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REVOLUTION FREQUENCY TRIGGER GENERATOR

Summary

An apparatus which produces pulses locked to the internal beam, has been constructed. The pulses may be used to trigger oscilloscopes, timing gear etc.

This report gives a brief discussion of the characteristics of the apparatus. A complete set of circuit diagrams is also added.

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PS/4331

1. Introduction

The harmonic number of the PS is 20 and, consequently, the voltage on the acceleration units has a frequency which is the 20th harmonic of the revolution frequency. So, if one divides this frequency by 20, one gets the revolution frequency.

In 1959-1960 a hard-tube version of a similar apparatus was constructed. However, as the auxiliary apparatus became more and more transistorized, the decision to rebuild the instrument into a transistorized version was taken in Spring 1962.

The present instrument was finally mounted in the C.C.R. in the autumn of the same year and has so far performed without major troubles. In December 1962 the hard-tube version was removed from the M.C.R.; thus one complete rack was cleared for other purposes.

Acknowledgements

I wish to thank B. Canard for the construction of most of the circuits, and T. van den Veen (formerly NP Division) for the fruitful discussions on construction techniques of fast decades. It was T. van den Veen who kindly provided me with prototypes of gates and flip-flops.

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2. Block diagram descriptions

The internal switching sequence is further illustrated in fig. 2. Upon reception of a start pulse, a gate pulse is formed in the gate pulse generator and opens gate 1.

Now the RF signal is applied to the shaper and shaped RF pulses are fed into the counter. The counter is arranged in such a way as to produce a level shift for 20 input pulses and 100 input pulses. Both of these two produce the wanted pulses (4 sorts) via an additional divider, shapers and emitter followers. A stop-pulse closes the gate and produces a reset pulse for the counter.

The reset pulse is delayed until the resetting action is over and then produces a trigger for the advance generator.

This advance generator may be set to produce any number of pulses between 0 and 19, the last pulse from this unit being generated well before gate 1 is opened again. The pulses from this generator are shaped and fed into the counter. This means that the counter gives the first level shift after having received 20 - N input pulses (N being the number of pulses generated in the advance generator).

The four sorts of pulses, which are formed in drawer 4, are sent to drawer 5 and applied to a gate 2 via a switch which permits one of the four to be chosen.

This gate 2 can either be short-circuited via S_2 (position direct) or, with S_2 in the position gated, it can be opened with the aid of gate pulse generator 2.

Gate pulse generator 2 can be triggered by any one of the 4 trigger pulses and it consists of a one-shot circuit, so arranged that the length of the shot can be varied between 10 μsec and 10 msec.

Thus, bursts of trigger pulses are formed in the gate 2 circuitry.

The gate pulse generator triggers also a pedestal generator. The steps of its circuit are advanced <u>after</u> the burst has occurred. These voltage steps permit four non-overlapping photos to be taken during one mchine cycle, if four triggers are applied to the circuit and if the pedestal signal is applied to the horizontal shift of the oscilloscope.

All circuits, with the exception of the advance generator, are of conventional construction and no detailed circuit description will be given. Wherever possible, Philips building blocks and standard MPS circuits have been used.

After the advance generator had been constructed, an article on a similar type of instrument appeared in "Electronics" (April,1963, pp. 40-41) and the interested reader is referred to that article for circuit explanation.

3. Characteristics

Inputs

Start pulse	: B.I.T., or, if available, a pulse well related to the bunching process at the beginning of the cycle.
Stop pulse	: M.H.2 or, if deceleration takes place, pulse PL (beam lost).
Selected trigger	: Any standard pulse, occurring during the acceleration cycle. Max. 4 of these can be applied. Revolution of trigger burst generator is a function of length of burst. For min. burst length this is about 20 kc/s.

Outputs

Revolution freq. pulses	: I RF/20	=	1 pulse / rev.
	II RF/40	=	1 pulse / 2 rev.
	IIIRF/100	=	1 pulse / 5 rev.
	IV RF/200	=	1 pulse /10 rev.

Outputs (contd.)

Pulse bursts : Pulses of one of these four catagories in bursts variable from:

Position switch	Length
1 (middle)	10 µsec - 100 µsec
2 (up)	100 " - 1 msec
3 (down)	1 msec - 10 msec

Pulse form : Amplitude + 5 V (terminate in 75 ohms)

Duration ∼ 300 ns

Rise time < 15 ns

Int. imp. ≪ 50 ohms

Connector : 75 ohms BNC at back

Pedestal : Four steps

1 -600 mV

2 -200 mV

3 +100 mV

4 +500 mV

Driving impedance : ≈ 20 kohms

Resolution frequ. : max. 20 kC/s

4. <u>Circuit Diagram Key</u>

I. <u>Fig. 5.3</u>

Timing circuitry etc. (all components with prefix 1)

R101	5k6	R111	170	R121	5k6	R131	560	R141	10k
102	1k2	112	+	k22	560	132	100k	142	10k
103	470	113	+	123	1k8	133	2k2	143	+
104	12k	114	+	124	22 ohms	134	10k	144	+
105	+	115	+	125	820 "	135	+	145	39 ohms
106	+	116	10k	126	1k2	136	+	146	+
107	+	117	+	127	220ohms	137	5k6	147	+
108	+	118	+	128	1k5	138	27k	148	4k7
109	10k	119	+	129	330	139	+	149	39 ohms
110	1k	120	+	130	680	140	+	150	3k5

R151	470ohms	C101	0.1 µF	C111	+	C121	0.01 µF
152	680 "	102		112	40 µF	122	0.01 "
153	560 "	103	16 pF	113	+		
154	100k	104	+	114	+		
		105	+	115	4 µF		
		106	+	116	0.1 "		
		107	+	117	0.1 "		
		108	100pF	118	1000 pF		
		109	+	119	40 pF		
		110	4 µF	120	40 pF		

D101	1N914	D111	+	T101	2N501	T111	2N501	V101	DM160
102	1N914	112	+	102	2N501	112	2N501		
103	1N914	113	+	103	+	113	2N501		
104	1N914	114	+	104	+	114	2N501		
105	1N914	115	FD100	105	2N708	115	OC141		
106	S555G	116	S555G	106	+	116	2N708		
107	1N914	117	S555G	107	+				
108	+	118	S555G	108	+				
109	+	119	+	109	+				
110	+			110	2N708				

Components marked with + are part of the Philips integrated units.

B 8.920.00 Flip-flop,

B 8.950.01 One-shot.

II. Fig. 5.4

Advance trigger generator (all components prefix 2)

R201	100k	C201	0.1 /uF	T201	2N1306	D201	FD100
202	5k6	202	1000pF				
203	1M						
204	10k						
205	5k6						
206	470ohms					B 8.950.01	one-shot
207	150k						
208	2k7						
209	68k						

III. Fig. 5.5

Counter (prefix 3)

R301	22ohms	R311	22ohms	T301	OC171	C301	0.01 /uF	D	all diodes
302	1k8	312	680 "	302	2N501	C302	0.01 /uF		are Q6-100
303	560 "					303	40pF		
304	560 "					304	40pF		
305	1k8					305	40pF		
306	1k8					306	0.01 /uF		
307	4k7					307	40pF		
308	680ohms					308	40pF		
309	680 "					309	0,01pF		
310	22 ohms					310	40pF		

IV. Fig. 5.6

Dividers and output stages (prefix 4)

R401	560ohms	R411	470ohms	C401	40pF	T401	OC171
402	680 "	412	470 "	402	0.01 /uF	402	2N501
403	1k8	413	5k6	403	100pF	403	2N708
404	22 ohms	414	5k6	404	0.1/uF		
405	-	415	560ohms			V401	DM160
406	1k8	416	35 ohms				
407	4k7	417	50kohms			D	all diodes
408	22 ohms						are Q6-100
409	680						
410	12k						

V. <u>Fig. 5.7</u>

Gating logic for bursts and pedestal.

R501	2k7	R511	220	R521	1k5	R531	820	R541	10k	R551	1k2
502	5k6	512	3k5	522	2k	532	10k	542	10k	552	1k5
503	1k2	513	330	523	4k7	533	4k7	543	10k	553	680
504	470	514	560	524	6k8	534	1k5	544	22k		
505	12k	515	1k	525	10k	535	12k	545	100k		
506	470	516	1k	526	4k7	536	4k7	546	100k		
507	1k8	517	2k2	527	1k	537	22k	547	10k		
508	22	518	2k2	528	10k	538	10k	548	5k pot		
509	820	519	2k2	529	100ohms	539		549	390 Ω		
510	560	520	33k	530	5k6	540	2k	550	750 Ω		

C501	0.1 µF	C511	40pF			T501	2N501
502	40pF	512	25nF			502	2N501
503	25pF	513	0.1 µF			503	2N501
504	0.01 µF	514	2000pF			504	2N501
505	1000pF	515	10nF			505	2N708
506	20 µF	516	20 µF			506	
507	2000pF	517	20pF			507	OC141
508	0,02	518	2000pF			508	21307
509	0.2 µF	519	0.01 µF			509	OC141
510	1 µF					510	2N1307

D501	IN914	D511	OA126/5	B501	B895000	S1	4pole/1
502	IN914	512	OA202	502	B892000	S2	2pole/1
503	IN914	513	0.1 µF	503	B892000	S3	4xsingle
504	IN914	514	OA85			S4	3pole/1
505	IN914	515	OA85				
506	S555G	516	OA85			L501	6,8 µH
507	IN914					L502	4.7 µH
508	S555G					L503	4.7 µH
509	OA126/5						
510	OA126/5						

VI. Fig. 5.8

Power supplies (prefix 6)

R601	22k	R611	3k3	R621	600Ω	C601	2500µF 12V	T601	2N1304	D601	IN347
602	1k	612	4k7			602	200µF 16V	602	ASZ15/18	602	IN2069
603	100k	613	500Ω			603	500µF 70V	603	ES3126	603	IS7036B
604	100k	614	1k			604	32µF 64V	604	2S301	604	IN2069
605	500ΩP	615	1k5	M1	1mA FSD			605	2N1304	605	IN2069
606	1k	616	4k7					606	ASZ15/18	606	IS7062
607	22k	617	82Ω 6W	I1	SBV8563			607	ES3126	607	10Z18
608	390k	618	600Ω	I2	SBV7561						
609	1k	619	1k								
610	10k	620	1k8								

VII. Fig. 5.9

Radio frequency amplifier (prefix 7)

R701	45k	R711	1k	R721	1k Ω	C701	0,01µF	C711	0,1µF	V701	D3A
702	15k	712	10k	722	1k Ω	702	0.1 µF	712	1 µF	702	E55L
703	68k	713	1k	723	510Ω	703	0.1 µF	713	0.1µF		
704	270 Ω	714	100Ω	724	5k	704	0.1 µF			D701	0A85
705	100 Ω	715	100Ω			705	0.1 µF				
706	270 Ω	716	33 Ω			706	0.1 µF			M.	1mAFSD
707	68k	717	470k			707	100 µF				
708	24 Ω	718	10k			708	0.1 µF				
709	120k	719	150 Ω			709	0.01µF				
710	150 Ω	720	120k			710	0.01µF				

VIII. Fig. 5.10

Branching unit

R801	470Ω	C801	0.1µF	D801	0A86
802	1k5				
803	270Ω			L801	100µH
804	220Ω			L802	Standard Pulse Transformer
805	1k				

APPENDIX 1

Sweep rates of Tektronix oscilloscopes

In the Tektronix oscilloscopes, as in any other oscilloscope, the maximum trigger frequency and the highest sweep rate are two entirely different things.

For low repetition rates (low sweeps) this is of no importance, but as one for beam observation purposes, one invariably works at the fastest sweep of the oscilloscope, care should be taken that every trigger pulse triggers the oscilloscope and that no trigger pulses arrive at the scope which may cause erratic triggering.

This is the reason why not simply the revolution frequency pulses alone are generated in the described instrument, but also signals like 1 pulse per 2,5 or 10 revolutions.

In the following table, the maximum sweep rates of Tektronix oscilloscopes (those types which we use) are given.

T A B L E 1

Maximum sweep rates of Tektronix oscilloscopes

Oscilloscope type or class	Sweep speed (setting) nanosec/cm	Sweep rate kilohertz	
540	100	200	) Sweep magnification
550	100	200	) does not affect the
580	50	200	) issue
517 A	20.000	1.5	
	10.000	3	
	5.000	6	
	2.000	10	
	1.000	20	
	500	50	
	200	50	
	100	50	
	50	50	
	20	50	
	10	80	
519 A	1.000	1	
	500	2	
	200	5	
	100	10	
	50	20	
	20	50	
	10	100	
	5	200	
	2	400	

T A B L E 2

Pulse repetition frequency of rev. freq. pulses

Class	P. RF beginning	P. RF after transition
1 pulse/rev RF/20	150 kc	470 kc
1 P/2 rev RF/40	75 kc	235 kc
1 P/5 rev RF/100	15 kc	47 kc
1 P/10rev RF/200	7,5 kc	23.5 kc