



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 Accelerometer, 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).

1.2.1 Door marker message from wheel to module

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

1.2.2 Wheel rotation counts from wheel to module

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

1.2.3 Wheel 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.

1.2.4 Module 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)

1.2.5 Module 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 accidentally 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:

1.6.1 Shopping 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.

1.6.2 Sign 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.