Wavetronix : High Performance Radar in the Traffic Industry

April 17th 2012
What Is Transportation Radar Performance

Reliable measurement of the following in all weather and across Industrial temperature range

Intelligent Transportations Systems (ITS)
- Volume of cars in each lane
- Vehicle speed
- Vehicle length

Intersection Detection
- Vehicle Presence in a zone
- Volume of cars in each lane
- Vehicle Time of Arrival at stop bar
Transportation Buying Process

DOT → Consultant → Contractors Bid

Government Buying:
Low bid mentality
State of Competition

CMD Single Sensor Licensing Price Model

• Vehicle Resolution >10’
• System subject to drift over time and temperature
• Tedious Configuration Process
• Problems with Jersey Barriers
• Speed estimate based on vehicle duration/ Avg veh len.
• Alignment of antenna temperamental
• Sensor cost about $4000
• Detection capability: 8 lanes, 200’, single side of road
Wavetronix Strategy

High performance radar
Version 1 (SS105)
• Digital wave radar – PLL locked to a crystal
• Auto configuration
• Antennas designed for application – easy installation
• Phase based speed measurement (Zero Doppler…)
• Address barriers in Software
• Detection capability 8 lanes 200’ – both sides of road

Version 2 (SS125)
• DDS based design
• 2 foot vehicle resolution
• Speed trap speed
• Detection capability 10 lanes 250’ – both sides of road
Frequency Modulated Continuous Wave (FMCW)

\[ \cos(\alpha) \cos(\beta) = \frac{1}{2} (\cos(\alpha - \beta) + \cos(\alpha + \beta)) \]
Wavetronix Strategy

High performance radar

Version 1 (SS105)
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Version 2 (SS125)
  • DDS based design
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  • Detection capability 10 lanes 250’ – both sides of road
A digitally driven transmit signal means the configuration never drifts. (Robust over temperature and aging)
Improved Range Resolution

FCC Unlicensed bands of interest
- Part 15.245 : 10.5 – 10.55 GHz (50 MHz of bandwidth)
- Part 15.249 : 24.0 – 24.25 GHz (250 MHz of Bandwidth)

Significance of Higher Frequencies
- Wavelength : 1 inch to 1.25 cm
- Smaller antennas
- Tighter manufacturing tolerances
Impact of Improved Resolution
Vehicle Based Detection

Zone Based – Defines a zone and then looks for vehicles inside the zone. – loops, radar, video, acoustic, etc.

- Vehicle Based – Finds vehicles then assigns it to a zone (lane)
Speed – Estimation Methods

Duration with average vehicle length
• Reasonable average speed measurement
• Problems with semi’s transition time & congestion

Doppler methods
• Doppler is zero at side fire position, but its derivative is at a maximum
• Phase slope can be used to measure speed
• Works best on the front or back of a vehicle
• Long vehicles provide a bias

Speed trap
• Measure delay between 2 antennas (use correlation)
• Most accurate method
Speed – Solve with Hardware
Separate Transmit and Receive Features
- amplification of the receive signal
- Reduced antenna separation – less speed accuracy
SmartSensor Speed Data
Speed – Improved with Transceiver Design

Increased antenna separation improves speed performance
Transceiver Design

No amplifier prior to mixing down

• Center fed antenna to reduce loss
• Microstrip transmission lines to reduce loss
Completed RF Board

- New Filters
- Via Feed Structure for Antennas
- RF Switch
- Mixers
Initial Antenna Response of Board
Revised Antenna Responses (Using RF Absorber)

Best Microstrip Performance

Best Co-planar Performance
Speed Performance of HD vs XCVR Lns 1, 2

Histogram of Lane 1 HD Spds
44'

Histogram of Lane 2 HD Spds
56'

Histogram for Lane 1 - 28'

Histogram for Lane 2 - 40'

More 1

More 0

Bin
-8 1
-7 0
-6 0
-5 2
-4 7
-3 21
-2 61
-1 93
0 37
1 8
2 0
3 3
4 0
5 0
6 0
7 0
8 0
More 1

Bin
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-7 0
-6 0
-5 1
-4 1
-3 4
-2 11
-1 37
0 26
1 3
2 0
3 0
4 0
5 0
6 0
7 0
8 0
More 0

More 83
Speed Performance of HD vs XCVR Lns 3, 4

Histogram of Lane 3 HD Spds 141'

Histogram for Lane 3 -89'

Histogram of Lane 4 HD Spds 153'

Histogram for Lane 4 -102'

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Remaining Problem

Large number of invalid speeds (low correlation) in 1st lane of roadway
Attributed to variability in the bounce path – the problem is worse when rumble strips are used
Proposed Solution

Vertically polarized antennas

Brewster’s Angle ($\theta$)

Reflecting media (asphalt, concrete or dirt)

Reflection Coefficient for Asphalt

![Graph showing reflection coefficient for asphalt with H-Pol and V-Pol lines.]
Intersection Stop-bar Detection

Requirements

- Detection based on two-dimensional position
- Detect stopped vehicles
Potential Technologies

Monopulse

• Measure angle of vehicle by ratio of $\Delta/\Sigma$ antenna patterns
• Vehicles at same range are differentiated using Doppler
• Centroiding can be a problem
Potential Technologies Cont’d

Multiple fixed beams

- Angle to vehicle determined by beam it is detected in – can do interpolation
- Vehicles at same range are differentiated using separate beams
  - Good for stopped traffic
- Potentially more expensive
Resolution at the Stop Bar

What if…

Vehicle Responses

Signal Level (dB)

0 20 40 60 80 100 120

0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7

Pulse Number

x 10^4
End Result
End Result

Matrix heatmap test 3.mov
Q & A
Thanks!