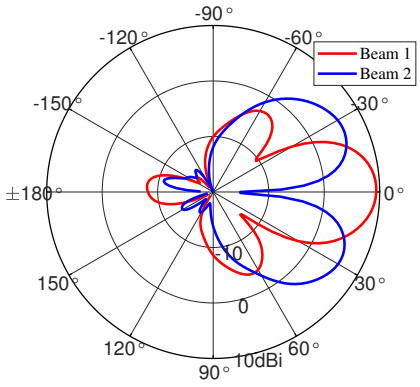

Figure 3: Simulated antenna patterns

proper beam for transmission. First, we measure the VCO frequency span by controlling the tuning voltage of the VCO. We utilize an N9030A PXA signal analyzer to measure the frequency of the signal transmitted by our prototype. Figure 4 shows the generated frequency of the VCO when the control voltage is changed from 3.5 to 5 V. As shown in the figure, the signal's carrier frequency ranges from 23.95 GHz to 24.25 GHz, providing 255 MHz of frequency span. This frequency span is more than what is required to cover the 24 GHz ISM band, therefore the mmPi prototype is able to change its center frequency to transmit on any channel assigned by the receiver.

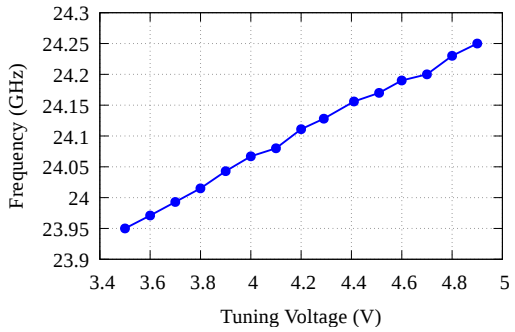

Figure 4: VCO's control voltage vs. carrier frequency

3.3 Range

In the next experiment, we empirically measure the radiated power of mmPi to evaluate the potential range of the designed communication system. We measure the received signal strength by a N9030A PXA Signal Analyzer using a patch and a horn antenna as the receiving antenna. The horn antenna is a Quinstar QWH-KPRS-00 antenna that provides about 20 dBi gain in the mid band. In addition, we have designed and fabricated the patch antenna, which provides about 6 dBi gain. we change the distance between the mmPi and the receiver from 1 to 7 meters and measure the LOS received signal. Figure 5 depicts the received signal strength when the receiver is placed at different distances from the mmPi board. The figure shows that the received signal strength is significantly high, sufficient to decode OOK signals even from distances as far as 7 meters with a simple patch antenna. Note that the typical noise floor for a 10 MHz channel is about -100 dBm. Therefore the signal strength values in Figure 5 are translated to high SNR values (i.e., 37 to 52 dB for the patch antenna).

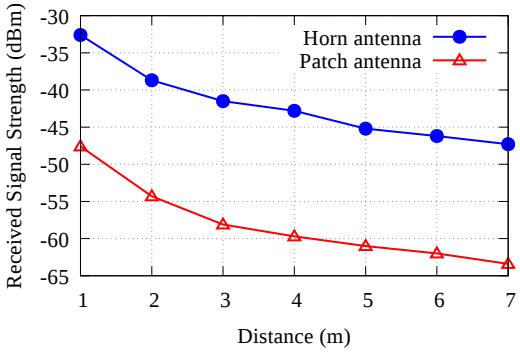

Figure 5: Measured Received Signal Strength (RSS) for different communication distances

4 CONCLUSIONS

In this work, we present the design of mmPi, a low-cost and low-power mmWave transmitter for Raspberry Pi. We experimentally evaluate the performance of our prototype implementation of mmPi. Our evaluations show that mmPi is able to tune its transmission frequency by adjusting the control voltage of the VCO. In addition, our measurements show that the received signal strength is strong enough for the on-off keying modulation when the distance between mmPi and the receiver is 7 meters or possibly more.

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