**Gatekeeper Module (Gatekeeper Systems model N-9390)**

**Theory of Operation**

The Gatekeeper Systems N-9390 wheel contains two microprocessors (NXP MKW31Z and ATMEL SAMS70 ) with a 2.4 GHz transceiver, a Acclelrometer, a Magnetometer, a flash memory, a Speaker driver with Speaker and LEDs. The MKW31Z uses two external crystals (32K and 32M) and ASMA70 uses another two crystal (32K and 12M) . The F antenna is internal to Module.

# 1 Module Functional Requirements

## 1.1 Provide real time direction of shopping cart

The module has a magnetometer sensor which is used to calculate direction of the cart realtime.

## 1.2 Bi-directional communication with the wheel(s)

When not in power save sleep mode, the module is in periodic bi-directional communication with the wheel(s). They communicate with each other using Athena FSK protocol in one of the defined Athena FSK channels (2.4GHz channel).

### 1.2.1Door marker message from wheel to module

When a wheel detects a door marker, it immediately communicates a door marker event to the module.

### 1.2.2Wheel rotation counts from wheel to module

The tracks its rotation count and periodically communicates it to the module.

### 1.2.3Wheel lock command from module to wheel

During navigation, if the module detects the cart going outside the defined perimeter boundary, it sends a lock signal to both wheels.

### 1.2.4Module lock warning alert

The module has a built in LED array and audio so that prior to sending a lock event to the wheel, the module can warn the user about a potential lock event about to happen. (Typical LED/audio pattern being blink LED and beep in alternating sequence for 6 seconds before physical locking of wheels)

### 1.2.5Module listens to Athena FSK broadcast messages

All modules listen to FSK broadcast messages. An example is a stop marker inside a store that is continuously sending stop events to all shopping cart entering the store. If accidently a shopping cart ends up navigating indoor, then by listening to this stop marker, a module can stop navigating immediately when it receives a broadcast message from stop marker.

## 1.3 Navigation Procedure

1) Wheel sends ‘door marker’ event to the module
2) On receiving ‘door marker’ event, module checks its calculated direction to determine if cart is moving outdoor or indoor.
3) If cart is moving outdoor, the module starts the navigation algorithm processing. It calculates the real-time position of the cart from the rotations it receives from the wheel(s) and the direction information it calculates.
4) If position of cart calculated is mapped to be outside the perimeter map it has in its memory, then the module will send lock command to the wheel after providing warning using its led and audio.

## 1.4 Module Sleep

When there is no cart movement for prolonged duration of time, it stops communicating with the wheel and goes to sleep to save battery power.

## 1.5 Motion Detection

The module has an accelerometer sensor which is primarily used to wake the module up from sleep. Once motion detected, the module tries to communicate with the wheel. The wheel in turn wakes up from sleep when there is a rotation.

## 1.6 Module orientation and location

There are two options to mount the module to a shopping cart:

### 1.6.1Shopping Cart Handle Mounting

When mounting a module to a shopping cart handle, it is typically mounted facing up at roughly 10deg angle with the horizontal ground plane.

### 1.6.2Sign Mounting

The module can also be mounted to the sign that goes on the inside of front portion of the cart. In this case it is mounted vertical to the ground plane facing up.

# 2. N-9390 RF 500 MSK Channel Plan

The N-9390 divides the complete 2401 – 2481 MHz operating band is divided into 256 channels, numbered 0 through 255.

When operating with 500 kbps MSK modulation, the center frequency of the Nth channel is 2401.0 + 0.3142N MHz.

***500 MSK Announce Channel Map***

| Channel | Frequency | Channel | Frequency | Channel | Frequency | Channel | Frequency | Channel | Frequency |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 2401.0000 | **52** | 2417.3384 | **104** | 2433.6768 | **156** | 2450.0152 | **208** | 2466.3536 |
| **1** | 2401.3142 | **53** | 2417.6526 | **105** | 2433.9910 | **157** | 2450.3294 | **209** | 2466.6678 |
| **2** | 2401.6284 | **54** | 2417.9668 | **106** | 2434.3052 | **158** | 2450.6436 | **210** | 2466.9820 |
| **3** | 2401.9426 | **55** | 2418.2810 | **107** | 2434.6194 | **159** | 2450.9578 | **211** | 2467.2962 |
| **4** | 2402.2568 | **56** | 2418.5952 | **108** | 2434.9336 | **160** | 2451.2720 | **212** | 2467.6104 |
| **5** | 2402.5710 | **57** | 2418.9094 | **109** | 2435.2478 | **161** | 2451.5862 | **213** | 2467.9246 |
| **6** | 2402.8852 | **58** | 2419.2236 | **110** | 2435.5620 | **162** | 2451.9004 | **214** | 2468.2388 |
| **7** | 2403.1994 | **59** | 2419.5378 | **111** | 2435.8762 | **163** | 2452.2146 | **215** | 2468.5530 |
| **8** | 2403.5136 | **60** | 2419.8520 | **112** | 2436.1904 | **164** | 2452.5288 | **216** | 2468.8672 |
| **9** | 2403.8278 | **61** | 2420.1662 | **113** | 2436.5046 | **165** | 2452.8430 | **217** | 2469.1814 |
| **10** | 2404.1420 | **62** | 2420.4804 | **114** | 2436.8188 | **166** | 2453.1572 | **218** | 2469.4956 |
| **11** | 2404.4562 | **63** | 2420.7946 | **115** | 2437.1330 | **167** | 2453.4714 | **219** | 2469.8098 |
| **12** | 2404.7704 | **64** | 2421.1088 | **116** | 2437.4472 | **168** | 2453.7856 | **220** | 2470.1240 |
| **13** | 2405.0846 | **65** | 2421.4230 | **117** | 2437.7614 | **169** | 2454.0998 | **221** | 2470.4382 |
| **14** | 2405.3988 | **66** | 2421.7372 | **118** | 2438.0756 | **170** | 2454.4140 | **222** | 2470.7524 |
| **15** | 2405.7130 | **67** | 2422.0514 | **119** | 2438.3898 | **171** | 2454.7282 | **223** | 2471.0666 |
| **16** | 2406.0272 | **68** | 2422.3656 | **120** | 2438.7040 | **172** | 2455.0424 | **224** | 2471.3808 |
| **17** | 2406.3414 | **69** | 2422.6798 | **121** | 2439.0182 | **173** | 2455.3566 | **225** | 2471.6950 |
| **18** | 2406.6556 | **70** | 2422.9940 | **122** | 2439.3324 | **174** | 2455.6708 | **226** | 2472.0092 |
| **19** | 2406.9698 | **71** | 2423.3082 | **123** | 2439.6466 | **175** | 2455.9850 | **227** | 2472.3234 |
| **20** | 2407.2840 | **72** | 2423.6224 | **124** | 2439.9608 | **176** | 2456.2992 | **228** | 2472.6376 |
| **21** | 2407.5982 | **73** | 2423.9366 | **125** | 2440.2750 | **177** | 2456.6134 | **229** | 2472.9518 |
| **22** | 2407.9124 | **74** | 2424.2508 | **126** | 2440.5892 | **178** | 2456.9276 | **230** | 2473.2660 |
| **23** | 2408.2266 | **75** | 2424.5650 | **127** | 2440.9034 | **179** | 2457.2418 | **231** | 2473.5802 |
| **24** | 2408.5408 | **76** | 2424.8792 | **128** | 2441.2176 | **180** | 2457.5560 | **232** | 2473.8944 |
| **25** | 2408.8550 | **77** | 2425.1934 | **129** | 2441.5318 | **181** | 2457.8702 | **233** | 2474.2086 |
| **26** | 2409.1692 | **78** | 2425.5076 | **130** | 2441.8460 | **182** | 2458.1844 | **234** | 2474.5228 |
| **27** | 2409.4834 | **79** | 2425.8218 | **131** | 2442.1602 | **183** | 2458.4986 | **235** | 2474.8370 |
| **28** | 2409.7976 | **80** | 2426.1360 | **132** | 2442.4744 | **184** | 2458.8128 | **236** | 2475.1512 |
| **29** | 2410.1118 | **81** | 2426.4502 | **133** | 2442.7886 | **185** | 2459.1270 | **237** | 2475.4654 |
| **30** | 2410.4260 | **82** | 2426.7644 | **134** | 2443.1028 | **186** | 2459.4412 | **238** | 2475.7796 |
| **31** | 2410.7402 | **83** | 2427.0786 | **135** | 2443.4170 | **187** | 2459.7554 | **239** | 2476.0938 |
| **32** | 2411.0544 | **84** | 2427.3928 | **136** | 2443.7312 | **188** | 2460.0696 | **240** | 2476.4080 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **33** | 2411.3686 | **85** | 2427.7070 | **137** | 2444.0454 | **189** | 2460.3838 | **241** | 2476.7222 |
| **34** | 2411.6828 | **86** | 2428.0212 | **138** | 2444.3596 | **190** | 2460.6980 | **242** | 2477.0364 |
| **35** | 2411.9970 | **87** | 2428.3354 | **139** | 2444.6738 | **191** | 2461.0122 | **243** | 2477.3506 |
| **36** | 2412.3112 | **88** | 2428.6496 | **140** | 2444.9880 | **192** | 2461.3264 | **244** | 2477.6648 |
| **37** | 2412.6254 | **89** | 2428.9638 | **141** | 2445.3022 | **193** | 2461.6406 | **245** | 2477.9790 |
| **38** | 2412.9396 | **90** | 2429.2780 | **142** | 2445.6164 | **194** | 2461.9548 | **246** | 2478.2932 |
| **39** | 2413.2538 | **91** | 2429.5922 | **143** | 2445.9306 | **195** | 2462.2690 | **247** | 2478.6074 |
| **40** | 2413.5680 | **92** | 2429.9064 | **144** | 2446.2448 | **196** | 2462.5832 | **248** | 2478.9216 |
| **41** | 2413.8822 | **93** | 2430.2206 | **145** | 2446.5590 | **197** | 2462.8974 | **249** | 2479.2358 |
| **42** | 2414.1964 | **94** | 2430.5348 | **146** | 2446.8732 | **198** | 2463.2116 | **250** | 2479.5500 |
| **43** | 2414.5106 | **95** | 2430.8490 | **147** | 2447.1874 | **199** | 2463.5258 | **251** | 2479.8642 |
| **44** | 2414.8248 | **96** | 2431.1632 | **148** | 2447.5016 | **200** | 2463.8400 | **252** | 2480.1784 |
| **45** | 2415.1390 | **97** | 2431.4774 | **149** | 2447.8158 | **201** | 2464.1542 | **253** | 2480.4926 |
| **46** | 2415.4532 | **98** | 2431.7916 | **150** | 2448.1300 | **202** | 2464.4684 | **254** | 2480.8068 |
| **47** | 2415.7674 | **99** | 2432.1058 | **151** | 2448.4442 | **203** | 2464.7826 | **255** | 2481.1210 |
| **48** | 2416.0816 | **100** | 2432.4200 | **152** | 2448.7584 | **204** | 2465.0968 | | |
| **49** | 2416.3958 | **101** | 2432.7342 | **153** | 2449.0726 | **205** | 2465.4110 | | |
| **50** | 2416.7100 | **102** | 2433.0484 | **154** | 2449.3868 | **206** | 2465.7252 | | |
| **51** | 2417.0242 | **103** | 2433.3626 | **155** | 2449.7010 | **207** | 2466.0394 | | |

**N-9390 RF 1M FSK Channel Plan**

The N-9390 divides the complete 2402 – 2480 MHz operating band is divided into 79 channels, numbered 42 through 120.

| **1M FSK Chan** | | | | | |
|---|---|---|---|---|---|
| Channel | Frequency(MHz) | Channel | Frequency(MHz) | Channel | Frequency(MHz) |
| 41 | 2401.0 | 70 | 2430.0 | 99 | 2459.0 |
| 42 | 2402.0 | 71 | 2431.0 | 100 | 2460.0 |
| 43 | 2403.0 | 72 | 2432.0 | 101 | 2461.0 |
| 44 | 2404.0 | 73 | 2433.0 | 102 | 2462.0 |
| 45 | 2405.0 | 74 | 2434.0 | 103 | 2463.0 |
| 46 | 2406.0 | 75 | 2435.0 | 104 | 2464.0 |
| 47 | 2407.0 | 76 | 2436.0 | 105 | 2465.0 |
| 48 | 2408.0 | 77 | 2437.0 | 106 | 2466.0 |
| 49 | 2409.0 | 78 | 2438.0 | 107 | 2467.0 |
| 50 | 2410.0 | 79 | 2439.0 | 108 | 2468.0 |
| 51 | 2411.0 | 80 | 2440.0 | 109 | 2469.0 |
| 52 | 2412.0 | 81 | 2441.0 | 110 | 2470.0 |
| 53 | 2413.0 | 82 | 2442.0 | 111 | 2471.0 |

| | | | | | |
|---|---|---|---|---|---|
| 54 | 2414.0 | 83 | 2443.0 | 112 | 2472.0 |
| 55 | 2415.0 | 84 | 2444.0 | 113 | 2473.0 |
| 56 | 2416.0 | 85 | 2445.0 | 114 | 2474.0 |
| 57 | 2417.0 | 86 | 2446.0 | 115 | 2475.0 |
| 58 | 2418.0 | 87 | 2447.0 | 116 | 2476.0 |
| 59 | 2419.0 | 88 | 2448.0 | 117 | 2477.0 |
| 60 | 2420.0 | 89 | 2449.0 | 118 | 2478.0 |
| 61 | 2421.0 | 90 | 2450.0 | 119 | 2479.0 |
| 62 | 2422.0 | 91 | 2451.0 | 120 | 2480.0 |
| 63 | 2423.0 | 92 | 2452.0 | 121 | 2481.0 |
| 64 | 2424.0 | 93 | 2453.0 | | |
| 65 | 2425.0 | 94 | 2454.0 | | |
| 66 | 2426.0 | 95 | 2455.0 | | |
| 67 | 2427.0 | 96 | 2456.0 | | |
| 68 | 2428.0 | 97 | 2457.0 | | |
| 69 | 2429.0 | 98 | 2458.0 | | |

[2] The Site Configuration message can be very loosely compared to the Dynamic Host Configuration Protocol (DHCP), as it contains a variety of parameters which configure the N-9390's behavior on the GS2V2 wireless network.