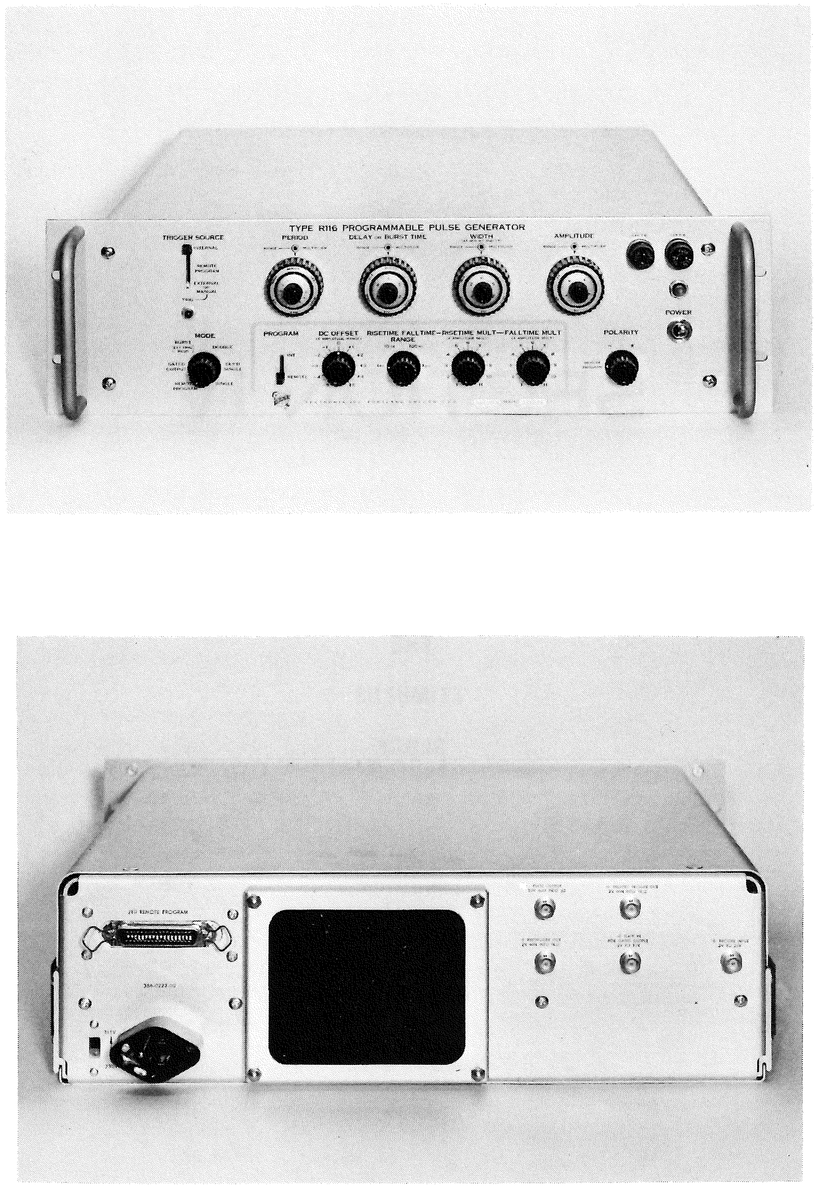

Fig. 10-1. Type R116 Mod 703L front and rear panel.

10

THE TYPE R116 PROGRAMMABLE PULSE GENERATOR

capabilities

The Type R116 is a multi-purpose programmable pulse generator with a wide range of output pulse characteristics. Repetition rates of up to 10 MHz are available with amplitudes of up to 10 V. Risetimes and falltimes may be as short as 10 ns. The Type R116 has 15 different parameters which may be programmed either from an external source or from the front panel. Eight of these parameters are programmed by switch closures. Seven are programmed by supplying external resistances. In this chapter switch programming will be referred to as digital programming, while those functions programmed by resistance will be termed analog programmable functions.

Front and rear panel views of the Type R116 Mod 703L appear in Fig. 10-1. A simplified block diagram of the Type R116 operating in SINGLE mode appears in Fig. 10-2. In SINGLE mode the Type R116 generates a sequence of pulses. The Period Generator is a free-running multivibrator with 5 ranges which are 100 ns, 1 μs, 10 μs, 100 μs and 1 ms. The period is varied between these ranges by the MULTIPLIER dial which is numbered between X1 and X11. With the PERIOD RANGE switch set at 100 ns and the MULTIPLIER at 1, the period of the output pulse is 100 ns. This gives a pulse repetition rate of 10 MHz. With the range switch at 1 ms and the MULTIPLIER at 11 the pulse period is 11 ms giving a pulse repetition rate of approximately 91 Hz. The pulse period is variable over the range of 100 ns to 11 ms.

period controls

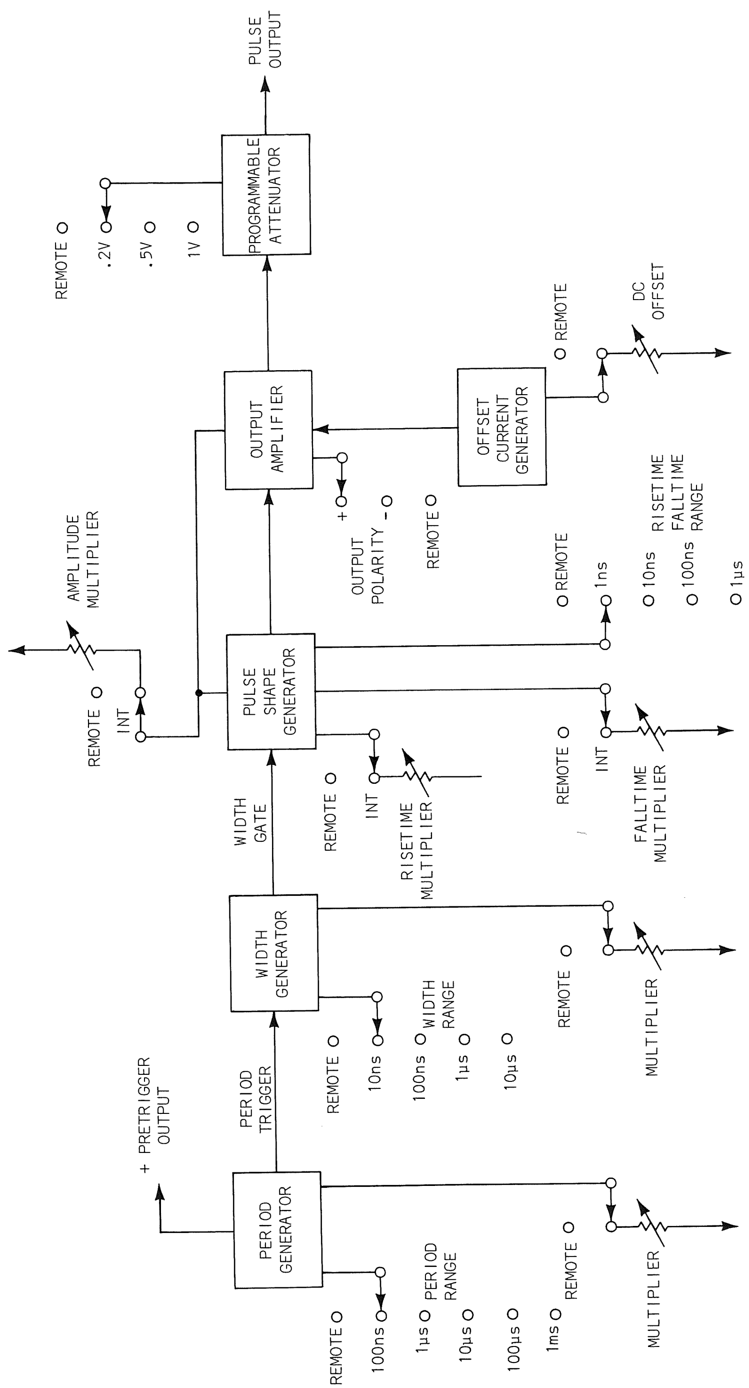

Fig. 10-2. R116 in single mode.

pretrigger and period trigger

The Period Generator (Fig. 10-2) generates two output signals. The Pretrigger coupled to a BNC connector either on the front panel or rear panel of the Type R116 is used to trigger the sampling system. It is generated between 30 and 50 ns ahead of the output pulse allowing ample time delay for the sampling system to observe the entire leading edge of a short risetime pulse. The other output signal of the Period Generator is the Period trigger which occurs at a rate determined by the PERIOD RANGE and MULTIPLIER controls. For example, if the RANGE control is set at 1 µs and the MULTIPLIER at 1 then the Period triggers will be generated at the rate of 1 per µs, or at a repetition rate of 1 MHz.

circuit functions

A ladder diagram showing the principal signals and their final effect upon the output pulse is shown in Fig. 10-3. The Period trigger coupled to the Width Generator activates a monostable multivibrator. The recovery time of the Width Generator is controlled by WIDTH RANGE and MULTIPLIER. WIDTH RANGE is a switch with four internal positions plus REMOTE program. WIDTH RANGES are 10 ns, 100 ns, 1 µs and 10 µs. The WIDTH MULTIPLIER is a potentiometer which multiplies width range between

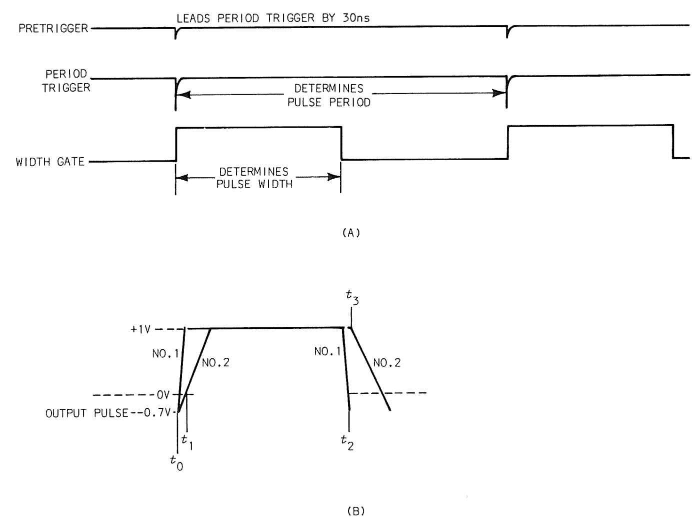

Fig. 10-3. Ladder diagram showing principal signals.

X5 and X55. For example, with the RANGE set at 10 ns and the MULTIPLIER at X5 the width of the pulse is 50 ns. With the potentiometer completely clockwise at the X55 position the width would be 550 ns. The output of the monostable multivibrator is the Width Gate. The width of the final pulse is determined by the width of the gate signal as indicated in Fig. 10-3. The Width Gate is connected to the Pulse Shape Generator block. Within the Pulse Shape Generator the risetime of the final pulse, the falltime and the final amplitude of the pulse delivered to the Output Amplifier are determined. A block diagram of the circuitry in the Pulse Shape Generator is shown in Fig. 10-4.

In Fig. 10-4 before the Width Gate goes positive the Current Steering Gate steers current from the Negative Constant Current Generator into the Risetime/Falltime Slope capacitor. This capacitor will be charged slightly negative with respect to ground by the amount of voltage drop across diode D1, the negative excursion clamp diode. The output level is approximately -0.7 V. When the Width Gate goes positive the Current Steering Gate disconnects the Negative Constant Current Generator and connects the Positive Constant Current Generator to the Risetime/Falltime Slope capacitor. The capacitor begins to charge positive at a constant rate from -0.7 V. The rate is determined by the amount of current the Positive Constant Current Generator is supplying. The current is determined by a potentiometer labeled RISETIME MULTIPLIER. Charging a capacitor through a constant current device results in a linear change in capacitor voltage. The Risetime and Falltime signals generated here are linear ramps.

linear ramp generators

It is important to note that until the capacitor voltage crosses 0 V no output pulse appears. When the Risetime/Falltime Slope capacitor is small in value and the slope of the risetime is very short no appreciable problem is encountered. On the other hand, when a large Slope capacitor is being used the elapsed time from -0.7 V until crossing 0 V may be important. This is shown in Fig. 10-3B. Two output pulse waveforms are shown. No. 1 has a fast risetime and falltime. No. 2 has a much slower risetime and falltime. The pulse begins at time t_0 when the leading edge of the Width Gate arrives. For the time it takes the Slope capacitor

slower vs faster risetime

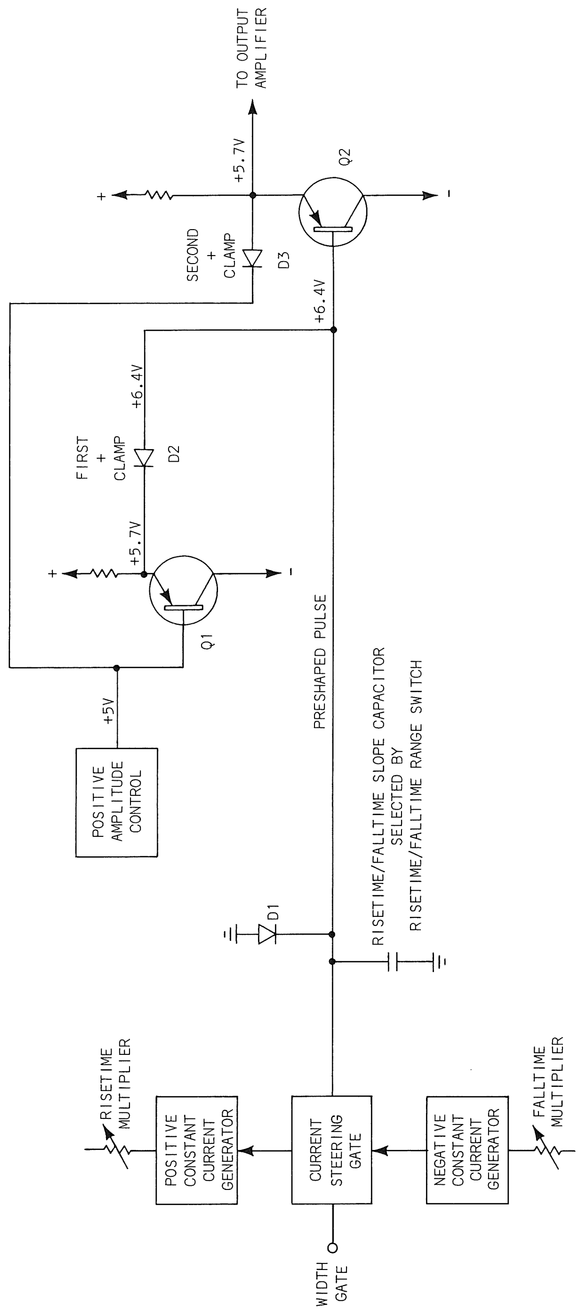

Fig. 10-4. Pulse shape generator.

to reach 0 V no output pulse appears. With No. 1 little difference is noted. Note however, with a much slower risetime as shown by waveform No. 2, the time from t_0 to t_1 is the time it takes this slower moving ramp to reach 0 V. The output pulse does not appear until the Slope capacitor charge crosses the 0 V level. The appearance of the output pulse is delayed from t_0 to t_1. Therefore as the risetime is varied, the apparent starting point of the output pulse varies with respect to the Pretrigger.

first clamp

Once the rising ramp crosses the 0 V level the output pulse begins to appear on the output line. The ramp continues to rise until diode D2, the First + Clamp, turns on and sets the upper level of the pulse. The voltage at the cathode of D2 is set by the output level of the Positive Amplitude Control block. For this discussion assume this output level to be +5 V. The voltage at D2 anode (when turned on) is approximately +6.4 V. This action clamps the pulse at +6.4 V.

second clamp

Emitter follower Q2 couples the pulse to the Second + Clamp diode D3. The voltage at the emitter of Q2 is +0.7 V above the level of the pulse. The cathode of D3 connects to the +5 level from the Positive Amplitude Control block. When the voltage at Q2 emitter crosses +5.7 V, D3 turns on clampling the pulse output. As the leading edge ramp rises, Q2 emitter rises also. Note that D3 will turn on before D2. This is because the voltage level at D3 anode is 1 semiconductor junction voltage drop *below* the level at D2 anode. The pulse level coupled to the output amplifier is +5.7 V for this example. This double clamp arrangement provides a flat top for the pulse which is free from stray noise and hum. In addition, changes in junction voltage drops due to temperature changes compensate each other. This assures a stable output pulse amplitude.

When the Width Gate switches to its quiescent level the Current Steering Gate again switches, the Positive Constant Current Generator is switched out of the circuit and the Negative Constant Current Generator is connected to the Risetime/Falltime Slope capacitor. The amount of negative current supplied is a function of the FALLTIME MULTIPLIER.

The Slope capacitor begins to charge back to its quiescent level at a slope set by the negative current.

negative edge shift

When the FALLTIME MULTIPLIER is set to X10 or X11 only a very small amount of current is supplied. This means that the appearance of the falling edge at the output of the generator, may be delayed as shown in Fig. 10-3B from t_2 to t_3. The reason for the apparent shift in the negative edge may be seen by examining the voltage levels shown in Fig. 10-4. When both clamp diodes D2 and D3 are turned on, Q2 is reverse biased by 0.7 V. Until the charge in the ramp Slope capacitor decreases to +5 V, Q2 remains off. Thus, if the negative slope is relatively slow, the rear corner of the pulse is delayed. This circuit provides independent control of the risetime and falltime of the output pulse. Note however, that only one capacitor is in the circuit at a time. Therefore, the choice is between X1 and X11 and 1 ns, 10 ns, 100 ns or 1 µs, the ranges available with the RISETIME FALLTIME RANGE switch.

slower rt and ft

Another point to be considered is that the falling edge of the output signal starts at the time the Width Gate signal goes negative. The actual end of the output pulse is determined by the time it takes the falling ramp to reach 0 V. The Slope capacitor continues to charge negative until clamp diode D1 turns on. The width of the pulses measured at the 50% points may vary considerably when risetimes and falltimes are varied. This is why the front panel WIDTH control is marked "AT MINIMUM RT AND FT." With slower RT and FT the apparent width of the pulse changes.

note

The user must recall two things of importance. One is that the apparent starting position and ending position of the pulse is a function of the risetime programmed. Two is that the apparent width of the pulse is a function of the Width Gate as well as the RISETIME and FALLTIME control settings.

output amplifier

The shaped pulse next couples to the Output Amplifier. The Output Amplifier performs several different functions. One is that additional positive clamping is applied to the signal. The Amplitude Multiplier is shown (Fig. 10-2) connected both to the Pulse Shape Generator and the Output Amplifier. The output pulse from the Pulse Shape Generator is clipped a bit more by a second clamp. The pulse may be inverted by the output POLARITY switch. The main function of the Output Amplifier is to amplify the pulse and combine it with the Offset Voltage being programmed.

DC offset

On the front panel, a DC OFFSET control is shown with a range of 0 to ±5 V. The maximum output amplitude possible is 10 V. To this 10 V may be added either +5 V or -5 V of DC offset. DC offset is essentially a variable polarity constant current generator programmed by the DC OFFSET control. The Output Amplifier drives a 50 Ω Programmable Attenuator. With all settings of the output attenuator the Output Amplifier drives 50 Ω. The Offset Current Generator may be set to supply up to a -100 or +100 mA. Assume the Offset Generator is set to supply -100 mA. This means that quiescently 100 mA is flowing through the output 50 Ω to ground. This places the quiescent output level of the amplifier at -5 V. The pulse when generated begins at the -5 V level, therefore, the base line of the pulse has been offset by 5 V. On the other hand, should the Offset Current Generator be demanding a +100 mA this current will be flowing from ground through the 50 Ω load. This places the output quiescently at a +5 V level and the base line of the pulse will be riding on a +5 V DC level. This variable voltage is entirely controlled by the potentiometer labeled DC OFFSET.

programmable attenuator

The Output Amplifier is coupled to the Programmable Attenuator. Three ranges of attenuation are provided: X1, X2 and X5. With the AMPLITUDE RANGE set to 1 V, the X1 attenuation ratio is used and the output of the amplifier is coupled directly through to the output jack. If the AMPLITUDE RANGE is at 0.5 V, then the output pulse level is divided by 2. At the 0.2 V position the programmable attenuator has a X5 attenuation ratio. The output signal is divided by 5 before being coupled to the output jack. Because the attenuator is coupled between the Output Amplifier and the output jack the DC offset value is modified by the amplitude range. For example, if the DC offset is set to be +5 V and the amplitude range is in the 0.2 V position, the offset will be divided by 5 as well as the amplitude of the pulse.

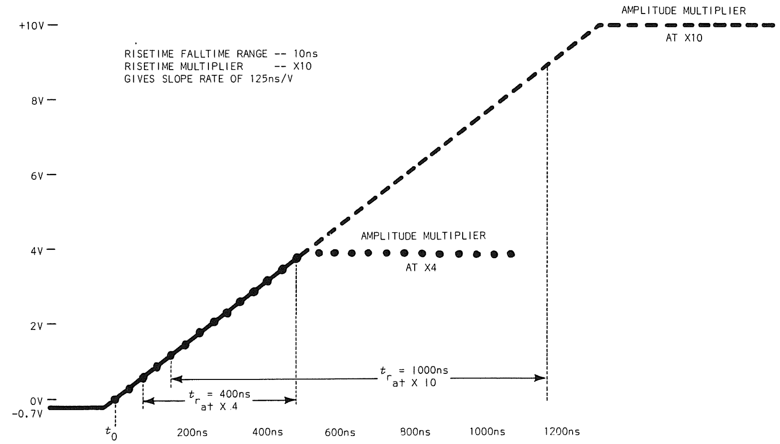

Fig. 10-5. Interaction of t_r t_f range, t_r multiplier and amplitude multiplier.

X amplitude multiplier

Referring to the front panel of the R116 in Fig. 10-1, note that the two controls, RISETIME MULTIPLIER and FALLTIME MULTIPLIER, are marked "X AMPLITUDE MULTIPLIER." Remember that the AMPLITUDE MULTIPLIER essentially sets the positive clamp level of the pulse. The MULTIPLIER has values between 2 and 10. Assume that the AMPLITUDE RANGE is in the 1 V position. The output amplitude of the pulse is variable between 2 V and 10 V. If the AMPLITUDE RANGE control is at 0.5 V then the multiplier varies the output between 1 V and 5 V. With the switch in the 0.2 V position then the output pulse amplitude is variable between 0.4 V and 2 V.

To understand why the RISETIME MULTIPLIER and the FALLTIME MULTIPLIER settings must be multiplied by the AMPLITUDE MULTIPLIER setting, refer to Fig. 10-5. Assume the RISETIME/FALLTIME RANGE is set to 10 ns with the RISETIME and FALLTIME MULTIPLIERS at 10. From the discussion of the R116 Pulse Shape Generator recall that the leading and trailing edges of the pulses are determined by a ramp generator. A ramp rises at a fixed slope. With these settings for RISETIME/FALLTIME RANGE and MULTIPLIERS, the ramp has a slope of 125 ns/V.

Assume the AMPLITUDE MULTIPLIER is set at 10. The clamp level is +10 V. The ramp rises from its quiescent -0.7 V until crossing the 0 V level. This is shown at time t_0. See Fig. 10-5. The ramp reaches +10 V after 1250 ns. The time between +1 V (10%) and +9 V (90%) is 1,000 ns. This risetime is read from the front panel by taking the RISETIME FALLTIME RANGE setting of 10 ns, multiplying by 10 (RISETIME MULT.) and by 10 again (AMPLITUDE MULTIPLIER). 10 x 10 x 10 = 1,000 ns which is the actual 10% to 90% risetime. If the AMPLITUDE MULTIPLIER is at X4, the ramp will reach a value of 4 volts after 500 ns. Refer to Fig. 10-5. The 10% - 90% time is 400 ns. 10 x 10 x 4 = 400 ns. Study shows that the risetime indicated by the controls must be multiplied by the AMPLITUDE MULTIPLIER setting in all cases. The same rule applies to the FALLTIME controls.

X10 vs X4

The student must be careful in interpreting the front panel controls. Assume the following settings:

RISETIME/FALLTIME RANGE - 1 ns

RISETIME MULTIPLIER - X 1

AMPLITUDE MULTIPLIER - X 2

These controls indicate a risetime of 2 ns. However, the Output Amplifier of the R116 does not have this fast a risetime/falltime capability. This capability is on the order of 10 ns. Therefore, any control setting calling for a risetime of less than 10 ns results in an uncalibrated time and is not permitted.

10 ns limit

The output risetime and falltime are not modified by the setting of the AMPLITUDE RANGE switch as it switches the Programmable Attenuator. Attenuating a signal with a certain risetime or falltime will not change the time relationships. The only effect will be to change the amplitude. This is illustrated in Fig. 10-6. For waveform No. 1 we assume the RISETIME/FALLTIME range x the RISETIME MULT x the AMPLITUDE MULTIPLIER gives us a risetime of 100 ns. With the AMPLITUDE RANGE control set at 1 V the output pulse is not attenuated and the overall risetime is 100 ns. Waveform No. 2 shows what happens if the AMPLITUDE RANGE is changed from 1 V to 0.5 V. This attenuates the signal from 10 V to 5 V but does not change the time it takes the waveform to reach 5 V. The risetime of the signal measured from 10% to 90% for waveform No. 2 is

attenuation and t_r

exactly the same as the risetime for waveform No. 1. Only the AMPLITUDE MULTIPLIER setting changes t_r or t_f, not the AMPLITUDE RANGE.

Refer to Fig. 10-1. The MODE switch located to the left side of the front panel shows 6 positions: SINGLE, DELAYED SINGLE, DOUBLE, BURST (EXTERNAL TRIGGER REQUIRED), GATED OUTPUT and REMOTE PROGRAM. We have discussed the operation of the circuit in the SINGLE mode only. Now consider the operation of the circuit in the DOUBLE mode. In this mode the R116 delivers a series of identical pairs of pulses. The first of these pulses is always delivered at a fixed interval after the PRETRIGGER is generated. The second pulse is delayed from the first pulse by a time determined by the DELAY or BURST TIME RANGE and MULTIPLIER controls. The delayed pulse is identical to the first pulse except for the time delay between the first and second pulses.

double mode

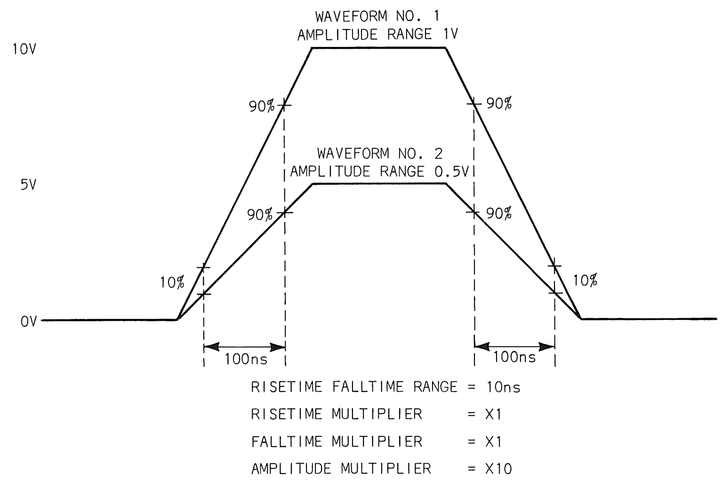

Fig. 10-6. Effect of amplitude range on t_r and t_f.

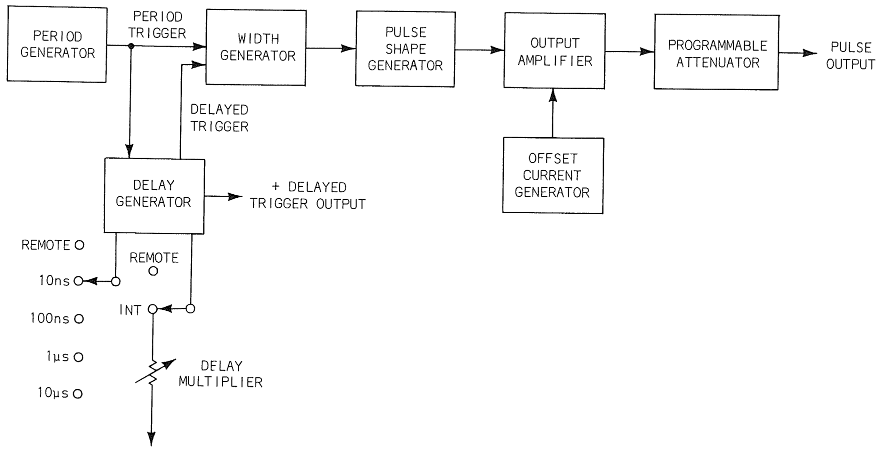

Fig. 10-7. Simplified block diagram of R116 in double pulse mode.

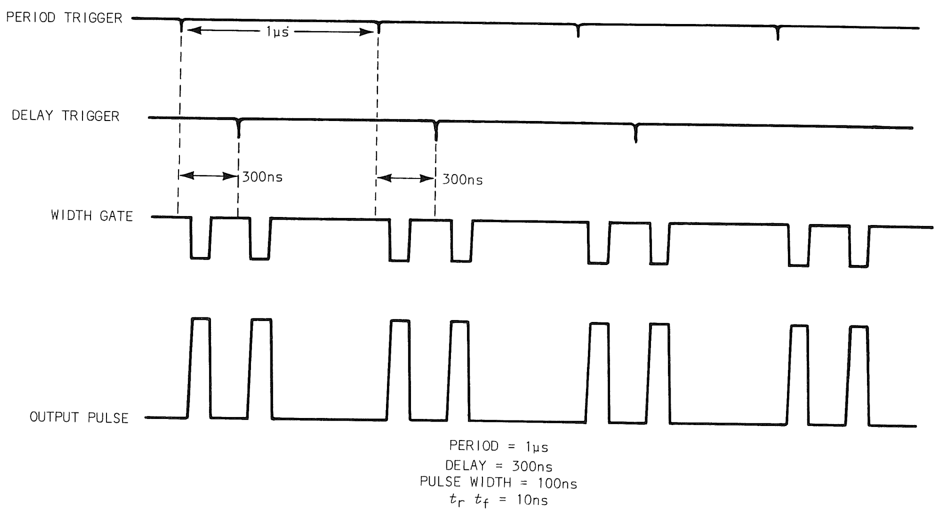

Fig. 10-8. Relationship of pulses in double pulse mode.

To clarify this action refer to Fig. 10-7. The block diagram is similar to the block diagram of Fig. 10-2 except for the addition of the Delay Generator block. Each time the Period Generator creates a Period Trigger it is coupled to both the Width Generator and the Delay Generator. The trigger pulse to the Width Generator causes an output pulse to appear as in SINGLE PULSE mode.

delay generator

The Delay Generator is a variable monostable multivibrator. Triggered by the Period Trigger into its unstable state, the multi recovers after a time determined by the setting of the DELAY RANGE and the DELAY MULTIPLIER controls. The minimum RANGE setting is 10 ns. The minimum setting of the DELAY MULTIPLIER is X5. Therefore, the mimimum delay is 50 ns. The maximum delay is 550 µs, DELAY RANGE at 10 µs and DELAY MULTIPLIER at X55. After the delay interval, the Delay multi recovers to its stable state and delivers a Delayed Trigger to the Width Generator. The Width Generator treats this signal in the same manner as it treats the Period Trigger. That is, a second output pulse (identical to the first) is now generated. In this mode then, the R116 delivers a pulse approximately 30 ns after the Pretrigger appears and, later after the delay interval, delivers a second identical pulse. See Fig. 10-8. The Delay Generator has a + DELAY TRIGGER OUT function. This trigger is delivered approximately 30 ns ahead of the Delayed Pulse and therefore serves as a pretrigger to enable sampling instruments to examine the Delayed Pulse only.

delayed single mode

In the DELAYED SINGLE mode the output of the Period Trigger is delivered only to the Delay Generator. It is *not* coupled to the Width Generator. Therefore, the only pulse that will be generated is the Delayed pulse. The Delay Generator cycles with the arrival of the Period Trigger and at the end of the delay interval, the Delayed Trigger is sent to the Width Generator. This results in the generation of a pulse in accordance with the setting of the various controls.

burst mode

In the BURST mode an external trigger is required so the Period Generator is locked out until the arrival of a trigger. When triggered, the Period Generator operates in a free running mode. The Delay Generator is used as the Burst Time Generator.

When the first trigger arrives, the Burst Generator goes into its unstable state. When it recovers, the Delay Trigger is coupled back to the Period Generator shutting the Period Generator off again. Therefore, with the arrival of an external trigger, the R116 will deliver a number of identical pulses for a time determined by the setting of the DELAY or BURST TIME controls. The first pulse is delivered at a fixed time interval after the external trigger arrives. The minimum burst width is 50 ns and the maximum width is 550 μs. Note that when operating in the BURST mode the operation of the circuit is essentially the same as when operating in the SINGLE PULSE mode.

gated output mode

The fifth mode of operation is the GATED OUTPUT mode which requires an external +Gate. Suppose for example, that a +Gate with 1 ms duration is coupled to the R116 +Gate In connector. When +Gate crosses +2 V the Period Generator (which has been locked out) turns on. The Period Generator operates as in SINGLE mode generating a series of identical pulses. These pulses continue as long as the +Gate is above +2 V. For the example stated, after the 1 ms +Gate ends, the output pulse train ends.

internal or external triggering

In the SINGLE, DELAYED SINGLE and DOUBLE modes the operator has a choice of INTERNAL or EXTERNAL triggering. When in INTERNAL trigger mode the Period Generator free runs. When the TRIGGER SOURCE switch is placed in the EXTERNAL or MANUAL TRIGGER position the Period Generator is disabled and is converted to a Trigger Shaping Amplifier. A Period Trigger is delivered only when an External Trigger is applied. The pulse *period* is determined by the external source. A MANUAL TRIGGER push-button on the front panel enables an operator to test the operation of the circuit in EXTERNAL trigger mode.

programming traps

Because of the versatility of the Type R116, there are a number of potential traps in the setting or programming of functions. For example, assume the Type R116 is in SINGLE PULSE mode, and the PERIOD RANGE is set for 1 μs. Further assume that the WIDTH controls make the Width Gate 2.4 μs wide. It is obviously impossible to get a pulse 2.4 μs wide with a period of 1 μs. Instead a pulse which is 2.4 μs wide is generated and a number of the Period Triggers are skipped. Fig. 10-9 shows what could happen under these conditions. The Period Trigger

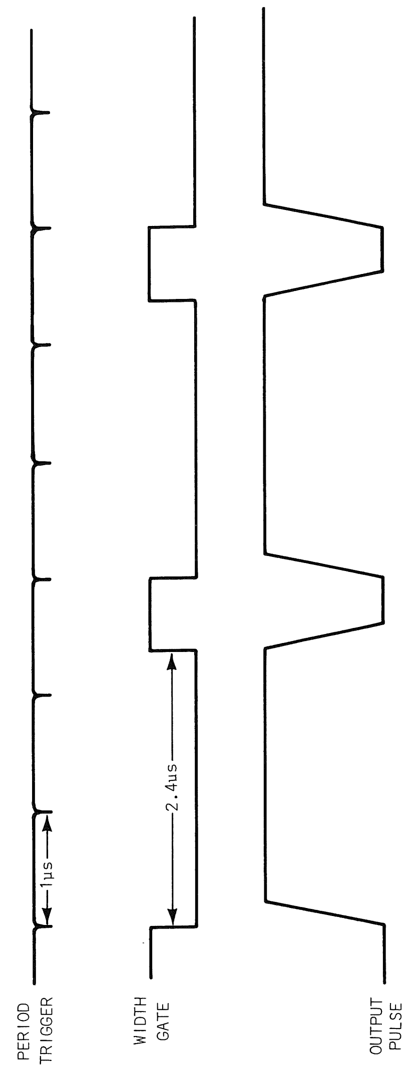

Fig. 10-9. Effect of setting width control for a pulse width greater than period control.

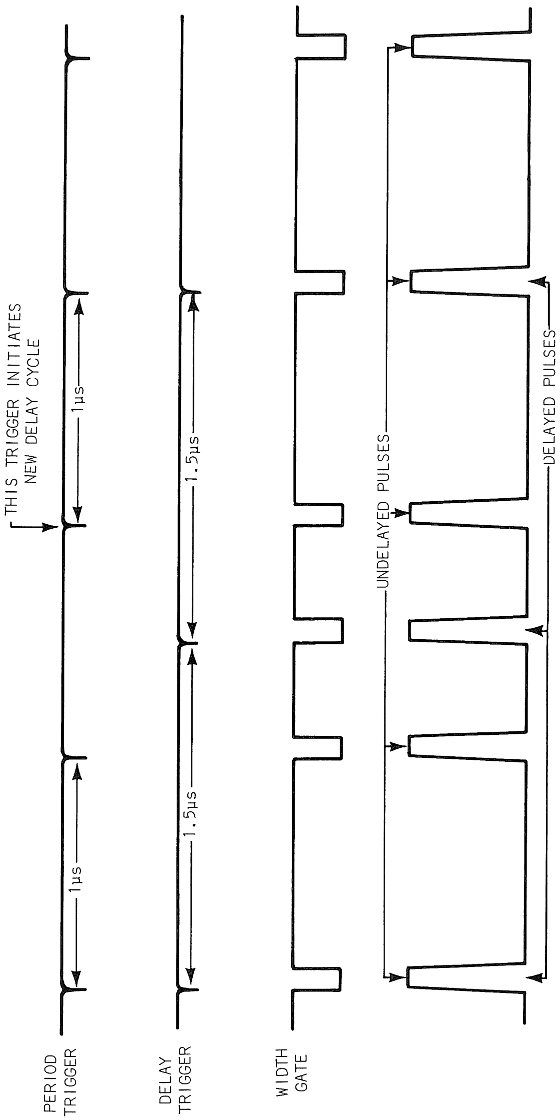

Fig. 10-10. Effect of setting delay control for a delay greater than the period (in double pulse mode).

is delivered at 1 µs intervals. The Width Gate (generated by the monostable multivibrator) will generate its gate with a width of 2.4 µs (depending upon the setting of the RISETIME and FALLTIME controls). Note in Fig. 10-9 that 2 Period Triggers are delivered during the duration of the Width Gate. These Triggers are ignored by the Width Gate multi. At the end of 2.4 µs the Width Gate circuit recovers and is regenerated by the next Period Trigger. For the example given, the period between pulses will be 3 µs with a pulse WIDTH setting of 2.4 µs. Therefore the setting of the PERIOD controls in this case is not accurate. This is only one example but an almost unlimited number of other examples could be cited to show the need for proper setting of the controls.

delayed trigger and double mode

A second source of potential error occurs when operating in the DOUBLE mode. In this mode the Delay must be less than the Period. In Fig. 10-8 recall that the Period was 1 µs and the Delay was 300 ns. This resulted in a pair of pulses occurring every 1 µs. Supposing however, through operator error the Delay is greater than the Period. See Fig. 10-10. For this example we assume the Period Trigger is delivered every 1 µs. The DELAY controls are set for a delay of 1.5 µs. The Delay Generator is a monostable multivibrator which ignores any new triggers until it has completed its own timing cycle. The net result is shown in the diagram. The first Period Trigger generates the first Width Gate and also initiates the first cycle of the Delay Generator. 1 µs later the next Period Trigger appears generating the second pulse but does not initiate a new Delay Generator cycle. The Delay Generator recovers 1.5 µs after the first Period Trigger. At that time the Delay Trigger generates another Width Gate. 0.5 µs later the third Period Trigger and second Delay Trigger simultaneously generate another Width Gate. The delayed pulse is masked by the underlayed pulse. On an oscilloscope the pattern would repeat that shown in Fig. 10-10 indefinitely. The Delay is now uncalibrated. As long as the DELAY time is set less than about 90% of the PERIOD, no problem is encountered.

Since the Delay is continuously variable over a wide range, the Delay could be set at precisely 1 µs. In this case only the undelayed pulse will ever appear. This will also occur if the Delay is set to exactly 2 µs, 3 µs, etc. In addition, DELAY can be set too short. If the circuitry generating the pulse has not had time to complete the first pulse before a second pulse (demanded by the Delay Trigger) is to be generated, no second pulse appears. If the DELAY is set too short the Delayed pulse simply disappears.

disappearing pulse

A third problem area is illustrated in Fig. 10-11. The operator must be careful to set the RISETIME/FALLTIME controls for an appropriate risetime in relation to the width and period desired. Consider output pulse No. 1 where the RISETIME controls are set for a risetime and falltime of 1 µs. Recall from the discussion of the Pulse Shape Generator block that the risetime and falltime are determined by ramp generators. The risetime ramp is generated at the negative edge of the width gate. It rises until it reaches the +2 V clamp level. When the positive edge of the Width Gate occurs, the Ramp Generator is reversed and runs back to -0.7 V. Recall that any voltage below 0 does not appear at the output. At the second negative edge of the Width Gate, the identical pulse is again generated.

t_r, t_f too slow

Suppose that the RISETIME/FALLTIME controls are set too slow. See output pulse No. 2. The RISETIME/FALLTIME controls are set for a 3 µs risetime with a Width Gate of 2 µs. The risetime ramp does not have time to reach the 2 V clamp level. At the first negative edge of Width Gate the risetime ramp is generated and, if allowed to, would rise until crossing the +2 V level 3 µs later. Before this time however, the positive edge of Width Gate occurs reversing the direction of the Ramp Generator. From that point then the ramp runs down at the rate of 1 V/1.5 µs reaching 0 V before the next negative edge of the Width Gate. With the next negative edge of Width Gate a second risetime ramp is generated and so on. The R116 AMPLITUDE controls are now uncalibrated since the output amplitude never reached the programmed 2 V level.

no pulse at all

It is possible by using longer ramps to have no pulse at all. For example, if the Width Gate were 50 ns with the 3 µs risetime/falltime programmed, the output signal would never have a chance to rise from its quiescent -0.7 V to 0 V, and no pulse would appear in the output.

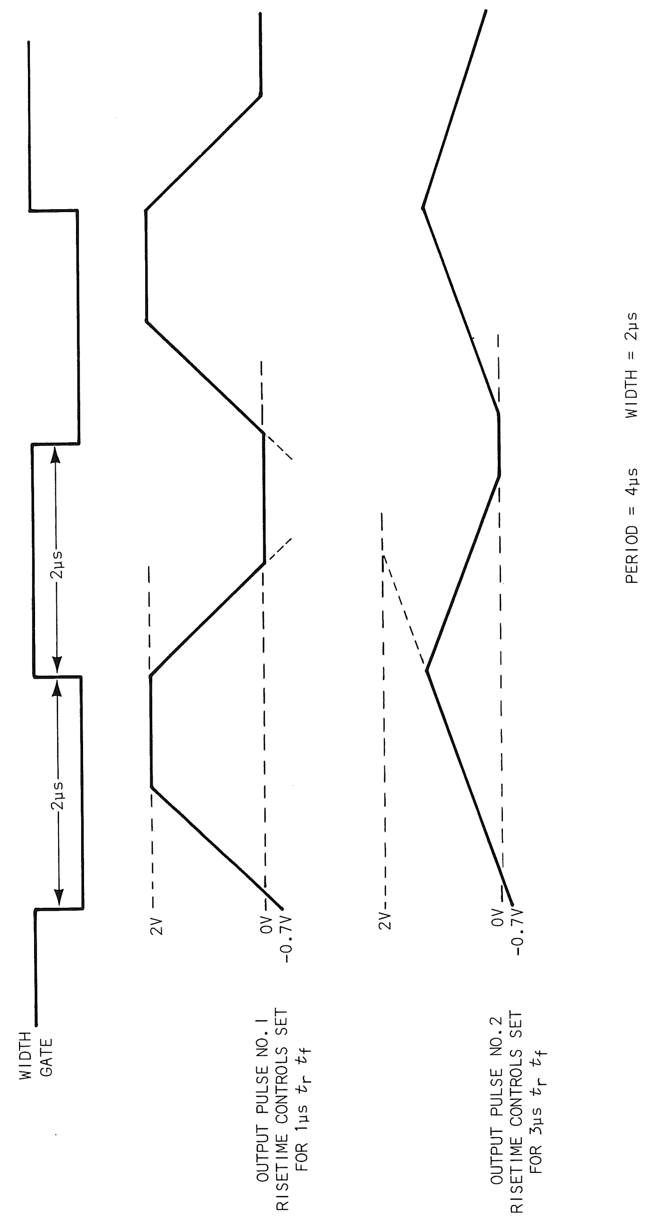

Fig. 10-11. Setting risetime/falltime in relationship to width/period.

	250 CHAR	BIT VALUE 8	4	2	1		
122	74	10µs	1µs	100ns	UNASSIGNED	S	
	75	40.0	20.0	10.0	5.0	P	DELAY (M - 5 = P)
	76	4.0	2.0	1.0	0.5		
	77	DELAYED(S)	DOUBLE	BURST	GATED	S	MODE
	78	1ms	100µs	10µs	1µs	S	
	79	8.0	4.0	2.0	1.0	P	PERIOD (M - 1 = P)
	80	0.8	0.4	0.2	0.1		
	81	10µs	1µs	100ns	1.0V	S	WIDTH RANGE/AMPLITUDE RANGE
	82	0.5V	1µs	100ns	10ns	S	AMPLITUDE RANGE/t_r-t_f RANGE
	83	-OFFSET(S)	4.0	2.0	1.0	P	OFFSET (M = P)
	84	0.8	0.4	0.2	0.1		
	85	40.0	20.0	10.0	5.0	P	WIDTH (M - 5 = P)
	86	4.0	2.0	1.0	0.5		
	87	-POLARITY(S)	4.0	2.0	1.0	P	POLARITY/AMPLITUDE (M - 2 = P)
	88	0.8	0.4	0.2	0.1		
	89	8.0	4.0	2.0	1.0	P	t_r (M - 1 = P)
	90	0.8	0.4	0.2	0.1		
	91	8.0	4.0	2.0	1.0	P	t_f (M - 1 = P)
140	92	0.8	0.4	0.2	0.1		

Fig. 10-12. External program format programmed from a Type 250.

Figs. 10-9, 10-10 and 10-11 illustrate 3 specific examples of problems. In actual practice it is possible to have combinations of those problems at the same time with completely unpredictable results. The simplest way of avoiding any problems is to sketch the desired waveform with the desired parameters on paper before setting up the Type R116 controls or external program. Sketching the waveform on paper ahead of time helps to avoid impossible pulse parameter control settings.

plan ahead

digital program

All functions of the Type R116 may be externally programmed. The following functions are programmed digitally:

- Trigger Source
- Mode
- Period Range
- Delay or Burst Time Range
- Width Range
- Amplitude Range
- Polarity
- Risetime/Falltime Range.

analog program

Seven functions are analog programmed:

- Period Multiplier
- Delay or Burst Time Multiplier
- Width Multiplier
- Amplitude Multiplier
- DC Offset (Polarity of offset requires a separate switch closure)
- Risetime Multiplier
- Falltime Multiplier.

Programming of the Type R116 in a system is done with the Type 250 Auxiliary Program Unit. A program format for the R116 programmed from a Type 250 is shown in Fig. 10-12. The standard character positions for the program cards are characters 74 through 92 (a total of 19). Of these characters one bit is unassigned, therefore, a total of 75 bits is required to program the Type R116. For those seven functions which are analog programmed a resistance must be switched into the circuit by the programmer. For the eight digitally programmed functions a switch closure to ground or a saturated transistor must be provided. In the program format the letter S for a character indicates that character is a switch closure character. Examples are characters 74 and 77. Characters labeled P, such as 75 and 76, are analog characters, that is, the card placed in character 75 position contains a number of reed switches and a number of resistors which are switched in or out of the circuit by the reed relays. The Shift Register card for the Type 240/250 provides an ideal place to provide resistance values when they are required.

s and p

corrective formulas

Fig. 10-12 shows correction formulas for those characters which program multiplier functions. Several of the front panel multipliers have ranges like X2 to X10 (AMPLITUDE MULTIPLIER) and X5 to X55 (DELAY MULTIPLIER). Designing a suitable program format for these multipliers presents a problem since programming a character to 0000 (analog resistance 0 Ω) does *not* result in a "0" MULTIPLIER setting. In the case of the AMPLITUDE MULTIPLIER programming an analog resistance of 0 Ω gives a X2 multiplier. The formula was derived to correct for this X2 minimum. For all other multipliers a similar formula is provided.

delay multi format

Character 74, bits 8, 4 and 2 program the DELAY RANGE. They duplicate the positions of the front panel DELAY RANGE switch. Bit 1 is unassigned. Characters 75 and 76 complete the DELAY programming by duplicating the programming functions of the DELAY MULTIPLIER potentiometer on the front panel. In character 75, bits 8, 4 and 2 are 40, 20 and 10 respectively. Bit 1 has a 5 value. In character 76 bits 8, 4, 2 and 1 have a standard BCD coding format. The DELAY MULTIPLIER is calibrated between X5 and X55. This special code allows any number between X5 and X55 to be programmed to the nearest 0.5 increments. The program scheme is such that if no bits are made true in character 74, the DELAY MULTIPLIER will automatically be X5. Making bit 2 of character 74 true will switch the MULTIPLIER range to X15. Making bit 8 true programs X45. The minimum possible delay is 5 times the DELAY RANGE. The delay formula reads M - 5 = P. M is the dial

reading of the DELAY MULTIPLIER control and P is the value to be programmed. The formula is interpreted in the following manner: Supposing that the operator wishes to duplicate the setting of the MULTIPLIER dial at its minimum value (X5). Therefore M = 5. 5 - 5 = 0. Therefore P = 0 and no bits are programmed true in either character 75 or character 76. If the desired MULTIPLIER setting is 25, then M is 25. 25 - 5 = 20. The programmer makes bit 4 of character 75 true. Stated in a different manner, the delay is always 5 units greater than the delay programmed in character 75 or 76.

delay plus 5

Character 77 is a digital programming bit. Bit 8 programs DELAYED SINGLE mode. Bit 4 programs DOUBLE PULSE. Bit 2 programs BURST mode. Bit 1 programs GATED mode. Setting character 77 to 0000 automatically programs SINGLE mode. For this character only 1 bit may be true at a time. Characters 78, 79 and 80 program the PERIOD RANGE and MULTIPLIER. Character 78 is a switch programming character. Bit 8 programs 1 ms range. Bit 4 programs 100 μs. Bit 2 programs 10 μs and and bit 1 programs 1 μs. If all bits of character 78 are zeros the PERIOD RANGE is 100 ns. Character 79 programs the digital value of the PERIOD MULTIPLIER. The MULTIPLIER dial is graduated between 1 and 11. The correction formula reads M - 1 = P. If the minimum PERIOD MULTIPLIER range (X1) is to be programmed, M is equal to 1. 1 - 1 = 0. P must be zero. Characters 79 and 80 must be all zeros. If the programmed PERIOD MULTIPLIER is to be X11, then the value of M is 11. 11 - 1 = P. Character 79 will be programmed 1010. The PERIOD MULTIPLIER may be programmed to the nearest 10th of an increment through the use of character 80.

character format

Character 81 contains 2 different functions of programming. Bits 8, 4 and 2 set WIDTH RANGE: 1 μs, 100 ns and 10 ns, respectively. If no bits are true in 8, 4 and 2, the 10 ns range is selected. Bit 1 of character 81 and bit 8 of character 82 program the AMPLITUDE RANGE. The three ranges available are: 1 V, 0.5 V and 0.2 V. If 1 V is required, then bit 1 of character 81 is made true. If 0.5 V range is to be selected, bit 8 of character 82 is made true. If neither of these two bits are made true, then R116 is automatically in the 0.2 V range.

Character 82, bits 4, 2 and 1 program the RISETIME/FALLTIME RANGE. The front panel RANGE switch markings are 1 μs, 100 ns, 10 ns and 1 ns. 1 ns is obtained by setting the three bits to 0. Both characters 81 and 82 are digital programmed characters.

offset format

Characters 83 and 84 program the OFFSET MULTIPLIER. The MULTIPLIER control is a potentiometer and may be set over the range 0 V through ±5 V. Bit 8 of character 83 is a switch closure bit which programs - OFFSET. If this bit is 0 then + OFFSET is automatically programmed. Bits 4, 2, 1 of character 83 and all of character 84 analog program the amount of offset. A maximum of ±5 V of offset may be programmed. Therefore, binary code higher than 0101 may not be programmed in character 83. If character 83 is programmed 0101, then character 84 must be programmed 0000. For example, if +4.8 V of offset is required, character 83 is programmed 0100 and 84 is 1000. No correction formula is required in this case.

Characters 85 and 86 program the WIDTH MULTIPLIER. The correction formula here is M - 5 = P since the WIDTH MULTIPLIER is calibrated between 5 and 55. Bit 8 of character 87 is a digital bit and programs the output pulse POLARITY. With bit 8 made true the output pulse will be negative. Bits 4, 2 and 1 of character 87 program the units of the AMPLITUDE MULTIPLIER. Bits 8, 4, 2 and 1 of character 88 program the tenths. The minimum dial setting of the AMPLITUDE MULTIPLIER is 2, therefore the correction formula is M - 2 = P.

Characters 89 and 90 program the RISETIME MULTIPLIER. Characters 91 and 92 are duplicates of 89 and 90 except they program the FALLTIME MULTIPLIER. The MULTIPLIER dials for either RISETIME or FALLTIME are labeled X1 to X11. The correction formula is M - 1 = P. Character 89 programs units while character 90 programs tenths.

11

THE TYPE R293 PROGRAMMABLE PULSE GENERATOR AND POWER SUPPLY

The Type R293 is a programmable pulse generator and two programmable power supplies. Fig. 11-1 is a front and rear view of an R293. The principal system's use of the R293 is the pulse generator section which the following discussion emphasizes. Recall from the discussion that the R116 has a minimum calibrated risetime and falltime of 10 ns. Many measurements require pulses with t_r and t_f of less than 10 ns. The Type R293 generates pulses with risetime and falltime equal to or less than 1 ns but t_r and t_f are not programmable. The pulses

pulse output

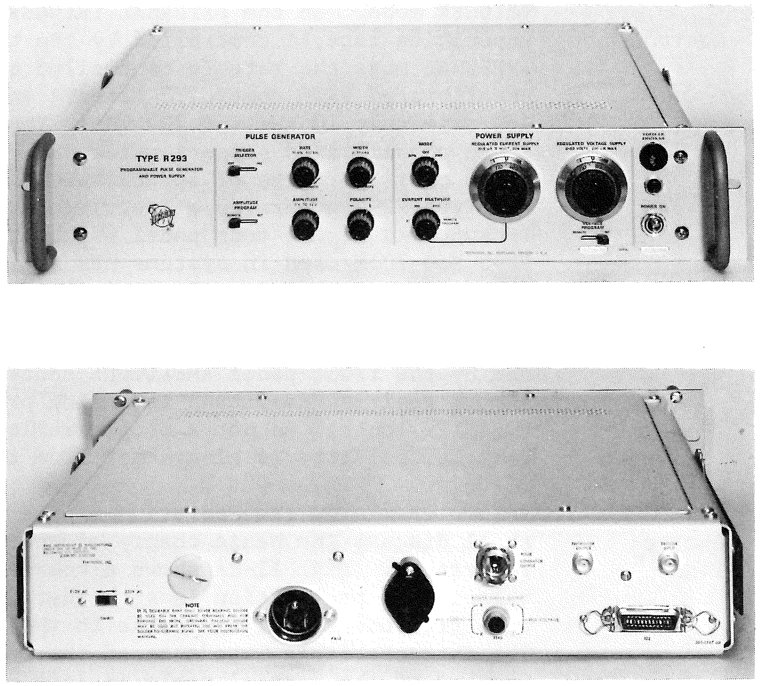

Fig. 11-1. R293 Mod 703M front and rear view.