ROADRUNNER TRAINING FOR COMPAQ

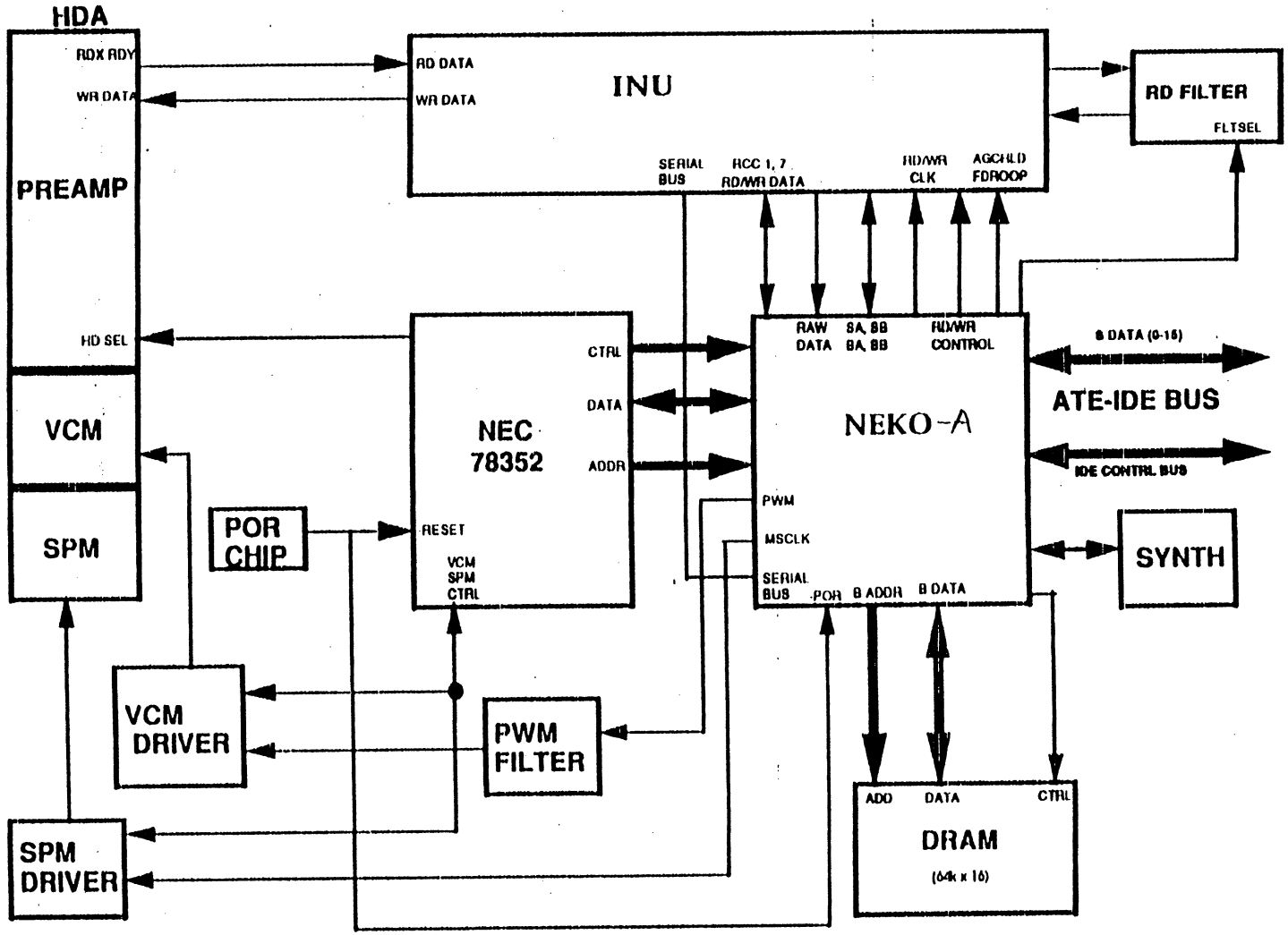
JUNE 1994

QUANTUM

ROADRUNNER ELECTRICAL OVERVIEW FOR COMPAQ TRAINING

Minh Pham - June 1994

AT Block Diagram



Key Components

Controller

- Thunderbolt Architecture
  - 32 MHz 78352 Processor
- Neko (ASIC)
  - Based on Thunderbolt KONI
  - ENDEC
  - Servo Logic
  - A/D Converter
  - Sequencer Handles Split Data Fields
  - 20 MByte/sec DRAM Buffer Bandwidth
  - 10 MByte/sec SCSI interface
  - 6 MByte/sec AT interface
- 128 KByte Buffer Ram
  - 96 KByte Cache
  - 32 KByte Drive Firmware (Diskware)

Key Components

Neko Overview

1 = not supported in SUMO
2 = not supported in KONI

DISK SEQUENCER

- 1,7 ENDEC and Address Mark Logic
- Programmable Sequencer (WCS)
- Supports Split Data Fields
1 • Supports ECC on the Fly 16 bit 1 burst
1 • Supports ID after Wedge

BUFFER MANAGER

1 • Supports 128 KBytes DRAM Buffer
- Buffer Segmentation
1 • 20 MByte/sec bandwidth
1 • Micro Access Channel for Diskware

Key Components

Neko Overview

1 = not supported in SUMO
2 = not supported in KONI

SERVO / MOTOR SUPPORT

1	• High Speed Serial Port
	• Track Number Acquisition (TNA) controller
	• A/D Converter
	• PWM / DAC
1*, 2	• 5 MHz Clock Output for Spindle Driver

READ / WRITE SUPPORT

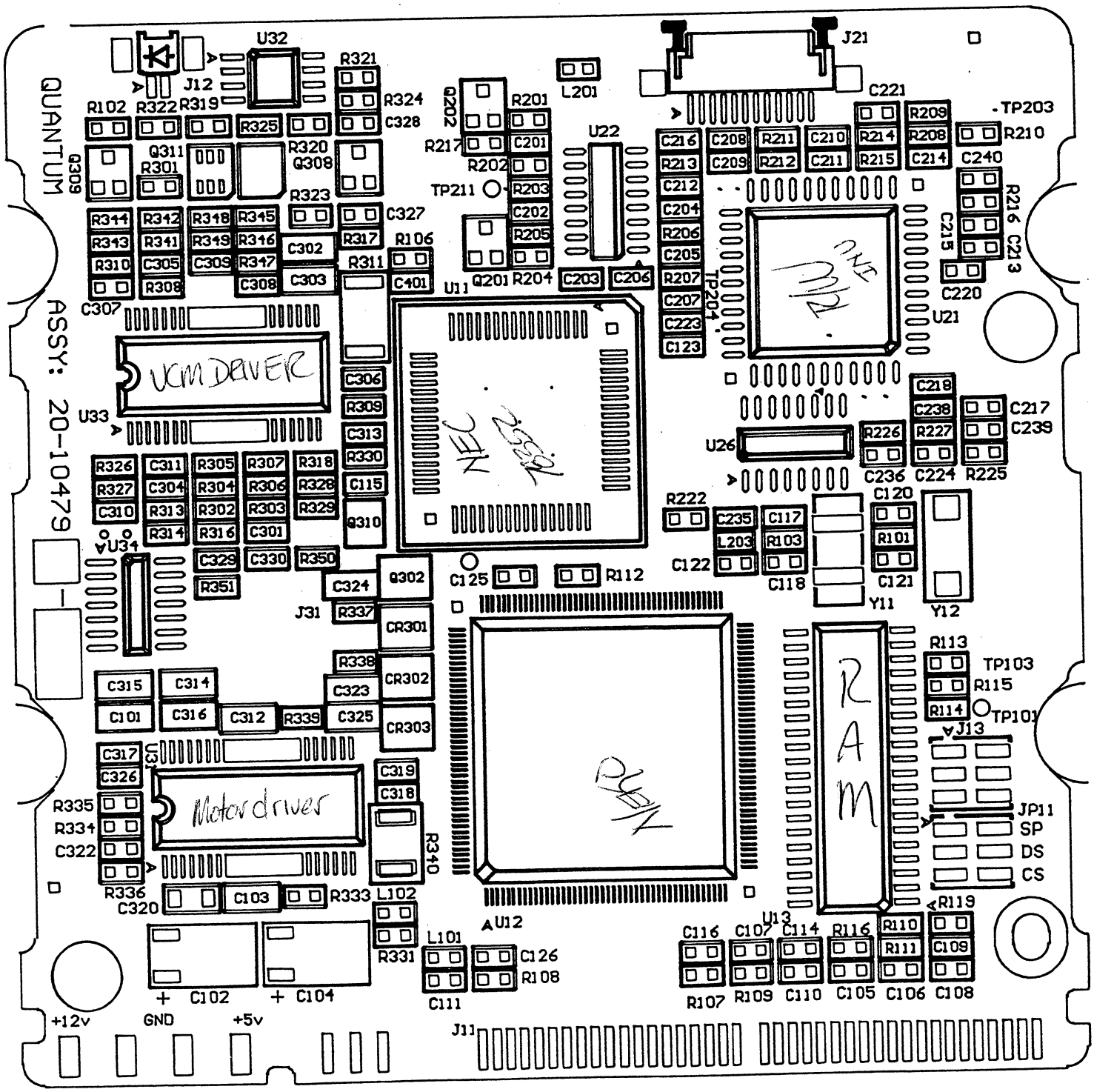
	• Support ATT Read Channel

INTERFACE

1	• Synchronous SCSI
1	• Advanced AT
1	• Noise Rejection Input Buffers

1 * SUMO has a 2 MHz Clock Output

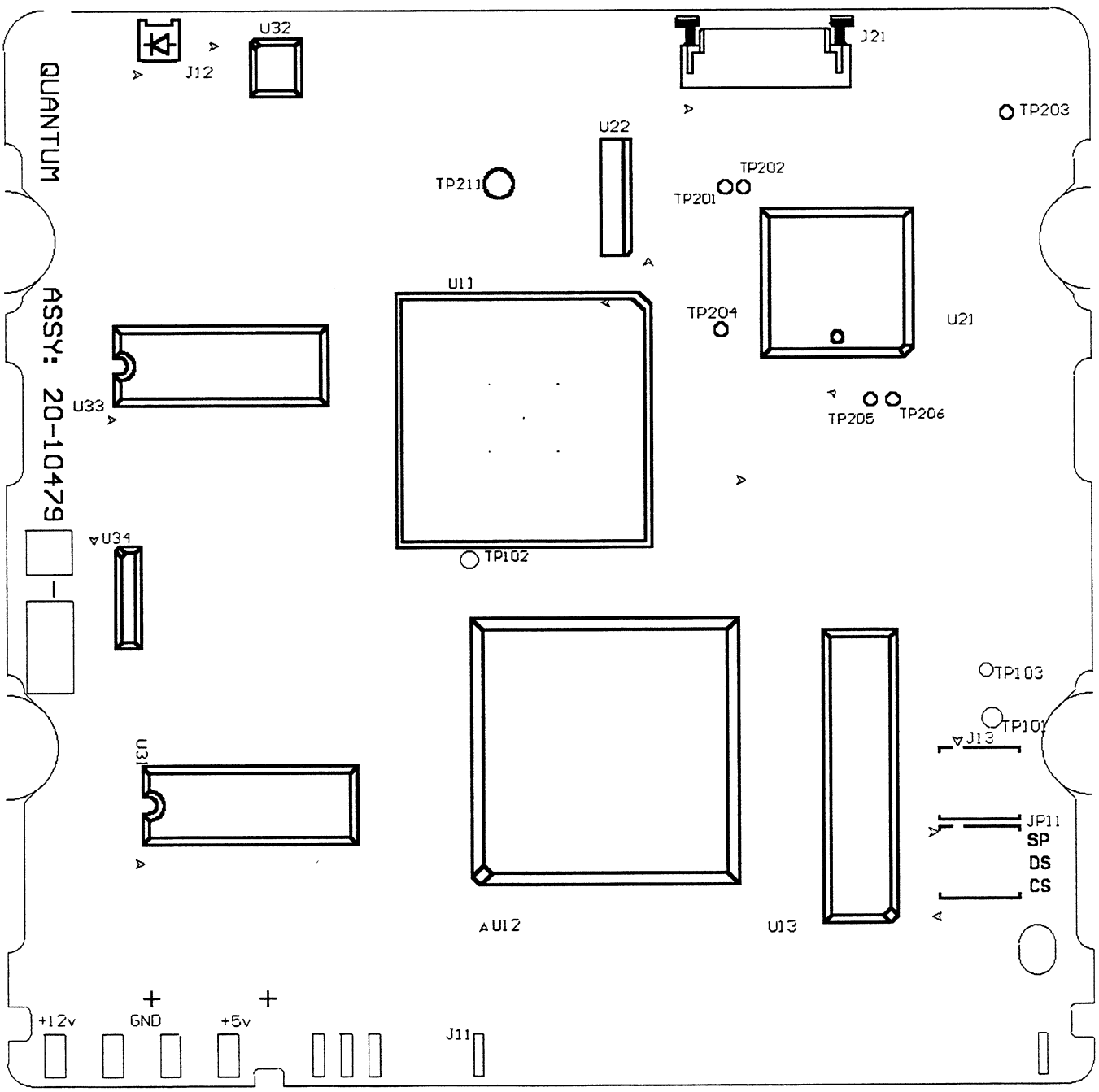
RoadRunner AT



TEST POINT MAP

TP101 -- TESTI01
TP102 -- TESTI02
TP103 -- INDEX
TP201 -- Positive IN, fitered
TP202 -- Negtive IN, fitered
TP203 -- Discrimination Voltage
TP204 -- Raw data
TP205 -- Read Clock
TP206 -- Read Data
TP211 -- -Wedge

ROADRUNNER AT



ROADRUNNER
READ/WRITE CHANNEL
OVERVIEW
FOR COMPAQ TRAINING

Minh Pham - June 1994

rev 2.7 MP 210 MB

zone	num. tracks	num sectors	total sectors
-1	10	89	890
0	216	100	21600
1	180	100	18000
2	196	100	19600
3	177	97	17169
4	120	94	11280
5	158	91	14378
6	65	89	5785
7	165	85	14025
8	120	82	9840
9	270	78	21060
10	149	72	10728
11	186	68	12648
12	145	65	9425
13	120	62	7440
14	159	58	9222
15	93	55	5115

total tracks =	2519	sectors/surf.=	207315

1 SURFACE AND 1 SPARE
SECTORS= 204796
CAPACITY = 104855552

2 SURFACES AND 1 SPARE
SECTORS= 412111
CAPACITY = 211000832

3 SURFACES AND 2 SPARES
SECTORS= 616907
CAPACITY = 315856384

4 SURFACES AND 2 SPARES
SECTORS= 824222
CAPACITY = 422001664

AT REQUIREMENTS

	105MB	210MB	315MB	420MB
Logical Cylinders	360	721	754	1008
Logical Heads	15	15	16	16
Logical sectors	38	38	51	51
Logical Diag. Cyl.	2	2	2	2
sectors	206,340	412,110	616,896	824,160
MegaBytes	105.646	211.000	315.851	421.970

rev 4.7 / P3

zone	num. tracks	num sectors	total sectors
-1	10	89	890
0	265	91	24115
1	83	89	7387
2	199	85	16915
3	5	85	425
4	157	82	12874
5	339	78	26442
6	128	73	9344
7	179	70	12530
8	114	68	7752
9	183	65	11895
10	148	62	9176
11	111	60	6660
12	112	58	6496
13	152	55	8360
14	152	52	7904
15	10	52	520

total tracks =	2337	sectors/surf.=	168795

1 SURFACE AND 1 SPARE	SECTORS=	166458
	CAPACITY =	85226496
2 SURFACES AND 1 SPARE	SECTORS=	335253
	CAPACITY =	171649536
3 SURFACES AND 2 SPARES	SECTORS=	501711
	CAPACITY =	256876032
4 SURFACES AND 2 SPARES	SECTORS=	670506
	CAPACITY =	343299072

SCSII REQUIREMENTS

	85MB	170MB	255MB	340MB
sectors	166,239	334,806	501,045	669,612
MegaBytes	85.114	171.421	256.535	342.841

AT REQUIREMENTS

	85MB	170MB	255MB	340MB
Logical Cylinders	977	1011	1011	1011
Logical Heads	10	15	15	15
Logical sectors	17	22	33	44
Logical Diag. Cyl.	2	2	2	2
sectors	166,430	334,290	501,435	668,580
MegaBytes	85.212	171.156	256.735	342.313

4.5.3 TYPICAL DISK FORMAT

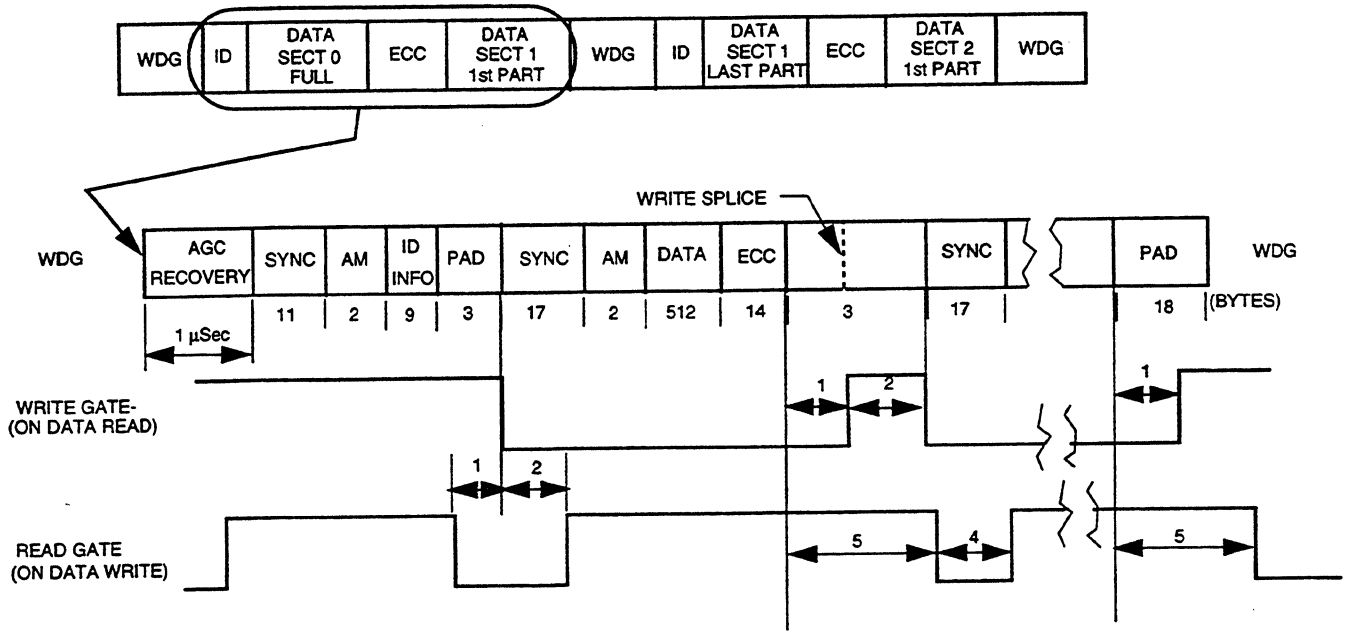
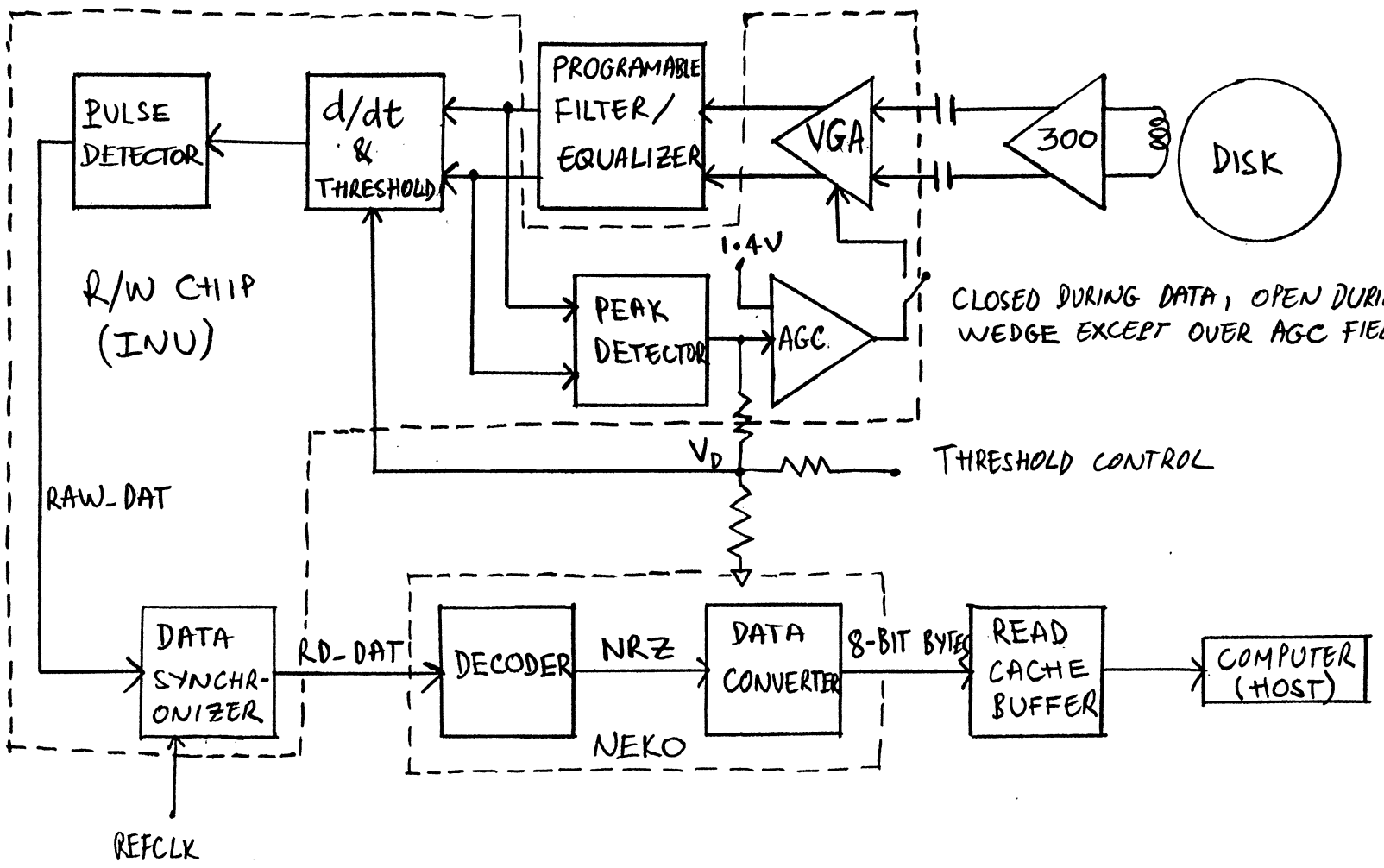


Figure 4-21. Disk Format

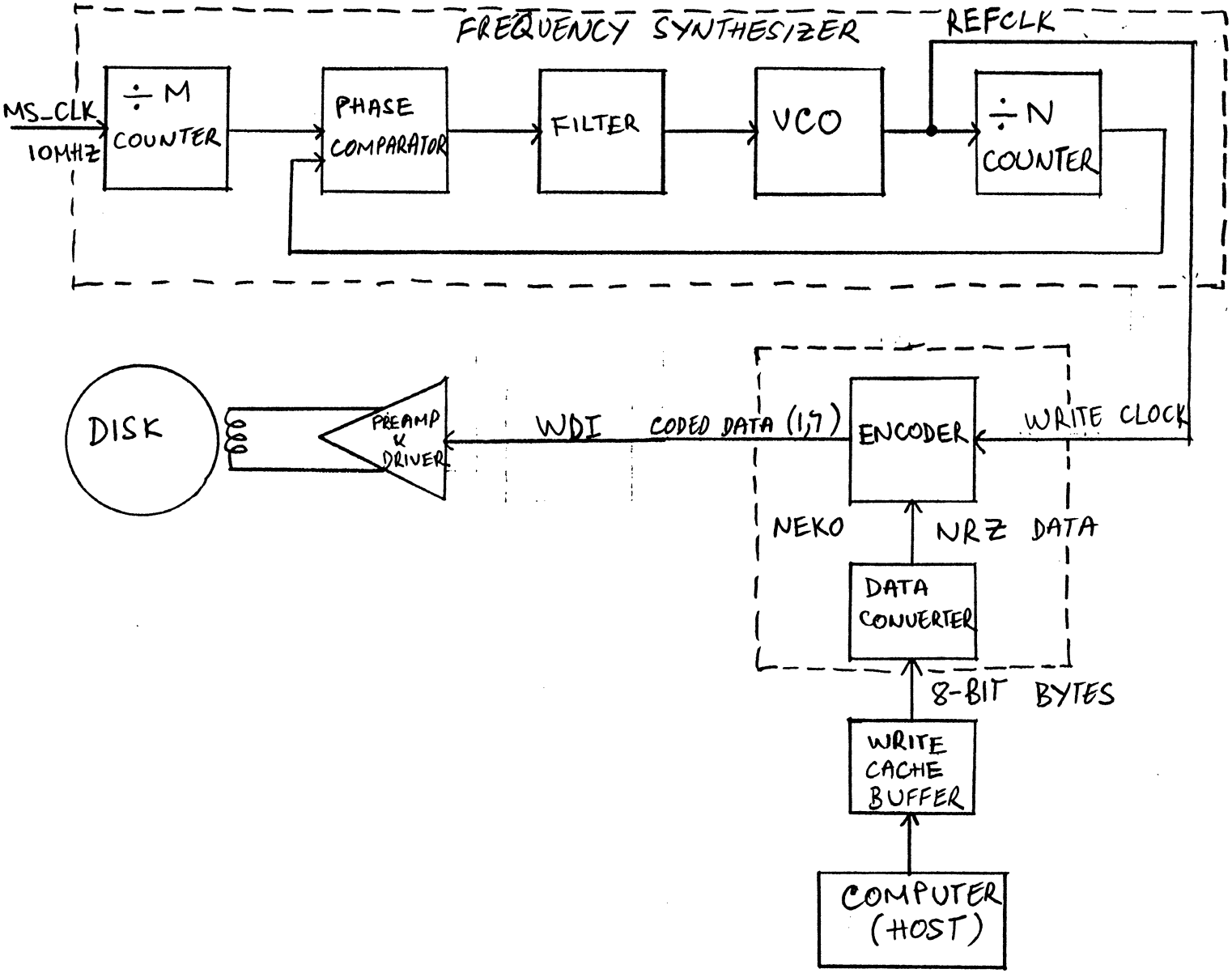
ROADRUNNER READ CHANEL

MINH PHAM 8-3-93



ROADRUNNER WRITE CHANEL

MINH PHAM 8-3-93



```
» rdp
» rdp
» rdp
» rdp
» rdp
» rdp
» rdp
» rdp
» rdp
» rdp
» rdid
```

hex

(15+1)+(69+1) = 22*4 + 106*4 = 88 + 424 = 512 bytes (Se...

7F+1 = 80h = 128*4 = 512 Bytes (Sector 0)

Sector 2

No	Counts	FB	SS	CH	Stat	No	Counts	FB	SS	CH	Stat	No	Counts	FB	SS	CH	Stat
00	00 15	7F	00	00	0100	26	00 41	53	80	1E	00 0100	52	00 6D	27	80	3C	00 0100
01	00 2B	69	80	01	00 0100	27	00 57	3D	80	1F	00 0100	53	00 7F	11	84	3D	00 0100
02	00 41	53	80	02	00 0100	28	00 6D	27	80	20	00 0100	54	00 15	7F	00	3F	00 0100
03	00 57	3D	80	03	00 0100	29	00 7F	11	84	21	00 0100	55	00 2B	69	80	40	00 0100
04	00 6D	27	80	04	00 0100	30	00 15	7F	00	23	00 0100	56	00 41	53	80	41	00 0100
05	00 7F	11	84	05	00 0100	31	00 2B	69	80	24	00 0100	57	00 57	3D	80	42	00 0100
06	00 15	7F	00	07	00 0100	32	00 41	53	80	25	00 0100	58	00 6D	27	80	43	00 0100
07	00 2B	69	80	08	00 0100	33	00 57	3D	80	26	00 0100	59	00 7F	11	84	44	00 0100
08	00 41	53	80	09	00 0100	34	00 6D	27	80	27	00 0100	60	00 15	7F	00	46	00 0100
09	00 57	3D	80	0A	00 0100	35	00 7F	11	84	28	00 0100	61	00 2B	69	80	47	00 0100
10	00 6D	27	80	0B	00 0100	36	00 15	7F	00	2A	00 0100	62	00 41	53	80	48	00 0100
11	00 7F	11	84	0C	00 0100	37	00 2B	69	80	2B	00 0100	63	00 57	3D	80	49	00 0100
12	00 15	7F	00	0E	00 0100	38	00 41	53	80	2C	00 0100	64	00 6D	27	80	4A	00 0100
13	00 2B	69	80	0F	00 0100	39	00 57	3D	80	2D	00 0100	65	00 7F	11	84	4B	00 0100

No	Counts	FB	SS	CH	Stat	No	Counts	FB	SS	CH	Stat	No	Counts	FB	SS	CH	Stat
14	00 41	53	80	10	00 0100	40	00 6D	27	80	2E	00 0100	66	00 15	7F	00	4D	00 0100
15	00 57	3D	80	11	00 0100	41	00 7F	11	84	2F	00 0100	67	00 2B	69	80	4E	00 0100
16	00 6D	27	80	12	00 0100	42	00 15	7F	00	31	00 0100	68	00 41	53	80	4F	00 0100
17	00 7F	11	84	13	00 0100	43	00 2B	69	80	32	00 0100	69	00 57	3D	80	50	00 0100
18	00 15	7F	00	15	00 0100	44	00 41	53	80	33	00 0100	70	00 6D	27	80	51	00 0100
19	00 2B	69	80	16	00 0100	45	00 57	3D	80	34	00 0100	71	00 7F	11	84	52	00 0100
20	00 41	53	80	17	00 0100	46	00 6D	27	80	35	00 0100	72	00 15	7F	00	54	00 0100
21	00 57	3D	80	18	00 0100	47	00 7F	11	84	36	00 0100	73	00 2B	69	80	55	00 0100
22	00 6D	27	80	19	00 0100	48	00 15	7F	00	38	00 0100	74	00 41	53	80	56	00 0100
23	00 7F	11	84	1A	00 0100	49	00 2B	69	80	39	00 0100	75	00 57	3D	80	57	00 0100
24	00 15	7F	00	1C	00 0100	50	00 41	53	80	3A	00 0100	76	00 6D	27	80	58	00 4100
25	00 2B	69	80	1D	00 0100	51	00 57	3D	80	3B	00 0100	77	00 7F	11	84	59	00 0000

```
» fclose
```

Cyl 0 , H 0

cyl 2330 , Hd 0

£ rdid

No	Counts	FB	SS	CH	Stat°No	Counts	FB	SS	CH	Stat°No	Counts	FB	SS	CH	Stat
00	00 2B 25	80	16	7C	0100°26	00 00 59	00	28	7C	0100°52	00 00 53	82	05	7C	0100
01	00 00 53	82	17	7C	0100°27	00 2B 25	80	28	7C	0100°53	00 00 59	00	06	7C	0100
02	00 00 59	00	18	7C	0100°28	00 00 53	82	29	7C	0100°54	00 2B 25	80	06	7C	0100
03	00 2B 25	80	18	7C	0100°29	00 00 59	00	2A	7C	0100°55	00 00 53	82	07	7C	0100
04	00 00 53	82	19	7C	0100°30	00 2B 25	80	2A	7C	0100°56	00 00 59	00	08	7C	0100
05	00 00 59	00	1A	7C	0100°31	00 00 53	82	2B	7C	0100°57	00 2B 25	80	08	7C	0100
06	00 2B 25	80	1A	7C	0100°32	00 00 59	00	2C	7C	0100°58	00 00 53	82	09	7C	0100
07	00 00 53	82	1B	7C	0100°33	00 2B 25	80	2C	7C	0100°59	00 00 59	00	0A	7C	0100
08	00 00 59	00	1C	7C	0100°34	00 00 53	82	2D	7C	0100°60	00 2B 25	80	0A	7C	0100
09	00 2B 25	80	1C	7C	0100°35	00 00 59	00	2E	7C	0100°61	00 00 53	82	0B	7C	0100
10	00 00 53	82	1D	7C	0100°36	00 2B 25	80	2E	7C	0100°62	00 00 59	00	0C	7C	0100
11	00 00 59	00	1E	7C	0100°37	00 00 53	82	2F	7C	0100°63	00 2B 25	80	0C	7C	0100
12	00 2B 25	80	1E	7C	0100°38	00 00 59	00	30	7C	0100°64	00 00 53	82	0D	7C	0100
13	00 00 53	82	1F	7C	0100°39	00 2B 25	80	30	7C	0100°65	00 00 59	00	0E	7C	0100

No	Counts	FB	SS	CH	Stat°No	Counts	FB	SS	CH	Stat°No	Counts	FB	SS	CH	Stat
14	00 00 59	00	20	7C	0100°40	00 00 53	82	31	7C	0100°66	00 2B 25	80	0E	7C	0100
15	00 2B 25	80	20	7C	0100°41	00 00 59	00	32	7C	0100°67	00 00 53	82	0F	7C	0100
16	00 00 53	82	21	7C	0100°42	00 2B 25	80	32	7C	0100°68	00 00 59	00	10	7C	0100
17	00 00 59	00	22	7C	0100°43	00 00 53	82	33	7C	0100°69	00 2B 25	80	10	7C	0100
18	00 2B 25	80	22	7C	0100°44	00 00 59	00	00	7C	0100°70	00 00 53	82	11	7C	0100
19	00 00 53	82	23	7C	0100°45	00 2B 25	80	00	7C	0100°71	00 00 59	00	12	7C	0100
20	00 00 59	00	24	7C	0100°46	00 00 53	82	01	7C	0100°72	00 2B 25	80	12	7C	0100
21	00 2B 25	80	24	7C	0100°47	00 00 59	00	02	7C	0100°73	00 00 53	82	13	7C	0100
22	00 00 53	82	25	7C	0100°48	00 2B 25	80	02	7C	0100°74	00 00 59	00	14	7C	0100
23	00 00 59	00	26	7C	0100°49	00 00 53	82	03	7C	0100°75	00 2B 25	80	14	7C	0100
24	00 2B 25	80	26	7C	0100°50	00 00 59	00	04	7C	0100°76	00 00 53	82	15	7C	4100
25	00 00 53	82	27	7C	0100°51	00 2B 25	80	04	7C	0100°77	00 00 59	00	16	7C	0000

£ fclose

Product: RoadRunner

Rev :4.9 7/2/93 effectively removed 2 zones (2 and 15), changed OD and ID radii — Format for ID-after-Wedge

Req Cap	171.421	MBytes		Bytes	uSec	Srv Fq	26.65387	MHz		
Spare	1	per cyl	Wr-Wdg		5	Srv Clk	37.51801	nSec		
			Overhead	2	2.2					
Surf	2		ID Pre	7		Srv N	385	Clocks		
			ID AM	2		Nservos	78	samples		
Rod	1.7875	in	ID Data	6						
Rid	0.8490	in	ID CRC	3		Tservo	14.44	uSec		
Stroke	0.9385	in	ID Pad	1		Tdata	192.06	uSec		
			ID Gap	2						
Trk Den	2670	tpi	DSg Pre	11		Srv OH	6.76	%		
			DSg AM	2		Fmt OH	0.00	%		
RPM	3599.54	rpm	DSg Pad	3						
			DSg ECC	14		Achieved Capacity =		335,253	Blocks	
System cyls	10							171.6495	MBytes	
								100.13	%	
Guard cyls	4					Excess Blocks =		447		

Tinner	Zone	Router	Rinner	Ntracks	Nsect	BPI	FCI	Rdata (Mbps)	FRcode (MHz)	Fmax (MHz)	Window (nsec)	Num Blk	Eff (%)	Skew In [deg]	Skew Out [deg]
	OD		1.7875												
-1	16	1.7875	1.7841	10	89	40,753	30,565	27.41	41.11	10.28	24.32			18.1	18.1
264	0	1.7838	1.6849	265	91	43,896	32,922	27.88	41.82	10.45	23.91	24115	80.21	16.3	18.1
347	1	1.6845	1.6538	83	89	43,965	32,974	27.41	41.11	10.28	24.32	7387	79.80	15.7	16.2
546	2	1.6534	1.5793	199	85	44,137	33,103	26.27	39.41	9.85	25.37	16915	79.50	14.3	15.7
551	3	1.5789	1.5774	5	85	44,190	33,142	26.27	39.41	9.85	25.37	425	79.50	14.3	14.3
708	4	1.5770	1.5186	157	82	44,402	33,301	25.42	38.13	9.53	26.23	12874	79.28	13.1	14.2
1047	5	1.5182	1.3916	339	78	45,011	33,758	23.61	35.42	8.85	28.24	26442	81.18	10.7	13.1
1175	6	1.3913	1.3437	128	73	45,279	33,959	22.93	34.40	8.60	29.07	9344	78.22	9.7	10.6
1354	7	1.3433	1.2766	179	70	45,717	34,288	22.00	33.00	8.25	30.30	12530	78.19	8.3	9.7
1468	8	1.2763	1.2339	114	68	46,016	34,512	21.40	32.11	8.03	31.15	7752	78.07	7.4	8.3
1651	9	1.2336	1.1654	183	65	46,539	34,905	20.44	30.67	7.67	32.61	11895	78.13	5.9	7.4
1799	10	1.1650	1.1100	148	62	47,005	35,254	19.67	29.50	7.38	33.90	9176	77.47	4.7	5.9
1910	11	1.1096	1.0684	111	60	47,378	35,534	19.08	28.62	7.16	34.94	6660	77.27	3.7	4.6
2022	12	1.0680	1.0265	112	58	47,775	35,831	18.48	27.73	6.93	36.07	6496	77.10	2.7	3.7
2174	13	1.0261	0.9695	152	55	48,341	36,256	17.67	26.50	6.63	37.74	8360	76.50	1.2	2.7
2326	14	0.9692	0.9126	152	52	48,450	36,337	16.67	25.00	6.25	40.00	7904	76.67	-0.3	1.2
2336	15	0.9122	0.9089	10	52	48,650	36,487	16.67	25.00	6.25	40.00	520	76.67	-0.4	-0.3
	Guard	0.9085	0.8497	158										-2.1	-0.4

Product: RoadRunner 210

Rev :2.6 211.0 MB PMP Second Pass 1/31/94

Format for ID-after-Wedge

	Req Cap	211	MBytes		Bytes	uSec	Srv Fq	26.65387	MHz							
	Spare	1	per cyl	Wr-Wdg		5	Srv Clk	37.51801	nSec		AT Logical Set up					
				Overhead	2	2.2					Logical Cylinders	721				
	Surf	2		ID Pre	7		Srv N	385	Clocks		Logical Heads	15				
				ID AM	2		Nservos	78	samples		Logical sectors	38				
	Rod	1.7962	in	ID Data	6						Logical Diag. Cyl.	2				
	Rid	0.8471	in	ID CRC	3		Tservo	14.44	uSec							
	Stroke	0.9491	in	ID Pad	1		Tdata	192.06	uSec		sectors	412,110				
				ID Gap	2						Logical MegaBytes	210.417				
	Trk Den	2670	tpi	DSg Pre	11		Srv OH	6.76	%							
				DSg AM	2		Fmt OH	0.00	%							
	RPM	3599.54	rpm	DSg Pad	3											
				DSg ECC	14		Achieved Capacity =		412,113	Blocks						
	System cyls	10							211.0019	MBytes						
									100.00	%						
	Guard cyls	5					Excess Blocks =		3							

Tinner	Zone	Router	Rinner	Ntracks	Nsect	BPI	FCI	Rdata (Mbps)	FRcode (MHz)	Fmax (MHz)	Window (nsec)	Num Blk	Eff (%)	Skew In [deg]	Skew Out [deg]
	OD		1.7962		-										
-1	16	1.7962	1.7928	10	89	40,556	30,417	27.41	41.11	10.28	24.32			18.2	18.3
215	0	1.7925	1.7119	216	104	48,901	36,675	31.56	47.33	11.83	21.13	22464	80.99	16.8	18.2
395	1	1.7116	1.6445	180	101	50,188	37,641	31.11	46.67	11.67	21.43	18180	79.77	15.5	16.7
591	2	1.6441	1.5711	196	100	51,783	38,837	30.67	46.00	11.50	21.74	19600	80.13	14.1	15.5
742	3	1.5707	1.5146	151	97	52,100	39,075	29.74	44.62	11.15	22.41	14647	80.14	13.1	14.1
862	4	1.5142	1.4696	120	94	52,351	39,263	29.00	43.50	10.88	22.99	11280	79.65	12.2	13.1
1020	5	1.4692	1.4104	158	91	52,438	39,329	27.88	41.82	10.45	23.91	14378	80.21	11.0	12.2
1085	6	1.4101	1.3861	65	89	52,457	39,343	27.41	41.11	10.28	24.32	5785	79.80	10.5	11.0
1250	7	1.3857	1.3243	165	85	52,635	39,476	26.27	39.41	9.85	25.37	14025	79.50	9.3	10.5
1370	8	1.3239	1.2793	120	82	52,705	39,529	25.42	38.13	9.53	26.23	9840	79.28	8.4	9.3
1640	9	1.2790	1.1782	270	78	53,164	39,873	23.61	35.42	8.85	28.24	21060	81.18	6.2	8.4
1790	10	1.1778	1.1220	150	72	53,455	40,091	22.61	33.91	8.48	29.49	10800	78.26	4.9	6.2
1975	11	1.1217	1.0528	185	68	53,936	40,452	21.40	32.11	8.03	31.15	12580	78.07	3.3	4.9
2120	12	1.0524	0.9984	145	65	54,322	40,741	20.44	30.67	7.67	32.61	9425	78.13	2.0	3.3
2240	13	0.9981	0.9535	120	62	54,718	41,039	19.67	29.50	7.38	33.90	7440	77.47	0.8	2.0
2414	14	0.9531	0.8883	174	58	55,203	41,402	18.48	27.73	6.93	36.07	10092	77.10	-1.0	0.8
2518	15	0.8880	0.8494	104	55	55,179	41,384	17.67	26.50	6.63	37.74	5720	76.50	-2.1	-1.0
	Guard	0.8490	0.8475	5										-2.2	-2.1

QUANTUM CORPORATION
500 McCarthy Blvd.
Milpitas, CA 95035

CONTINUATION ENGINEERING

ROADRUNNER

AN OVERVIEW OF SERVO SYSTEM

FOR COMPAQ TRAINING

PRESENTED BY PHILLIP NGUYEN

DATE: 6/21/94

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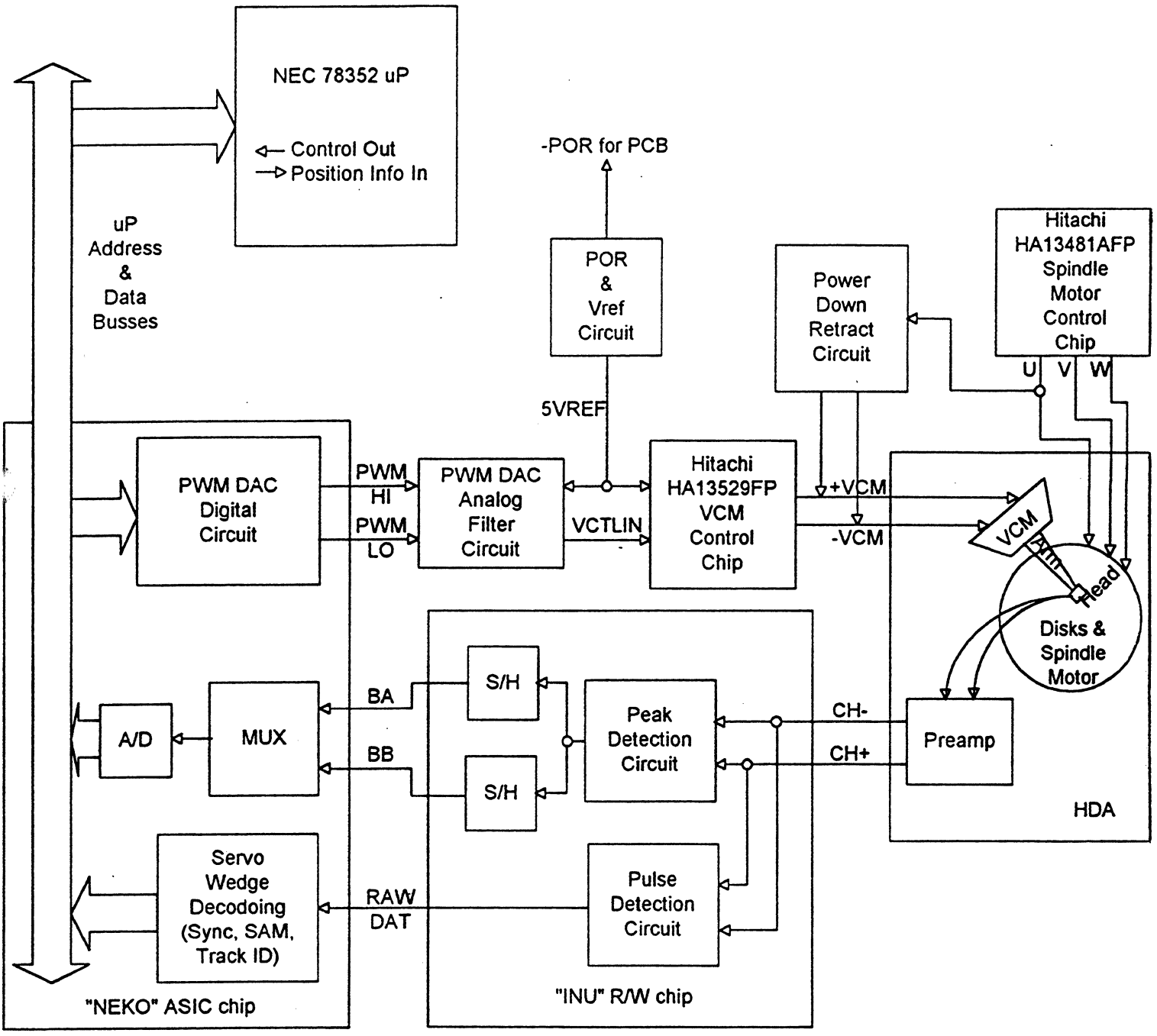
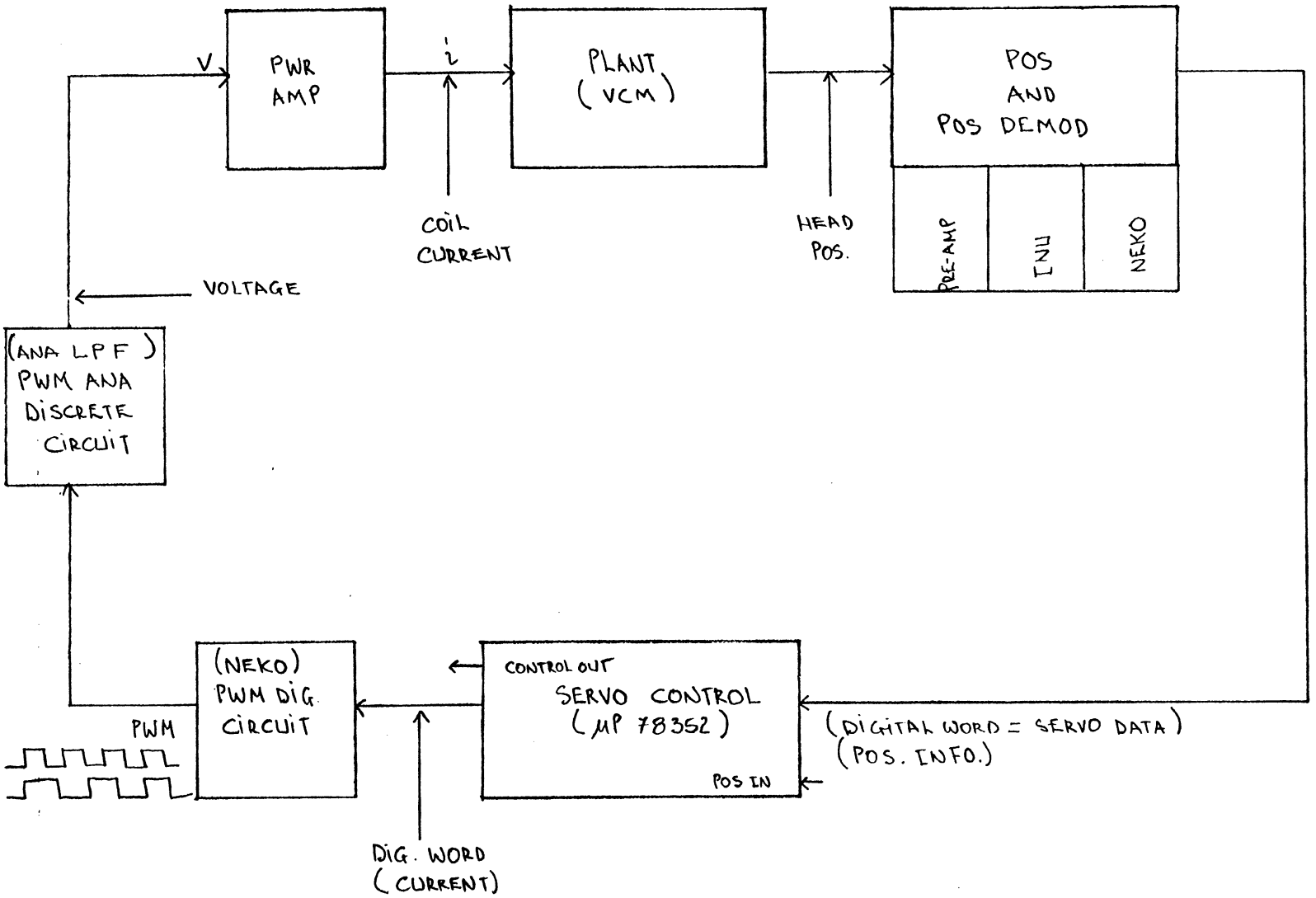
Roadrunner Servo-Mechanical System: Hardware Block Diagram



9/11/93 Joe Lillig

ROADRUNNER SERVO CONTROL BLOCK DIAGRAM



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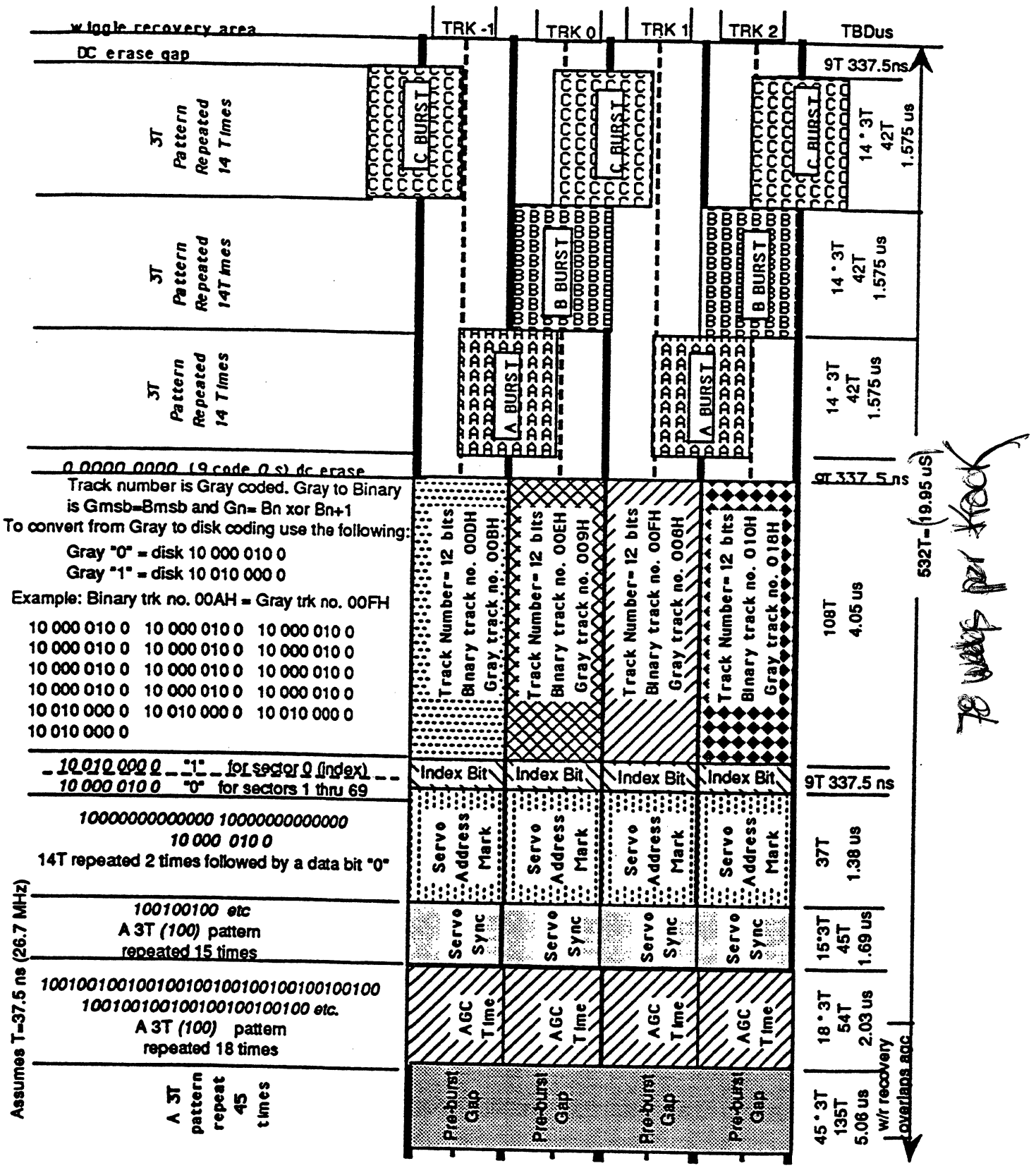
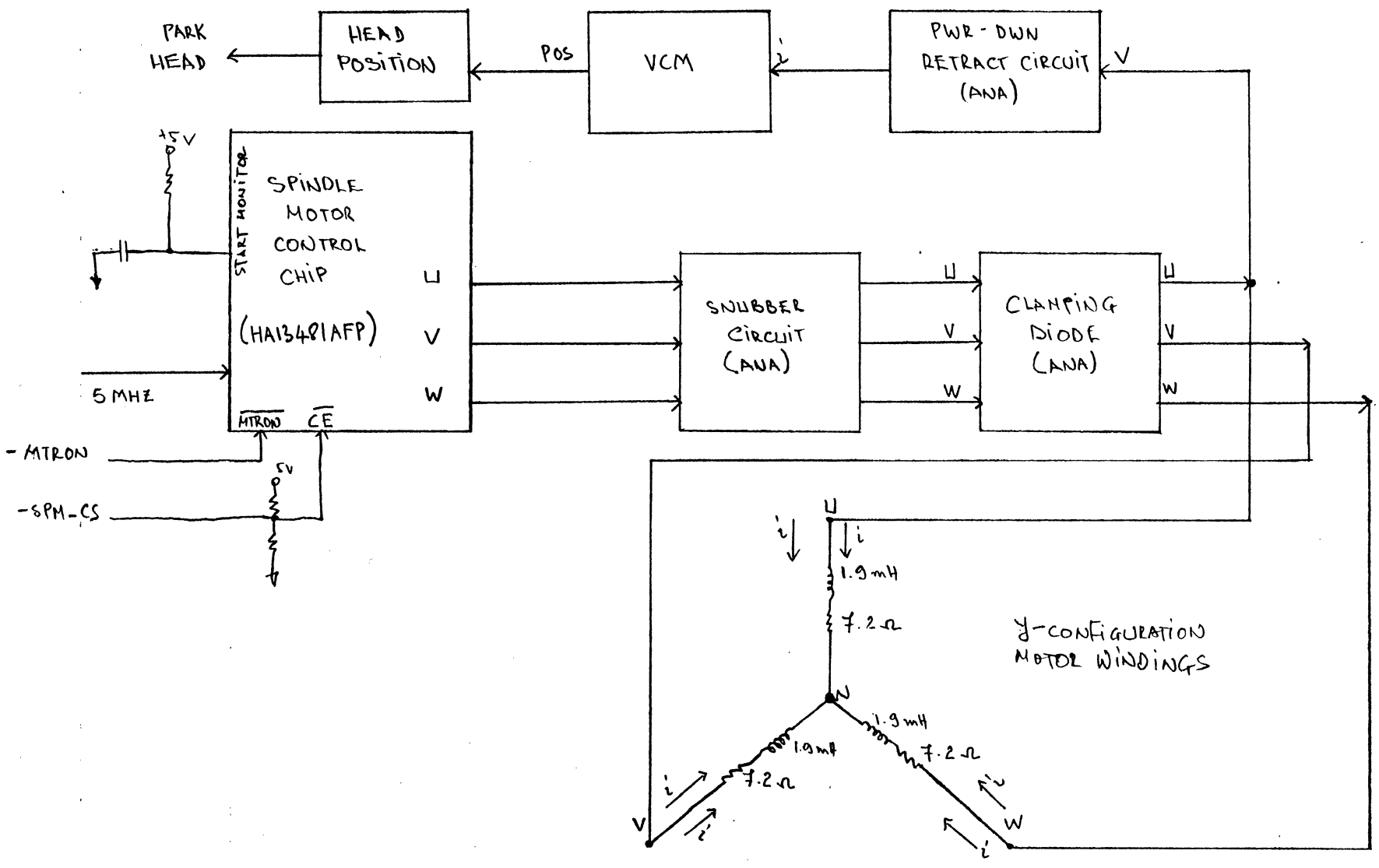
ROADRUNNER
Servo Wedge Pattern





ROADRUNNER SPINDLE MOTOR AND RETRACK BLOCK DIAGRAM

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P.5

HA13481AFP

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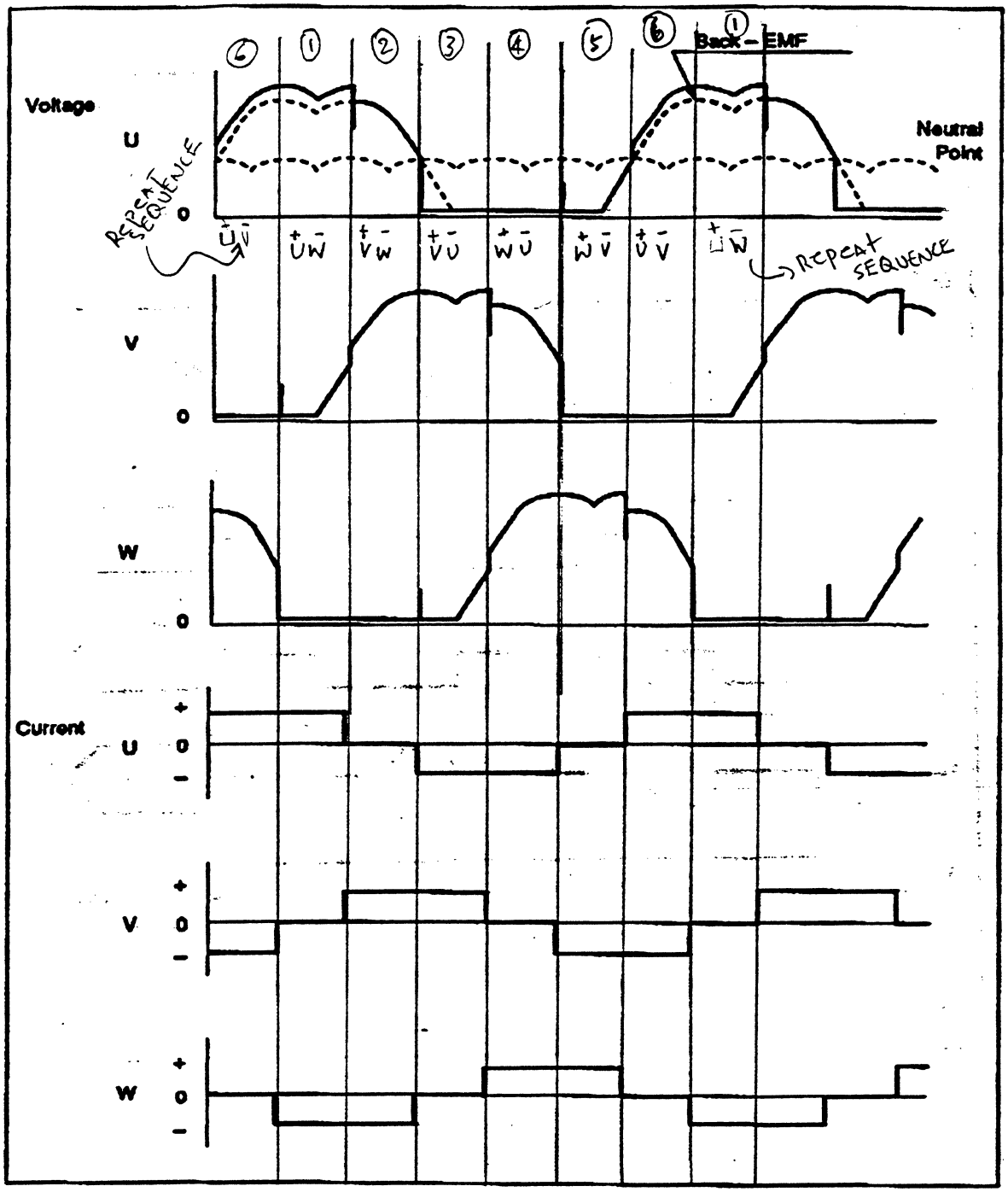
Running (FOR IDEAL CASE)



' + ' = UPPER TRANSISTOR ON

' _ ' = LOWER TRANSISTOR ON

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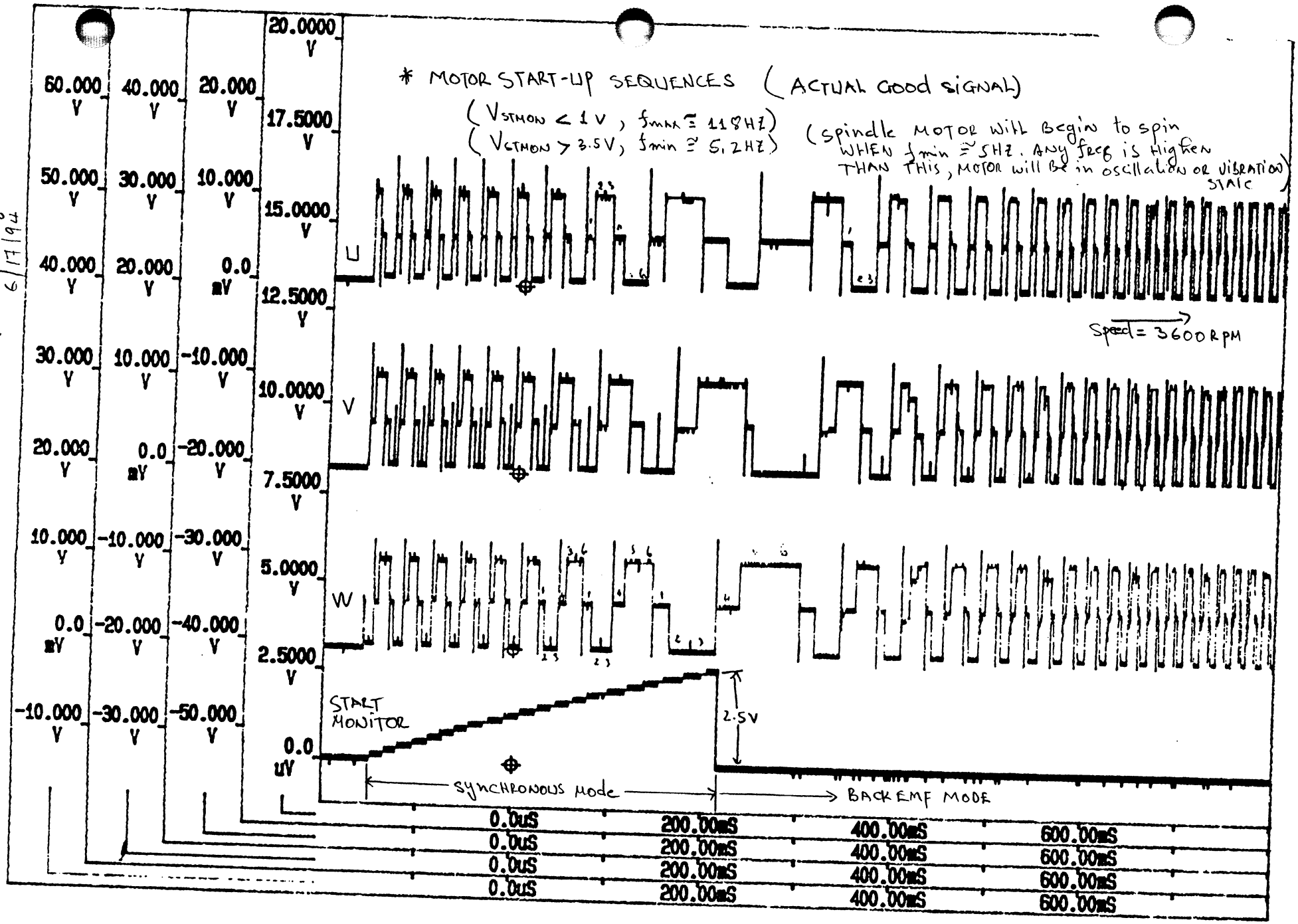

FOR ACTUAL APPLICATION (RUNNING)

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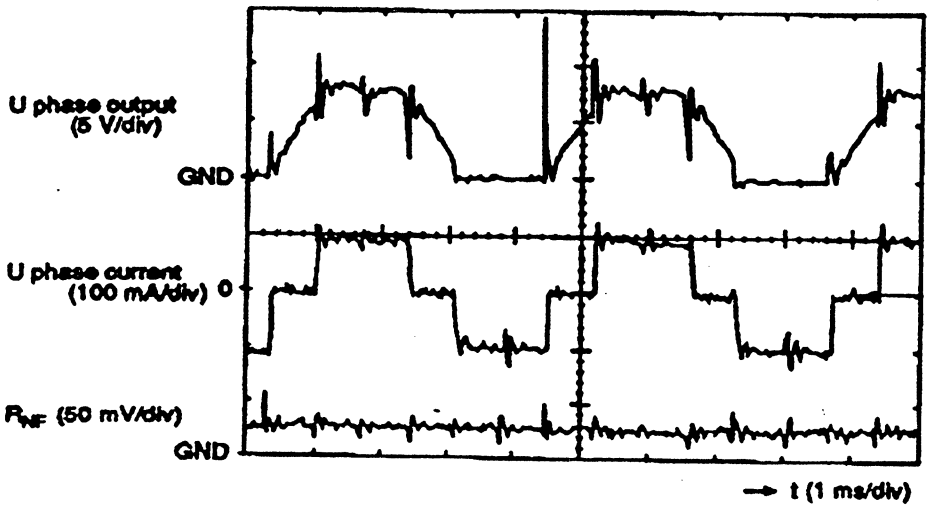
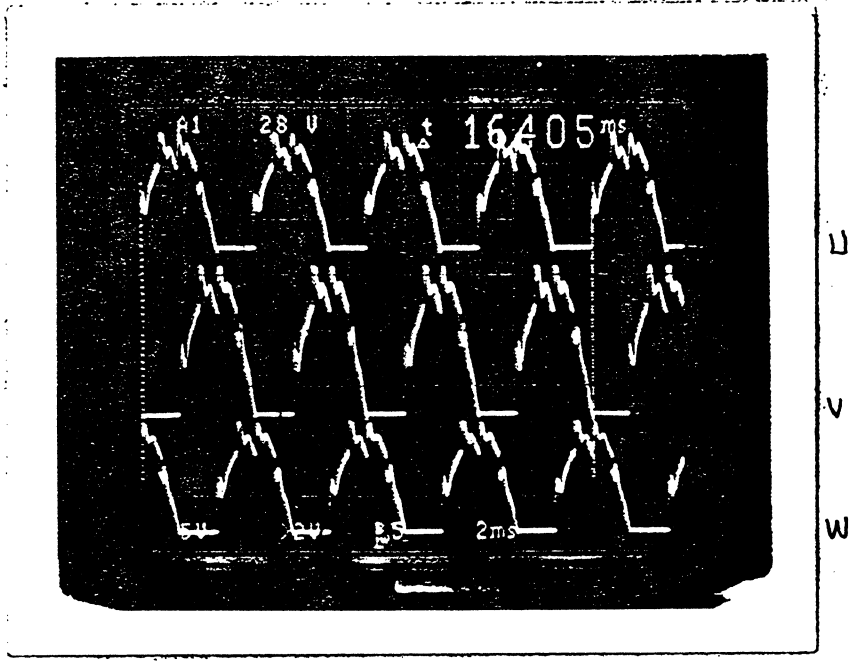


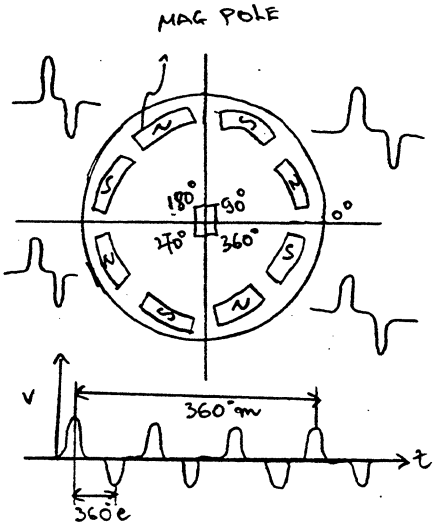


ACTUAL MOTOR SIGNAL AT RUNNING

$$\theta_e = \frac{P}{2} \times \theta_m \text{ (Formula)}$$

ROADRUNNER:

- 8 mag. pole, 9 STATOR slots, 3 PHASES
  - $\therefore \theta_e = \frac{8}{2} \times \theta_m$
  - $\rightarrow \theta_e = 4\theta_m$
  - e.i. if $\theta_m = 90°$, THEN $\theta_e = 360°$

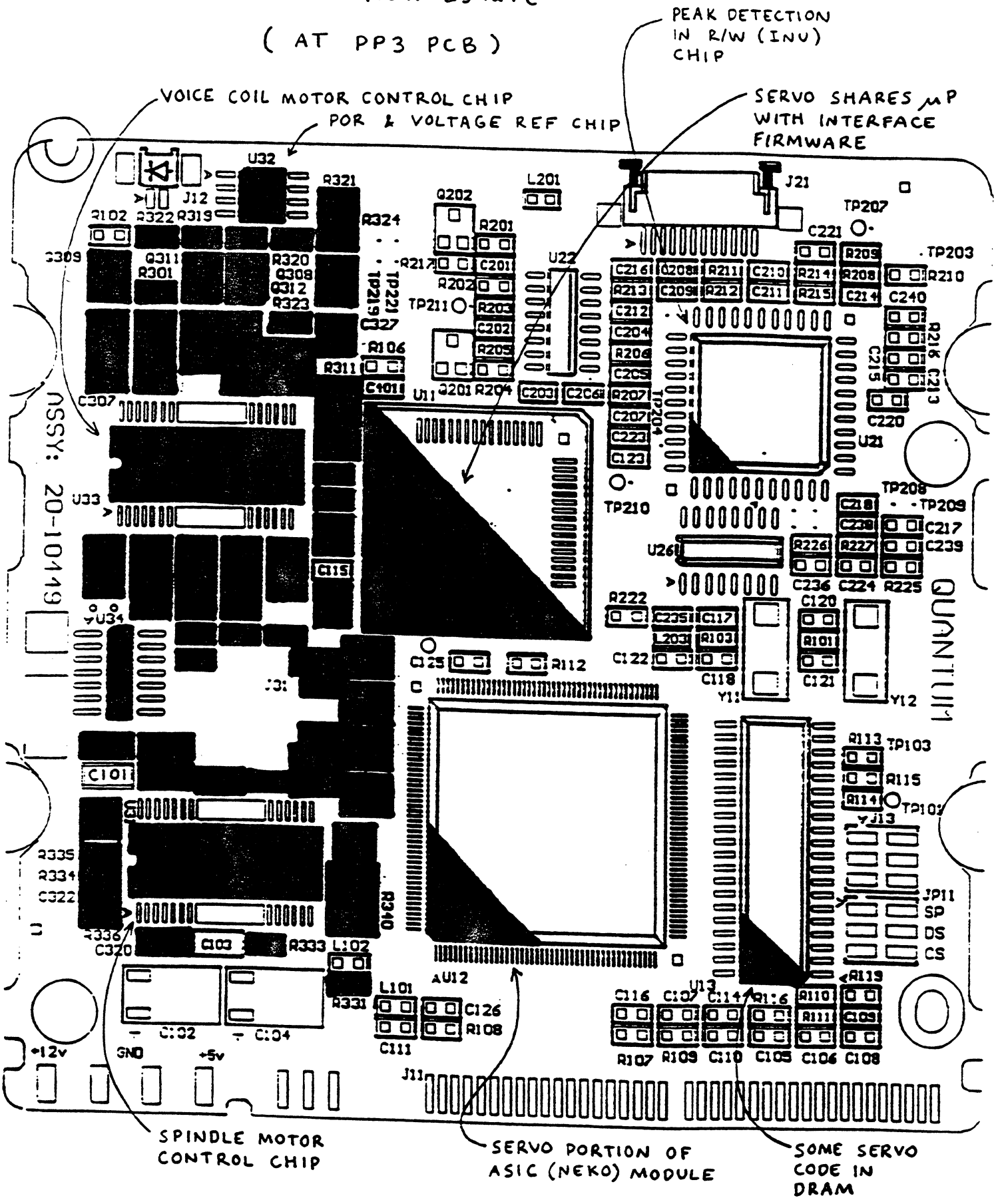


Roadrunner Servo

PCB Real Estate

(AT PP3 PCB)

7/6/93
Joe Lillig



ROADRUNNER SERVO PARAMETERS

- TPI	2670 trks/in
- Track pitch	375 ui/trk
- Number of Cyl.	2337
- Spindle speed	3600 RPM
- Servo samples/rev	78
- Servo sample freq	4.68 Khz
- Servo sample time	214 usec

Phillip Nguyen - 6/17/94

PHILLIP NGUYEN
6/17/94

* GIVEN : ① SPINDLE SPEED = 3600 RPM = 3600 $\frac{\text{Revolution}}{\text{Minute}}$

② NUMBER of Wedges = 78 $\frac{\text{Wedges}}{\text{Revolution}}$

* FIND : ① SERVO SAMPLING freq
② SERVO SAMPLING Period

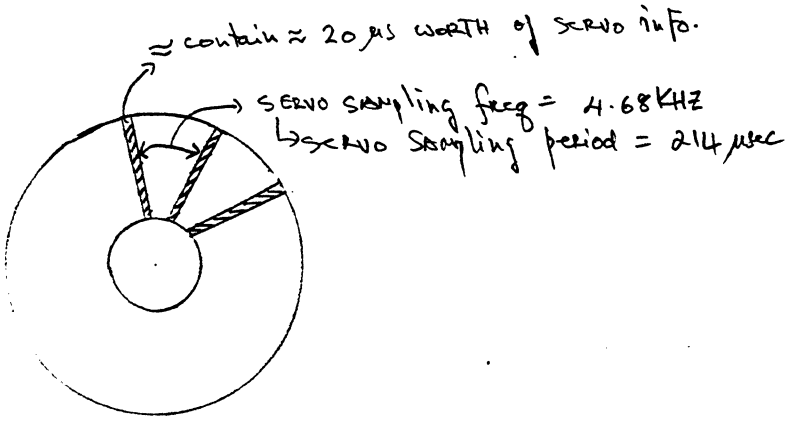
* SOLUTION :

$360\cancel{0}\ \frac{\text{REV}}{\cancel{\text{min}}} \times \frac{1\ \cancel{\text{min}}}{60\cancel{\text{sec}}} = 60\ \frac{\text{REV}}{\text{sec}}$ (Spindle frequency = f_{sp})

$T_{sp} = \frac{1}{f_{sp}} = \frac{1}{60} = 16.666\ldots\ \text{mS}$ (IT takes $\approx$ 16.6 m sec to complete a Revolution)

SERVO SAMPLING freq = $60\ \frac{\cancel{\text{REV}}}{\text{sec}} \times 78\ \frac{\text{Wedges}}{\cancel{\text{REV}}} = 4{,}680 \approx 4.68\ \text{KHZ}$

SERVO SAMPLING Period = $\frac{1}{f_s} = \frac{1}{4.68} \cong 214\ \mu\text{sec}$



- FOR SERVOING, USE A & C BURST ONLY
- FOR SEEKING, USE A & B BURST ONLY
- USE TRACK NUMBER INFO FOR ROUGH POSITION, AND BURSTS FOR FINE POSITION.

Sequence of Servo Operations during RECAL

POWER UP STARTS HERE
- Initialize servo flags & parameters as required for power up

SERVO ERROR RECOVERY STARTS HERE
✓ Initialize RECAL pass counter

RECAL RETRY STARTS HERE
- Initialize servo parameters (like NULLI) to default values

✓ Initialize servo flags & parameters as required after power up

✓ Start spindle motor (if it's not already spinning)

✓ Monitor spindle motor speed until it reaches final value

✓ Hold actuator against crash stop to allow airloc to open (unless this is not a power up RECAL and actuator is already free)

✓ Unpark actuator: get head out over data tracks

- Map heads: Determine number of good heads
- Do "coarse" head gain calibration

✓ Lock onto a track

- Do "fine" head gain calibration
- Do "NULLI" bias calibration
- Do "Vscale" seek velocity trajectory calibration
- Seek to track 0 if appropriate

✓ shows operations done during short RECAL

10/6/93 Joe Lillig

Continuation Engineering

An Overview of Roadrunner Firmware

For Compaq Training

Presented by

Huan Nguyen

06/23/94

Roadrunner Firmware Overview

- *o Roadrunner Firmware & Features*
- *o Roadrunner Firmware Architecture Block Diagram*
- *o Power Saving Modes*
- *o Master/Slave Jumper and Cable Select*
- *o Master/Slave Compatibility*
- *o Roadrunner Cache*
- *o Reserved Cylinders*
- *o Configuration Page Contents*

Roadrunner Firmware & Features

o Leverage from Thunderbolt firmware.

o Supports Neko chip.

o Has 128K DRAM, 96K is used for cache buffer and 32K for diskware and firmware.

o Supports ID after wedge and also triple data split.

o Has wedge skew for both head skew and cylinder skew.

o Implements power saving modes and meets Energy Star requirement less than 1 watt in standby or sleep mode.

o Has ECC on-the-fly, off-track read recovery, and auto reallocation on errors.

o Has 1 spare sector per cylinder on disk drives with 1-3 heads and 2 for drives with 4 heads.

o Supports Selfscan.

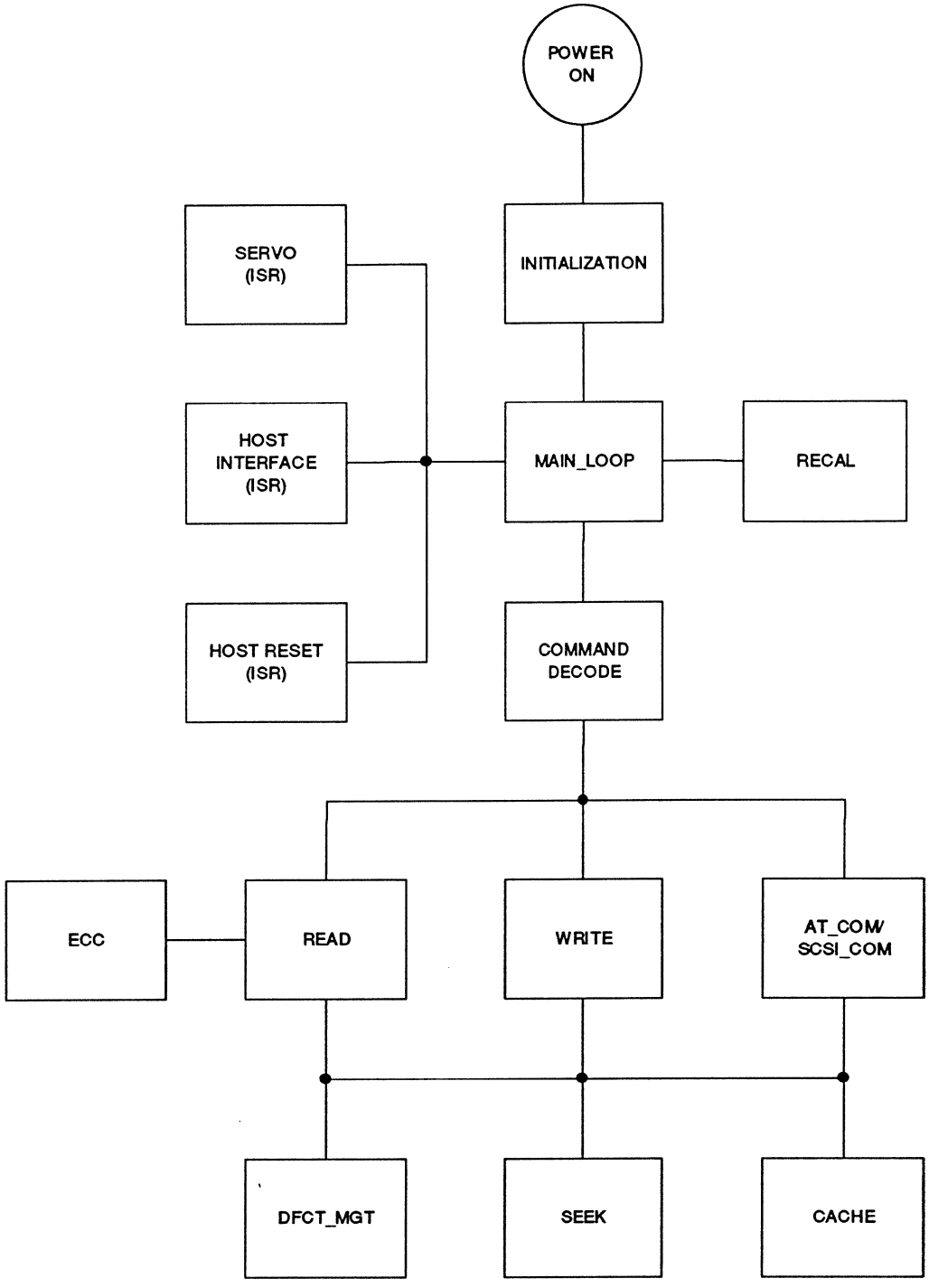
o Supports 1 defective wedge per track.

o Supports AT multiple commands.

o Supports AT DMA mode.

o Supports Auto-CHS update.

Roadrunner Firmware Architecture



Power Saving Modes

o Idle mode: this is the mode which has no active command, no active pre-fetch, and no active hyper-write. Firmware turns read channel off between wedges to save power consumption.

o Standby mode: turns off VCM, spindle motor, and read channel. Any new command will wake up the drive.

o Sleep mode: turns off VCM, spindle motor, and read channel. Only RESET (hard or soft reset) can wake-up the drive.

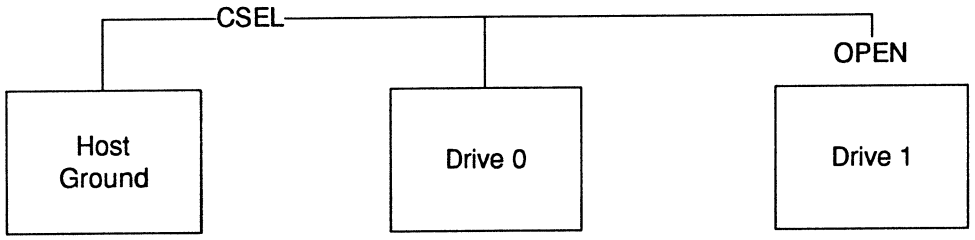
o Auto-power down (APD)

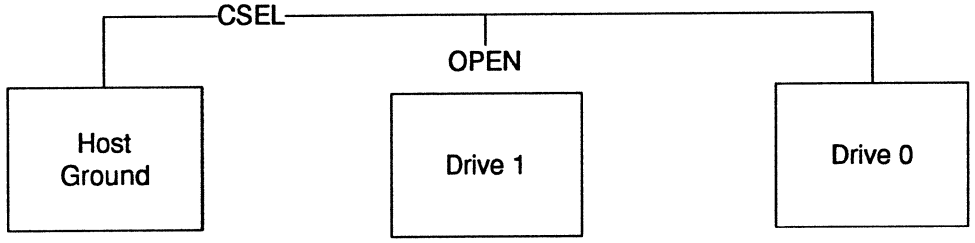
If NS = 0-0F0h, 0FCh-0FFh, 5 sec. interval is used. Time range is 1 min. to 21 min. 20 sec.

If NS = 0F1h-0FBh, 30 sec. interval is used. Time is 30 min to 5 1/2 hr.

Master/Slave Jumper and Cable Select

DS	CS	SP	DESCRIPTION
0	0	0	**Slave Drive** Compatible with drives using the PDIAG- line to handle Master/Slave communications.
1	0	0	**Master Drive** Uses DASP- to check for the presence of a Slave. These are the factory default settings.
0	0	1	**Slave Drive** The PDIAG- and DASP- lines are not driven.
1	0	1	**Master Drive** Uses the SP jumper to determine whether a Slave is present, without checking PDIAG- and DASP-.
0	1	X	**Slave or Master Drive**, depending on the state of the Quantum Cable Select signal (pin 28) at the IDE-bus interface connector. If the Signal state is set 0 (grounded), then the drive is configured as if DS were 1 (Master), described above. If the Cable Select signal is set 1 (high), then the drive is configured as if DS were 0 (Slave), described above.





Master/Slave Compatibility

o Compatible with ATA CAM specification.

Roadrunner Cache

o 96K cache buffer.

o Adaptive cache segment control. Will have 2 to 4 segments. Segment size is from 32K to 64K.

o Supports partial hit.

o Supports continuous prefetch and read ahead to improve the performance.

o Supports hyper-write.

Reserved Cylinders

The following is the negative cylinders usage layout.

Cylinder -1

Sector	Description	Size
0	Servo Writer	1
1	Test interlock	1
2	Reclassification	1
3-12	History queue	10
13-20	DS defect list	8
21-28	AS defect list	8
29-36	SS defect list	8
37-40	Reserved	4
41-44	Selfscan test script	4
45-48	Selfscan test results	4
49-52	Selfscan runout results	4
53-54	Selfscan wedge defects	2
55	Selfscan command history	1
56-59	Selfscan reserved	4
60	Burn-In results	1
61-62	Burn-In defect list	2
63	Burn-In parameters	1
64-65	Burn-In internal results	2
66	Burn-In reserved	1
67	Error logging header	1
68-88	Error logging details	21

Cylinder -2 and -3

Sector	Description	Size
0	Saved mode pages 1, 2, 20h, 37h, 38h, and 39h	1
1	Saved mode pages 3 and 4	1
2-7	Configuration pages	6
8-12	Working defect list	5
13-17	Primary defect list	5
18-22	Temporary defecf list	5
23-39	Format header bytes for 17 zones	17
40	Apple system sector for read/write of OS information	1
41-56	Selfscan overlay 1	16
57-72	Selfscan overlay 2	16
73-88	Reserved	16

Cylinder -4 and -5

Sector	Description	Size
0-63	Diskware overlays	64
64-79	Apple Burn-In overlay	16
80-88	Reserved	9

The end of list marker is placed after the last entry in the list (i.e., if there is only one defect, the end of list marker would be located at byte 06h).

The checksum is placed at the end of the list, and the empty area in the list is filled with zeros. When this byte is added to the rest of the bytes in the list, the lsb of the checksum will equal ASCII "L".

Table 6-17 shows a sample defect list.

Table 6-18. *Sample Defect List*

ENTRY	VALUE	DESCRIPTION
Defect Descriptor 1	24_H	Defect found at factory, on head 3 (In-line sparing transparent to user)
	07_H	Replacement Cylinder = 07 (LSB)
	00_H	Replacement Cylinder = 00 (MSB)
	07_H	Defective Cylinder = 07
	00_H	Defective Cylinder = 00 (MSB)
	03_H	Defective Head = 03
	02_H	Defective Sector = 02
Defect	00_H	Defect found in field, on head 2 (Automatically reallocated to location indicated)
	08_H	Replacement Cylinder = 08
	00_H	Replacement Cylinder = 00 (MSB)
	07_H	Defective Cylinder = 07
	00_H	Defective Cylinder = 00 (MSB)
	02_H	Defective Head = 02
	04_H	Defective Sector = 04
	FF_H	End of list marker

6.7.21 Configuration

In addition to the SET FEATURES command, the ProDrive LPS 127/170AT hard disk drive provides two configuration commands:

- The SET CONFIGURATION command, which enables the host to change DisCache and Error Recovery parameters
- The READ CONFIGURATION command, which enables the host to read the current configuration status of the drive

See Chapter 5 for more details about DisCache and setting cache parameters. Also see Chapter 5 for more information about error detection and defect management.

6.7.21.1 Read Configuration

The READ CONFIGURATION command displays the configuration of the drive. Like the SET CONFIGURATION command, this command is secured to prevent accidentally accessing it. To access the READ CONFIGURATION command, you must write the pattern shown in Table 6-18 to the Command Block Registers. The first byte, 01_H, is a subcode to the extended command code, $F0_H$.

Table 6-19. *Accessing the READ CONFIGURATION Command*

ADDRESS	VALUE	DEFINITION
1F2H	01H	Read Configuration Subcode
1F3H	FFH	Password
1F4H	FFH	Password
1F5H	3FH	Password
1F6H	AXH – Drive 0 BXH – Drive 1	Drive Select
1F7H	F0H	Extended Command Code

In Table 6-18:

- Only the value in address $1F2_H$ of the Command Block Registers is different from the SET CONFIGURATION command.
- Registers $1F2_H$ through $1F5_H$ must contain the exact values shown in the table. These values function as a key. The drive issues the message ILLEGAL COMMAND if the key is not entered correctly.
- The X indicates the value can be any hex value (0–F).
- To select the drive for which the configuration is to be displayed, set register $1F6_H$. For execution of the command to begin, load register $1F7_H$ with $F0_H$.

A 512-byte data field is associated with the READ CONFIGURATION command. A 512-byte read sequence sends this data from the drive to the host. The information in this data field represents the current settings of the configuration parameters. The format of the READ CONFIGURATION command data field, shown in Table 6-18, is similar to that for the data field of the SET CONFIGURATION command. However, in the READ CONFIGURATION command, bytes 0 through 31 of the data field are *not* KEY information, as they are in the SET CONFIGURATION command. The drive reads these bytes as *QUANTUM CONFIGURATION*, followed by eleven spaces. Users can read the configuration into a buffer, then alter the configuration parameter settings.

6.7.21.2 Set Configuration

The SET CONFIGURATION command is secured to prevent accessing it accidentally. To access the SET CONFIGURATION command, you must write the pattern shown in Table 6-19 to the Command Block Registers. The first byte, FF_H, is a subcode to the extended command code $F0_H$.

Table 6-20. *Accessing the SET CONFIGURATION Command*

ADDRESS	VALUE	DEFINITION
1F2H	FFH	Set Configuration Subcode
1F3H	FFH	Password
1F4H	FFH	Password
1F5H	3FH	Password
1F6H	AXH – Drive 0 BXH – Drive 1	Drive Select
1F7H	F0H	Extended Command Code

In Table 6-19:

- Registers $1F2_H$ through $1F5_H$ must contain the exact values shown above. These values function as a key. The drive issues the message ILLEGAL COMMAND if the key is not entered correctly.
- The X indicates the value can be any hex value (0–F).
- To select the drive being reconfigured, register $1F6_H$ should be set. For execution of the command to begin, load register $1F7_H$ with $F0_H$.

6.7.21.3 Set Configuration Without Saving to Disk

The SET CONFIGURATION WITHOUT SAVING TO DISK command is secured to prevent accidentally accessing it. To access this command, you must write the pattern shown in Table 6-20 to the Command Block Registers. The first byte, FE_H, is a subcode to the extended command code $F0_H$.

Table 6-21. *Set Configuration (Without Saving) Access Pattern*

ADDRESS	VALUE	DEFINITION
$1F2_H$	FE_H	Set Configuration Subcode
$1F3_H$	FF_H	Password
$1F4_H$	FF_H	Password
$1F5_H$	$3F_H$	Password
$1F6_H$	AX_H – Drive 0 BX_H – Drive 1	Drive Select
$1F7_H$	$F0_H$	Extended Command Code

In Table 6-20:

- Registers $1F2_H$ through $1F5_H$ must contain the exact values shown above. These values function as a key. The drive issues the message ILLEGAL COMMAND if the key is not entered correctly.
- The X indicates the value can be any hex value (0–F).
- To select the drive being reconfigured, set register $1F6_H$. For execution of the command to begin, load register $1F7_H$ with $F0_H$.

6.7.21.4 Configuration Command Data Field

A 512-byte data field is associated with this command. This data field is sent to the drive through a normal 512-byte write handshake. Table 6-21 shows the format of the data field. Bytes 0 through 31 of the data field contain additional KEY information. The drive issues the message ILLEGAL COMMAND if this information is not entered correctly. Bytes 32 through 39 control the operation of DisCache and error recovery procedure. The drive does not use bytes 40 through 511, which should be set to 0.

Table 6-22. *Configuration Command Format*

BYTE	BIT							
	7	6	5	4	3	2	1	0
0–31	QUANTUM CONFIGURATION KEY							
32	RESERVED = 0						PE	CE
33	NUMBER OF SEGMENTS							
34	RESERVED = 0							
35	RESERVED = 0							
36	AWRE	ARR	N/A	RC	EEC	N/A	N/A	DCR
37	NUMBER OF RETRIES							
38	ECC CORRECTION SPAN							
39	0	AR=0	ACHS	0	0	WCE	RUEE	R = 0
40–511	RESERVED = 0							

Note: All fields marked RESERVED = 0, R = 0 (short for RESERVED = 0), or N/A should be set to zero.

Quantum Configuration Key (Bytes 0-31)

Bytes 0–6 must contain the ASCII characters *Q, U, A, N, T, U,* and *M*; byte 7, the ASCII character *space*; and bytes 8–20 must contain the ASCII characters *C, O, N, F, I, G, U, R, A, T, I, O,* and *N*. Bytes 21–31 must contain an ASCII *space*. If this information is not entered correctly, the drive issues the message ILLEGAL COMMAND.

DisCache Parameters (Byte 32)

PE – Prefetch Enable (Byte 32, Bit 1): When set to 1, this bit indicates that the drive will perform prefetching. A PE bit set to 0 indicates that no prefetching will occur. The CE bit (bit 0) must be set to 1 to enable use of the PE bit. The default value is 1.

CE – Cache Enable (Byte 32, Bit 0): When set to 1, this bit indicates that the drive will activate caching on all READ commands. With the CE bit set to 0, the drive will disable caching and use the 64K RAM only as a transfer buffer. The default setting is 1.

Number of Cache Segments (Byte 33)

Byte 33 contains the number of cache segments available in the cache table. The default value for this byte is 1 for the ProDrive LPS 127/170AT.

Error Recovery Parameters (Byte 36)

AWRE – Automatic Write Reallocation Enabled (Byte 36, Bit 7): When set to 1, indicates that the drive will enable automatic reallocation of bad blocks. Automatic Write Reallocation is similar to the function of Automatic Read Reallocation, but is initiated by the drive when a defective block has become inaccessible for writing. An AWRE bit set to 0 indicates that the ProDrive LPS 127/170AT will not automatically reallocate bad blocks. The default setting is 1.

ARR – Automatic Read Reallocation (Byte 36, Bit 6): When set to 1, this bit indicates that the drive will enable automatic reallocation of bad sectors. The drive initiates reallocation when the ARR bit is set to 1 and the drive encounters a hard error—that is, the same nonzero ECC syndrome occurs on two consecutive retries. The default setting is 1. When the ARR bit is set to 0, the drive will not perform automatic reallocation of bad sectors. If RC (byte 36, bit 4) is 1, the drive ignores this bit. The default value is 1.

RC – Read Continuous (Byte 36, Bit 4): When set to 1, this bit instructs the drive to transfer data of the requested length without adding delays to increase data integrity—that is, delays caused by the drive's error-recovery procedures. With RC set to 1 to maintain a continuous flow of data and avoid delays, the drive may send data that is erroneous. When the drive ignores an error, it does *not* post the error. The RC bit set to 0 indicates that potentially time-consuming operations for error recovery are acceptable during data transfer. The default setting is 0.

EEC – Enable Early Correction (Byte 36, Bit 3): When set to 1, this bit indicates that the drive will use its ECC algorithm if it detects two consecutive equal, nonzero error syndromes. The drive will not perform rereads before applying correction, unless it determines that the error is uncorrectable. An EEC bit set to 0 indicates that the drive will use its normal recovery procedure when an error occurs: rereads, followed by error correction. If the RC bit (byte 36, bit 4) is set to 1, the drive ignores the EEC bit. The default setting is 0.

DCR – Disable Early Correction (Byte 36, Bit 0): When set to 1, this bit indicates that all data will be transferred without correction, even if it would be possible to correct the data. A DCR bit set to 0 indicates that the data will be corrected if possible. If the data is uncorrectable, it will be transferred without correction, though the drive will attempt rereads. If RC (byte 36, bit 4) is set to 1, the drive ignores this bit. The default setting is 0. The drive will post all errors, whether DCR is set to 0 or 1.

NUMBER OF RETRIES (Byte 37)

This byte specifies the number of times that the drive will attempt to recover from data errors by rereading the data, before it will apply correction. The drive performs rereads before ECC correction—unless EEC (byte 36, bit 3) is set to 1, enabling early correction. The default is eight.

ECC CORRECTION SPAN (Byte 38)

This byte specifies the size, in bits, of the largest Read Data error on which the drive can attempt error correction. The value for this byte is fixed at 16. This will correct a single burst of up to 48 bits in length, or one double burst of up to 24 bits each in length.

DRIVE PARAMETER (Byte 39)

AR (Auto Read) (Byte 39, Bit 6): When this bit is set to 1, Auto Read is enabled. When the bit is set to 0, Auto Read/Write is disabled. The default value is 0.

ACHS (Auto CHS (Cylinder, Head, Sector)) (Byte 39, Bit 5): When ACHS is set to 1, the hardware automatically updates the CHS value in the task file register. When the bit is 0, the CHS is not automatically updated. The default value is 1.

WCE – Write Cache Enable (Byte 39, Bit 2): When this bit is set to1, the ProDrive LPS 127/170AT hard disk enables the Write Cache. The host will terminate Write commands before data is completely written to the disk. When Write Caching is enabled, the WRITE command terminates when all of the data is transferred from the host to the buffer, even though all the data may not be written to the disk. Data continues to be written to the disk after the WRITE command terminates. If the following command is any command other than another WRITE command, the command is delayed until the remaining data is written to the disk. Upon completion, the new command continues normal execution.

If the next command is another WRITE command, cached data continues to be written to the disk while new data is added to the buffer. The default setting is 1.

RUEE – Reallocate Uncorrectable Error Enables (Byte 39, Bit 1): When set to 1, this bit indicates that the ProDrive LPS 127/170AT hard disk drive will automatically reallocate uncorrectable hard errors, if the ARR bit (byte 36, bit 6) is set to 1. The default setting is 1.

6.8 ERROR REPORTING

At the start of a command's execution, the ProDrive LPS 127/170AT hard disk drive checks the Command Register for any conditions that would lead to an abort command error. The drive then attempts execution of the command. Any new error causes execution of the command to terminate at the point at which it is occurred. Table 6-22 lists the valid errors for each command.