Ground Detection Sensor for Cane Harvester Base-Cutter Height Control

Thesis submitted by

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Abstract

The harvesting of sugar cane is the first stage in the commercial milling of sugar cane to produce sugar and plays a major role in determining the overall efficiency of the sugar production process. In Australia, where virtually all sugar cane is harvested using mechanical harvesters, efficient operation of the harvester is essential to reduce operating costs. One area of harvesting that has, on numerous occasions, been identified as an impediment to improved harvester efficiency is the adjustment of the base cutter height. Improper setting during harvesting has a number of serious consequences for sugar production including reduced production, crop damage, additional harvester running costs and inefficient transportation and milling of the sugar cane due to the introduction of dirt.

The overall aim of this thesis was to develop a ground detection sensor based on microwave radar technology that could sense ground level in front of a working sugar cane harvester. The eventual purpose of such a device would be to automatically control the cutting height to the optimum level and thus improving the efficiency of the harvesting, farming and milling processes.

The measurement technique investigated is based upon the use of a radio transmitter and receiver positioned on either side of the row of sugar cane. The principle of this design is that a receiver close to ground level would experience more attenuation from the soil than a receiver positioned well above ground

level. Thus, it was suggested that changes in the received signal strength with respect to the height above ground level could be used to detect changes in the height of the ground.

The project evolved in two main stages. Initially, work concentrated on verifying the sensing principle in the laboratory and later in the field. Testing verified the proposed measurement procedure with the following major conclusions. Firstly, for best results a radio signal of 2-3GHz polarised horizontal to the ground was most suitable. This signal provided the best compromise between being insensitive to the presence of the sugar cane while still allowing practical sized antennas to be employed. Secondly, field-testing showed that the sugar cane stalks do affect the ideal sensor response with the orientation and condition (density, leaf matter, etc) of the sugar cane having a noticeable influence on the measurements. These results suggested that a practical sensor would need to incorporate automatic compensation for the variations in the sugar cane and that some averaging or signal processing would have to be applied to remove the underlying trends.

The second stage of the project involved building a prototype sensor and testing it on a working sugar cane harvester. The prototype worked by measuring the received amplitude of a 2.4GHz, horizontally polarised microwave radio signal that was transmitted from one side of the sugar cane row to the other. For this application, multiple receivers are stacked vertically to measure the full height profile instantaneously. The idea of using multiple receivers with some

positioned well above the ground level, was to compensate for the changing density of the sugar cane. The transmitter and receiver antennas were based on rectangular microstrip patch antenna arrays. The low profile of these patch antennas meant that they were ideal for flush mounting on the harvesters' crop divider walls. Dedicated transmitter and receiver electronics was also needed to generate and detect the microwave radio signals used by this system. A full control system and data logger was developed for this application.

The prototype sensor that was developed was trialled on an Austoft harvester over a one week period in the Burnett region. Theses tests were used to confirm that the sensor would work and that it could survive the harsh conditions experienced during harvesting.

Overall, the aim of this thesis was to test the potential of the microwave ground height detection sensor for automated control of the base cutter height on sugar cane harvester and to develop a plan to use this technology in a commercial base cutter height control system.

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Declaration

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Publications arising from this work

1. WOODS, G.S., MASKELL, D.L. and RUXTON, A. "Microwave Ground Level Detection Sensor" 1999 Asia Pacific Microwave Conference, Singapore, 30 November - 3 December 1999, pp. 531-534.

2. PAGE, R.L. and WOODS, G.S. "Sensing of Ground Level through Sugar Cane using Microwave Techniques", Workshop on Applications of Radio Science (WARS'00), La Trobe University, 27th – 29th April, 2000.

3. WOODS, G.S. and PAGE, R.L. "Automated base cutter height control" JCU Sugar Technology 2000, Conference 8th November 2000.

4. WOODS, G.S., PAGE, R.L. and MASKELL, D.L. "Ground Height Detection Sensor for Control of Harvesting Equipment" 2002 Asia Pacific Microwave Conference, Kyoto, Japan, 19-22 November, 2002.

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