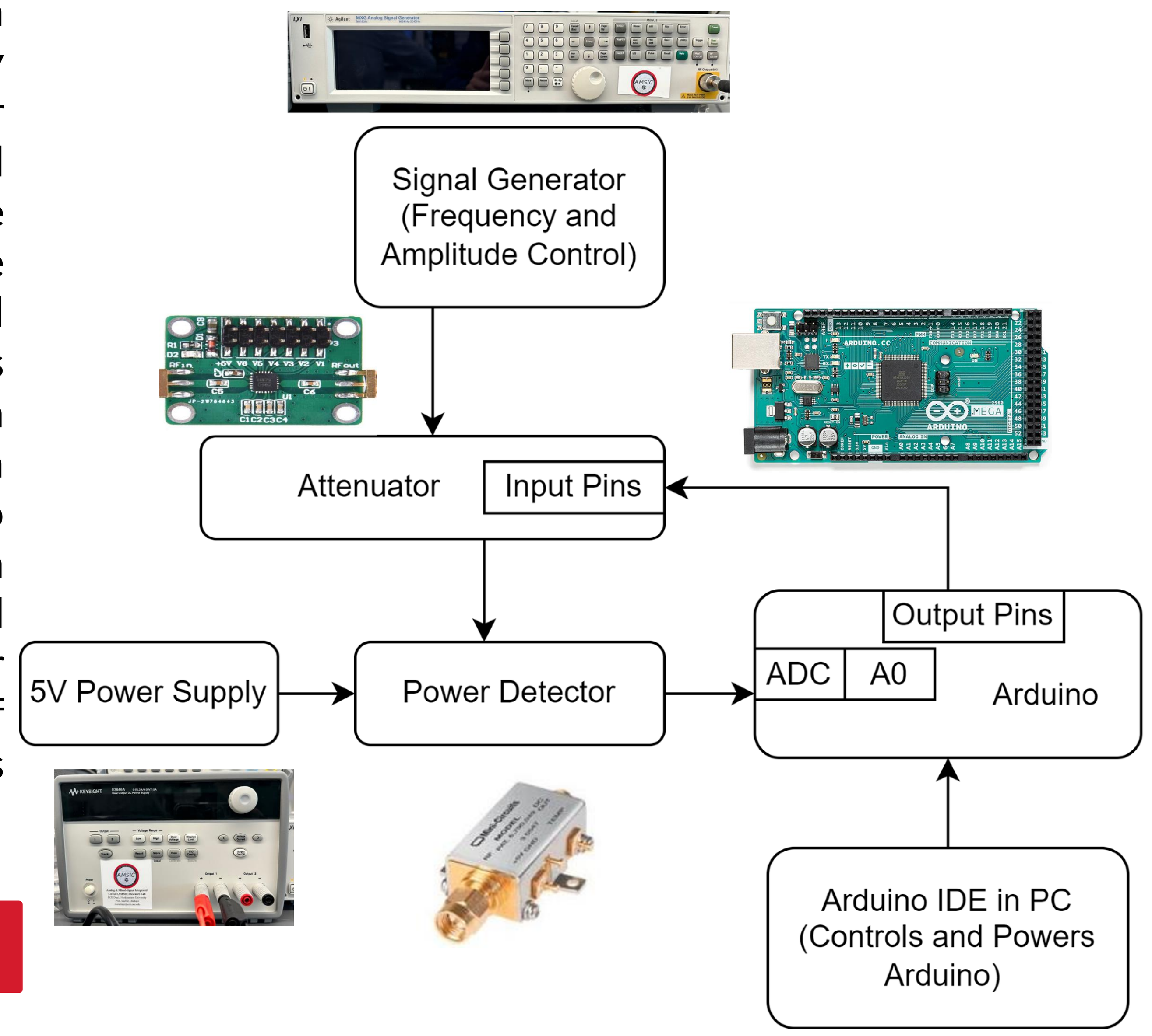
Interference:
Interference involves unwanted signals that disrupt desired signals in communication systems. Low-power receivers struggle with interference due to their narrow dynamic range, leading to issues like slow data transfer, dropped calls, buffering, and reduced battery life.

Frequency Selective Limiter (FSL):
The FSL is a more effective solution compared to traditional methods such as simple filtering. It attenuates signals within specific frequency ranges, especially those exceeding a predefined power threshold (P_{th}), helping to prevent distortion

in both the targeted and adjacent frequency bands.

Automatic Calibration:
Automatic calibration enhances the effectiveness of an FSL by allowing dynamic adjustment of attenuation levels to match varying signal environments. This ensures better interference reduction and adaptation to changes in signal strength.

Experimental Methods

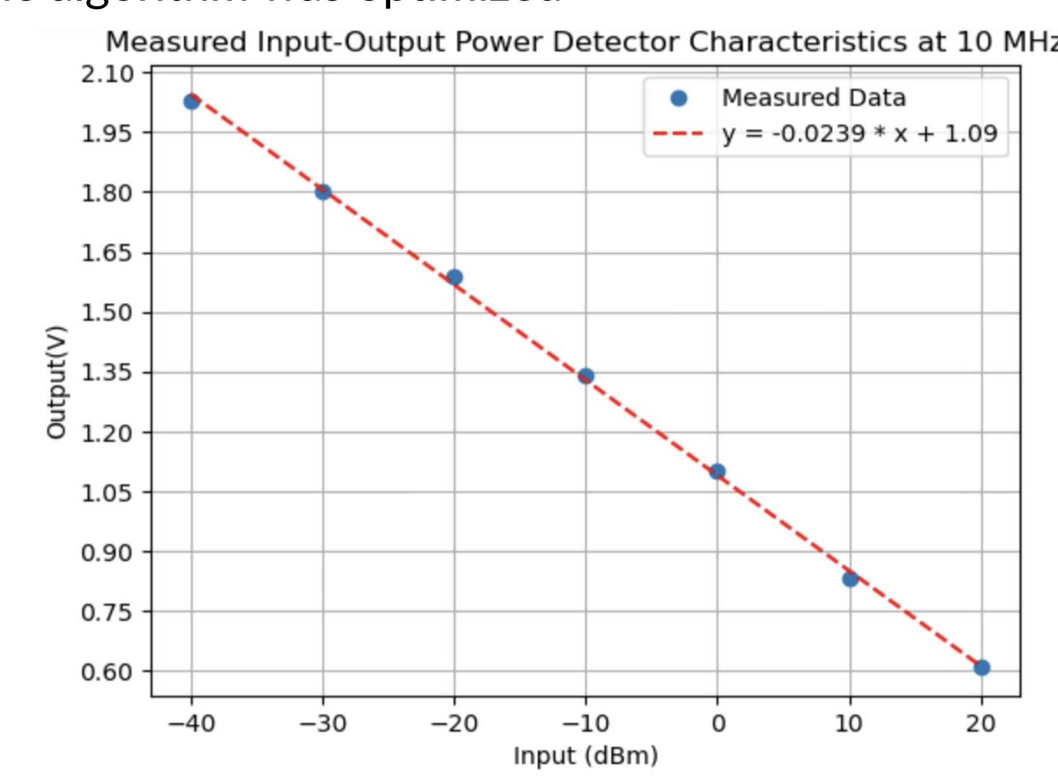


Equipment/Software Used:
- Analog Signal Generator
- Arduino IDE
- Arduino Mega 2560 Rev3
- RF Power Detector
- DC Power Supply
- Digital RF Attenuator

Power Detector:
- Power detector input-output characteristics were measured to find an equation for converting dBm to Volts
- Using the inverse, we convert from Volts to dBm in our code
- **Volt = -0.0239 * dBm + 1.09**
- **dBm = -41.841 * Volt + 45.6**

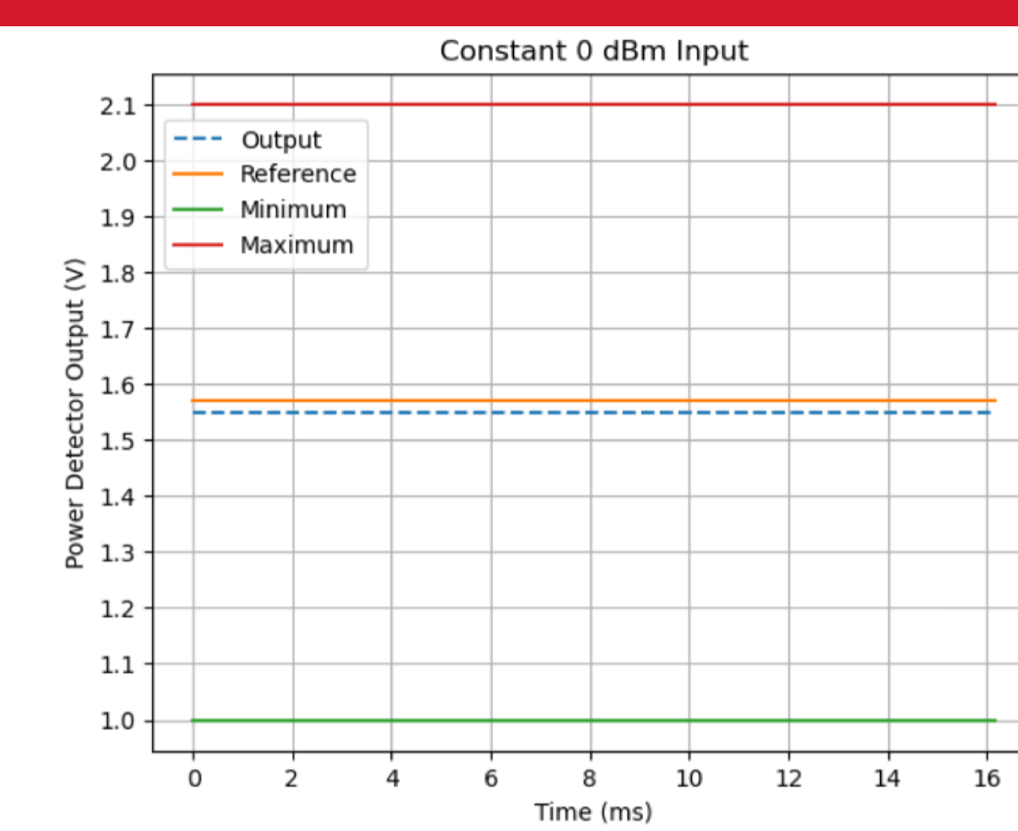
Component data collection:
- Tested how to set the attenuation level
- Recorded max. input/output voltages to prevent overload

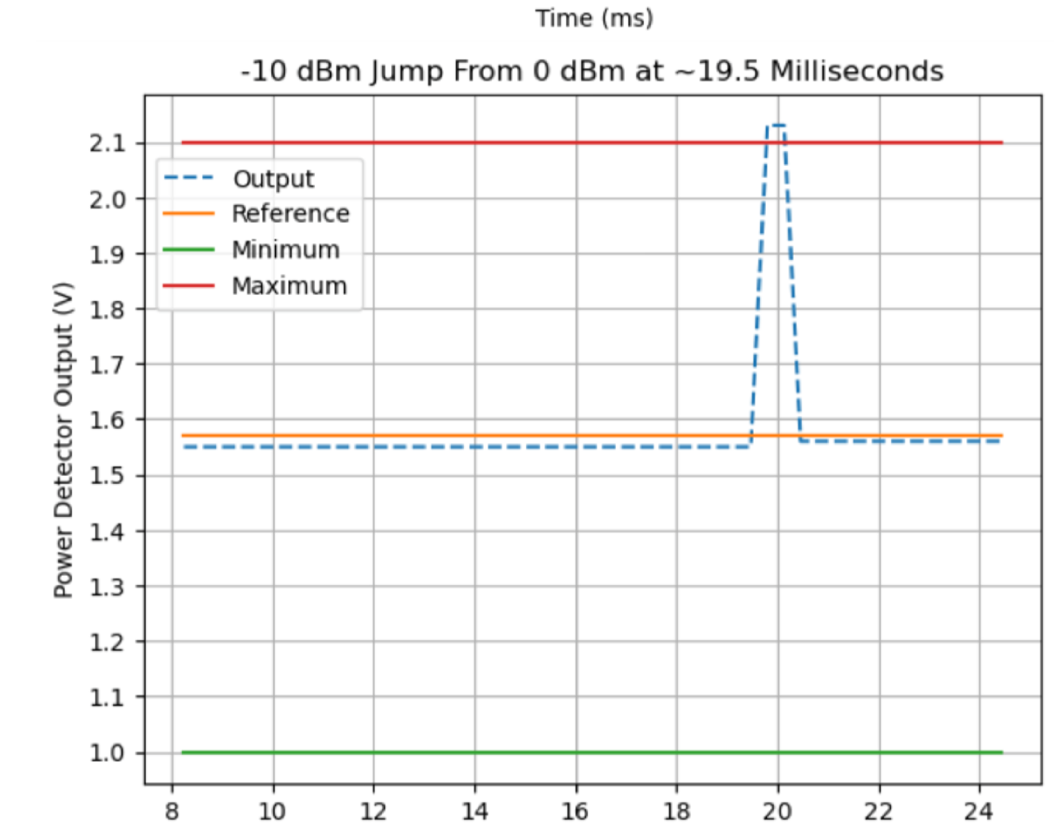
Dynamic Adjustment and Testing:
- Using the Arduino, we dynamically adjusted the attenuator based on a feedback control algorithm in the IDE.
- The algorithm was optimized



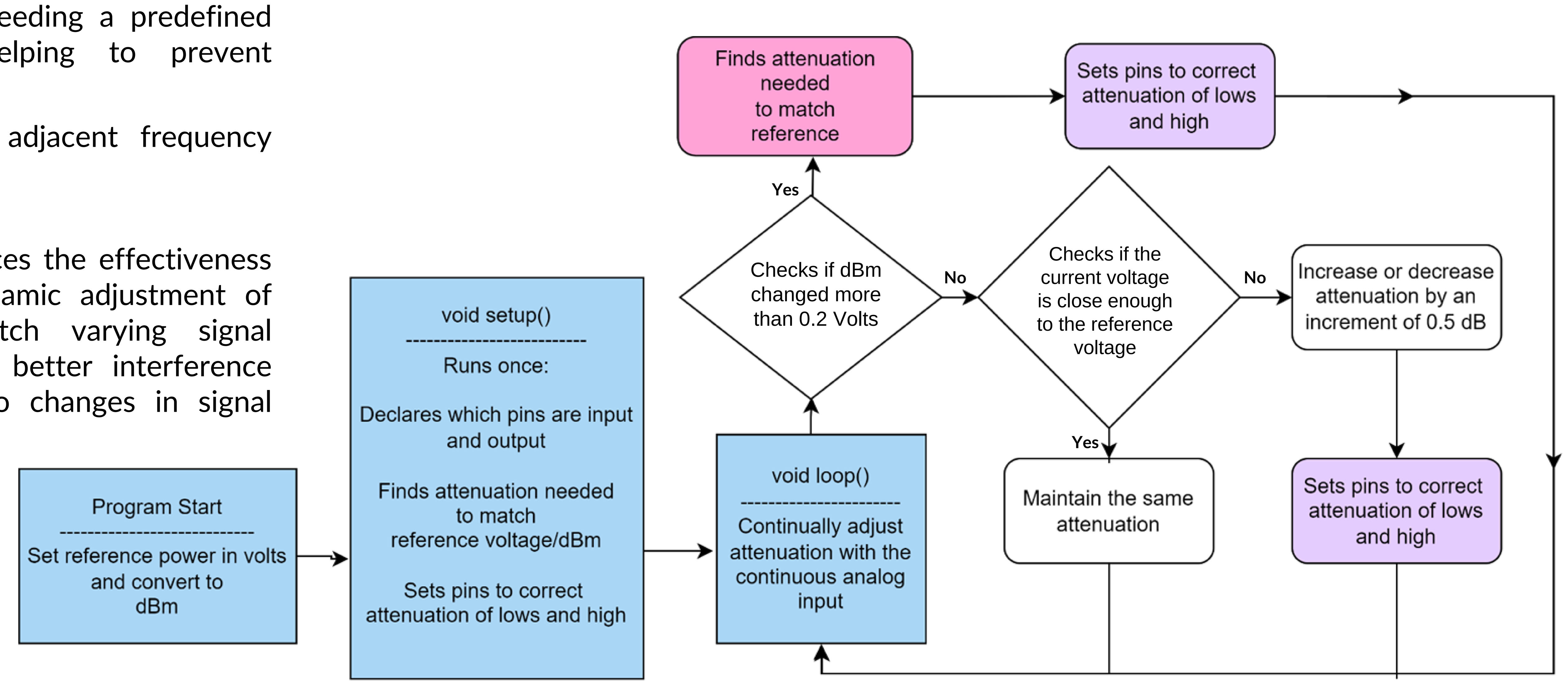
Results

Automatic Calibration Example:
- Our code is able to successfully detect a change in the power of the incoming signal and then recalibrate the attenuation level to match our reference voltage
- To the right, we have an example of the power changing from 0 dBm to -10 dBm. We can see how the output voltage (blue dashed) automatically calibrates back to the reference voltage of 1.57 volts (orange)





Calibration Flowchart:



Conclusion

Our results indicate that the same calibration approach can be utilized when the CMOS chip and FSL are available. The code and algorithm developed in this project can be modified to work directly with both, catering to the specific number of bits and delays. In the future, machine learning can be implemented into the algorithm to detect the specific signal frequency from the output voltage and the attenuation level to create specialized input-output equations that are not limited to 10 MHz.

References

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