FUNCTIONAL SPECIFICATION
FOR
MONTY – KENSINGTON GRAVIS

PREPARED BY: H.Y. LEUNG
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REVISION: 2

Revision History

Revision	Description	Date
1	First release to KGT	December, 23, 1999
2	CRC2 includes battery status P Defined operands for CRC1, CRC2 Defined switches and battery status bits polarity	March 3, 2000

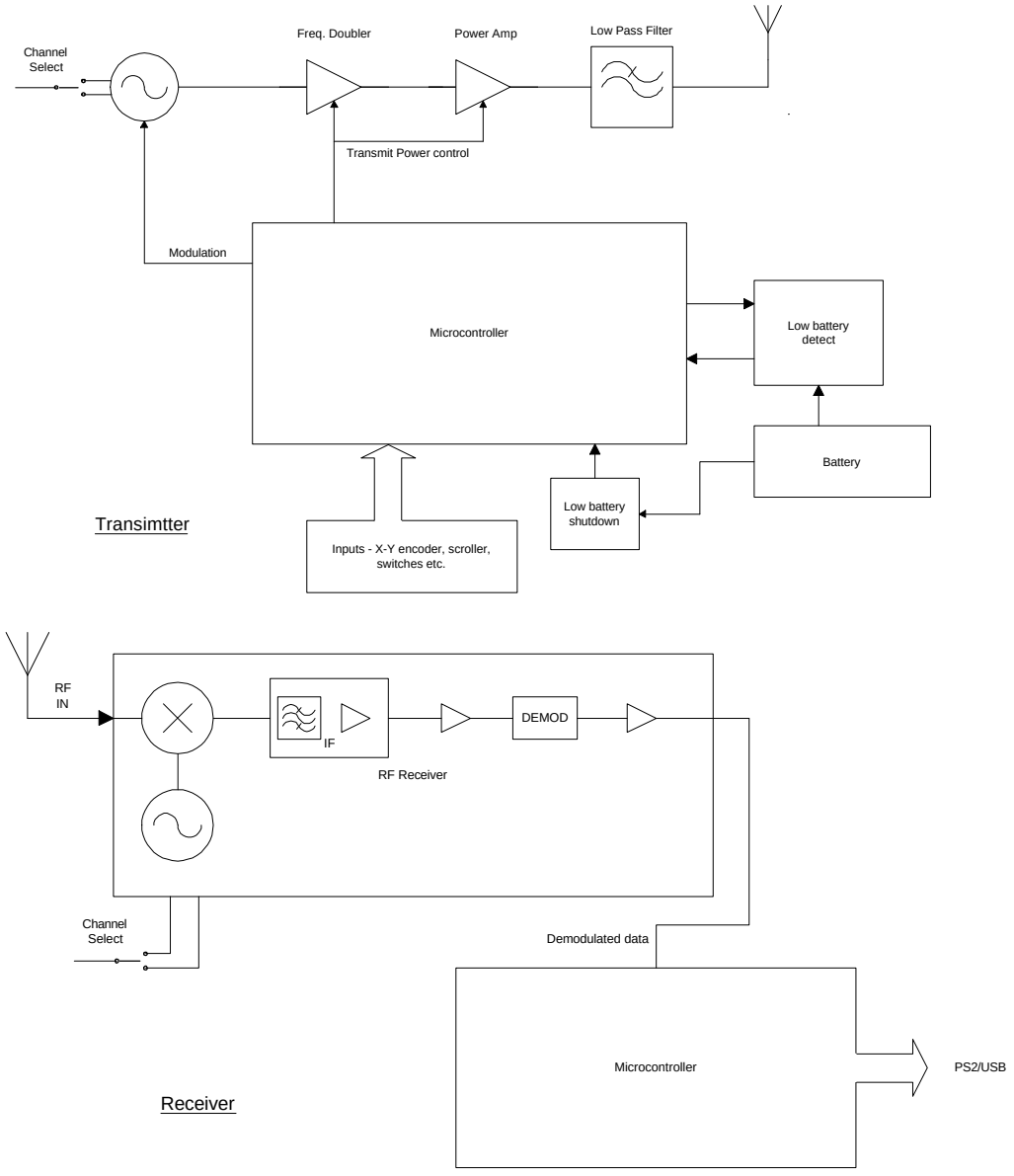
Introduction

PDE was requested by Gravis to design a RF trackball code named Monty. PDE has generated this functional specification for PI Engineering as a tool to migrate their existing USB-PS2 firmware to accommodate the serial data stream from the receiver electronics. This functional specification will cover the following aspects:

- An overview of the system
- Communication Protocol
- Electrical Signals
- System Specifications
- Appendix 1 – CRC Table

System Overview

The input status of the trackball is monitored by a microcontroller on the Transmitter board. Whenever the microcontroller sees a change in the status, it sends a stream of data to the microcontroller on the Receiver board through an RF link. The receiver microcontroller will extract the information carried in the data stream and report to the PC by the PS2 or USB connection. There is a channel selection mechanism on both Transmitter and Receiver to avoid jamming by another user in the same frequency channel. The RF carrier is FSK modulated by a stream of Miller Code base band signal.



Communication Protocol

The Data Packet

The transmitter remains in idle mode most of the time and transmits only if it sees a change in the trackball status. Before any packet is transmitted after the transmitter wakes up from the idle state, the Preamble and the Device ID are sent. The Preamble allows the receiver and detection circuitry to stabilize before the data packet is received. The Device ID identifies the transmitter to the receiver. After the Device ID, the Report Frames follow. The Report Frames will be sent as long as there is trackball status change.
The IFI, Inter-Frame Idle, acts as a delimiter. It terminates a frame and separates it from the next one. If there is no transition received after any timer longer than two IFI, the receiver should assume the transmitter has returned to Idle mode.

"Start of Frames", SOF, are provided for the Device ID and Report Frame for transition synchronization as well as frame identification. Also, SOF for the Device ID helps to identify the product type. SOF for the Device ID is '01XX' where XX is equal to '00' for Monty. SOF for Report Frames are '0001'. However, the receiver firmware should recognize the SOF of the Report Frames as one of these patterns '0001'or '001' with a leading IFI.

DATA PACKET

The Device ID

Bit #	Length	Description
0-3	4	Start of Frame Identifier b0b1b2b3 = 01XX where XX = 00 for Monty
4-7	4	4-bit ID

The Device ID is sent once only after the Preamble.

The Report Frame

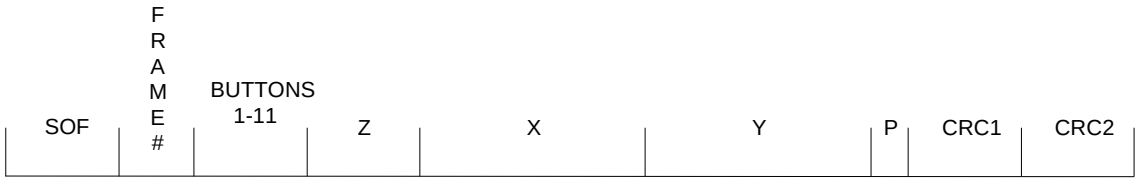
Each bit in the report Frame is defined as followings:

Bit #	Length	Description
0-3	4	Start of Frame Identifier b0b1b2b3 = 0001
4-5	2	Frame Number – Identifies the frame being sent
6-16	11	State of Button 1 – 11, with '1' represents closed of the switch
17-19	3	Z - Value of Vertical Scroll Axis, signed – DOWN scrolling is positive
20-26	7	Value of X – movement, signed – RIGHT is positive

27-33	7	Value of Y – movement, signed – DOWN is positive
34	1	P - Transmitter Battery Status, with '1' represents low battery condition
35-38	4	CRC1 including the frame #, buttons & Z
39-42	4	CRC2 including X , Y & P

Total number of bits: 43
Symbol Period: 0.4ms
Inter-Frame Idle time: 2.8ms

The same trackball status can be sent up to 4 times. The receiver should ignore any report Frame with Frame number larger than zero if a valid report frame with smaller frame number was received.



REPORT FRAME FORMAT

Bit Ordering

The low significant bit is sent first and the most significant bit is sent last.

Error Checking

The validity of the packet is ensured by two 4-bit CRC checksums. The following describes the CRC checksum provided by KGT.

The checksum is generated based on 16 bits of data with polynomial $x^4+x^2+x^1+1$. In the KGT documents, "gripcrc.inc" & "crcgen.inc", a table driven CRC algorithm which involve a 256-entry table (included in Appendix 1) are introduced:

1. Append '0' to the LSB to make it a 16 bit data if data is less than 16 bits.
2. Look up the CRC table indexed by the MSB of the 16 bit data.
3. XOR the result with the LSB of the 16 bit data.
4. Look up the CRC table indexed by the result in step 3.
5. The higher 4 bits is taken as the CRC for the 16-bit data.

There is no error recovery scheme provided. The receiver should drop any error packet and keep looking for the good packets.

Operands for CRC1 and CRC2 Evaluation

Operands for CRC1 is defined below:

	b7	b6	b5	b4	b3	b2	b1	b0
Higher Order	sw6	sw5	sw4	sw3	sw2	sw1	fm1	fm0
Lower Order	z2	z1	z0	sw11	sw10	sw9	sw8	sw7

Operands for CRC2 is defined below:

	b7	b6	b5	b4	b3	b2	b1	b0
Higher Order	y0	x6	x5	x4	x3	x2	x 1	x0
Lower Order	0	P	y6	y5	y4	y3	y2	y1

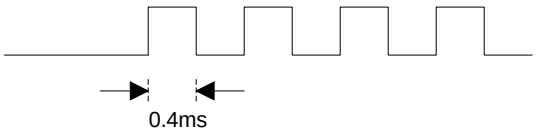
Where:

fm0,fm1 are bits for Frame Number.
sw1 to sw11 are switch status.
x0 to x6 are x-axis offset.
y0 to y6 are y-axis offset.
z0 to z2 are z-axis offset.
P is the battery status

Electrical Signals

Preamble

The preamble is a series of four ‘hi and ‘lo’ pairs. The preamble is provided to condition the receiver and detection circuit before receiving any data. Only one preamble is sent after the transmitter wakes up. The absolute level of the Preamble may be inverted.



The PREAMBLE

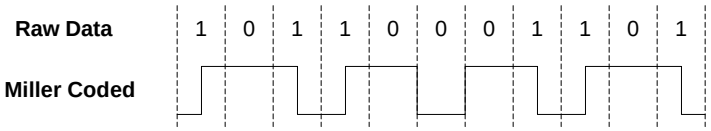
Inter-Frame Idle – 2.8ms

The IFI or Inter-Frame Idle time is the period at which there is no transition. The level can be high or low. If there is another Report Frame following the IFI, the level toggles after the IFI for the receiver firmware to synchronize the symbols. However, the level will or will not toggle if there is no other Report Frame after the IFI.

Miller Code Modulation

The Data in the Report Frame is encoded by Miller Code. The rules for the encoding scheme are:

1. “One” is represented by a signal transition at the midpoint of the symbol period.
2. “Zero” is represented by no transition unless 3.
3. For “Zero” followed by another “Zero”, a transition is placed at the end of the symbol period of the first symbol.



The advantages of Miller Code modulation are:

1. The bandwidth is only ½ of the bit rate.
2. No D.C. component.
3. The absolute polarity of the signal level is not important

However, the receiver firmware must be able to deduce the transition timing relative to the beginning of a symbol period.

System Specifications

RF Specification

A simple data transmitter/receiver pair operating in the "Radio Control" Band at 27 MHz

Channels:	26.995MHz - Channel 1 27.195MHz – Channel 2
Bandwidth:	8kHz
Modulation:	FSK
Deviation:	+/- 2kHz
Data Rate:	2.5kbps
Max. Modulation Frequency:	½ data rate = 1.25kHz (square wave)
Min. Modulation Frequency:	¼ data rate = 625Hz (square wave)
Transmitter Output Power:	-5dBm into antenna approx.
Oscillation Stability:	transmitter & receiver crystal controlled +/- 100ppm
Channel Switching:	by mechanical switch

Power Source

- Transmitter – 2 AAA Alkaline Battery (1100mAh)
- Battery Life – T.B.D.
- Low Battery Threshold Voltage – T.B.D.
- Low Battery Shutdown Voltage – 2V

Input Devices

- 2 – axes quadrature encoder for X-Y position encoding
- 1 – axes quadrature scroller for Z position encoding
- 11 – input buttons

Appendix

1. CRC Table

Data	CRC	Data	CRC	Data	CRC	Data	CRC	Data	CRC	Data	CRC	Data	CRC	Data	CRC
0	00h	32	40h	64	80h	96	c0h	128	70h	160	30h	192	f0h	224	b0h
1	70h	33	30h	65	f0h	97	b0h	129	00h	161	40h	193	80h	225	c0h
2	e0h	34	a0h	66	60h	98	20h	130	90h	162	d0h	194	10h	226	50h
3	90h	35	d0h	67	10h	99	50h	131	e0h	163	a0h	195	60h	227	20h
4	b0h	36	f0h	68	30h	100	70h	132	c0h	164	80h	196	40h	228	00h
5	c0h	37	80h	69	40h	101	00h	133	b0h	165	f0h	197	30h	229	70h
6	50h	38	10h	70	d0h	102	90h	134	20h	166	60h	198	a0h	230	e0h
7	20h	39	60h	71	a0h	103	e0h	135	50h	167	10h	199	d0h	231	90h
8	10h	40	50h	72	90h	104	d0h	136	60h	168	20h	200	e0h	232	a0h
9	60h	41	20h	73	e0h	105	a0h	137	10h	169	50h	201	90h	233	d0h
10	f0h	42	b0h	74	70h	106	30h	138	80h	170	c0h	202	00h	234	40h
11	80h	43	c0h	75	00h	107	40h	139	f0h	171	b0h	203	70h	235	30h
12	a0h	44	e0h	76	20h	108	60h	140	d0h	172	90h	204	50h	236	10h
13	d0h	45	90h	77	50h	109	10h	141	a0h	173	e0h	205	20h	237	60h
14	40h	46	00h	78	c0h	110	80h	142	30h	174	70h	206	b0h	238	f0h
15	30h	47	70h	79	b0h	111	f0h	143	40h	175	00h	207	c0h	239	80h
16	20h	48	60h	80	a0h	112	e0h	144	50h	176	10h	208	d0h	240	90h
17	50h	49	10h	81	d0h	113	90h	145	20h	177	60h	209	a0h	241	e0h
18	c0h	50	80h	82	40h	114	00h	146	b0h	178	f0h	210	30h	242	70h
19	b0h	51	f0h	83	30h	115	70h	147	c0h	179	80h	211	40h	243	00h
20	90h	52	d0h	84	10h	116	50h	148	e0h	180	a0h	212	60h	244	20h
21	e0h	53	a0h	85	60h	117	20h	149	90h	181	d0h	213	10h	245	50h
22	70h	54	30h	86	f0h	118	b0h	150	00h	182	40h	214	80h	246	c0h
23	00h	55	40h	87	80h	119	c0h	151	70h	183	30h	215	f0h	247	b0h
24	30h	56	70h	88	b0h	120	f0h	152	40h	184	00h	216	c0h	248	80h
25	40h	57	00h	89	c0h	121	80h	153	30h	185	70h	217	b0h	249	f0h
26	d0h	58	90h	90	50h	122	10h	154	a0h	186	e0h	218	20h	250	60h
27	a0h	59	e0h	91	20h	123	60h	155	d0h	187	90h	219	50h	251	10h
28	80h	60	c0h	92	00h	124	40h	156	f0h	188	b0h	220	70h	252	30h
29	f0h	61	b0h	93	70h	125	30h	157	80h	189	c0h	221	00h	253	40h
30	60h	62	20h	94	e0h	126	a0h	158	10h	190	50h	222	90h	254	d0h
31	10h	63	50h	95	90h	127	d0h	159	60h	191	20h	223	e0h	255	a0h