LOW COST DOPPLER RADAR FOR STORMWATER VELOCITY PROFILING

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Usually Doppler radars are intended to respond to the radial component of the velocity vector directly in line with the antenna main beam [1]. The availability of the low cost (< $5AUD), low power (5V DC), small size (37mm x 45mm x 8mm), X-band (f = 10.535 GHz) radar system HB100 [2] (Fig. 1) using four resonant patch antennas allows for stormwater network monitoring and potential flood prediction. By positioning this radar at the highest point inside the pipe and above the water surface, the unit can monitor the flow perpendicular to the radar beam and parallel to the pipe axis.

The finite beamwidth (36 degrees x 72 degrees [2]) results in specular reflections from both receding and oncoming ripples in the water surface. Assuming minimal air flow inside the pipe and no water movement perpendicular to the pipe axis, the surface ripple Doppler frequency shift can be determined.

Experiments were conducted in a rectangular water tank (910 mm x 38 mm x 45 mm). Fig 2 shows the frequency spectrum of surface water waves with the narrow beamwidth of the antenna array in the direction of flow. The waves were generated by a manually controlled paddle repeating at approximately 3 times each second. The stationary water surface was positioned 40 mm and 400mm below the radar antenna and the wave heights were approximately 10 mm.

The spectrum received is similar to that reported in [1] with a finite spectral Doppler bandwidth from 0.2-0.3 Hz so that the surface wave phase velocity can be determined from the Doppler spectrum. With a stated range of 20 m, the HB100 would be suitable for storm water pipes of all commonly available diameters and for almost all under-road culverts in Australia. The significance of this work lies predominantly in availability and utility of Doppler radar sensing of surface ripple velocity. There remains a challenge to convert this velocity to volume outflow in the confines of a stormwater pipe.

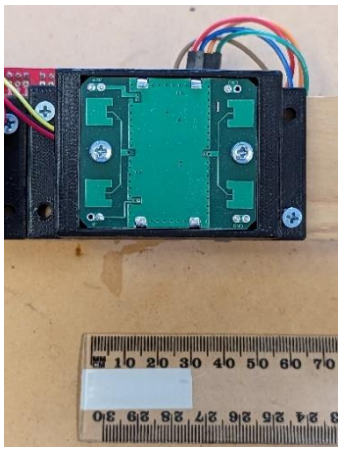

Fig. 1: HB100 antenna array.

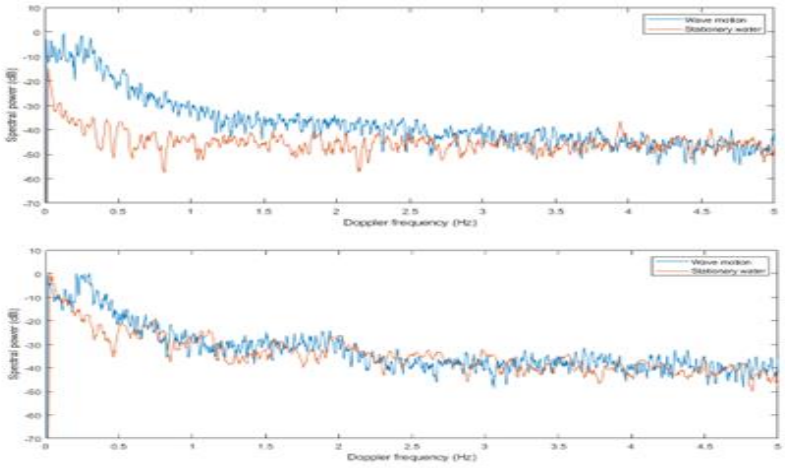

Fig. 2. The Doppler frequency spectrum (normalized dB) of the water current (blue line) and the stationary water surface (orange line) with 7 point moving average smoothing through both data sets. Top: 400mm range, Bottom 40mm range.

[1] F. Alimenti, S. Bonafoni, et al, "Noncontact measurement of river surface velocity and discharge estimation with a low-cost Doppler radar sensor", *IEEE Trans Geoscience and Remote Sensing*, vol. 58(7), pp 5195-5207, 2020.
[2] K. Kratzer, "Measurement of flow velocities of fluids by low-cost radar sensor HB100". https://www.th-deg.de/Fakult%C3%A4ten/emt/mapr-konferenz/Paper_Korbinan_Kratzer.pdf accessed 20 Nov 2023.