1.4 Specifications

1.4.1 Generator

OUTPUT - single-shot pulse.

ACTUATION - dual-switch system:
CHARGE establishes internal potential;
PULSE applies stored potential to output via pulse-forming network.

PULSE REPETITION RATE - 6/minute, maximum; 2/minute maximum with Model 210 auxiliary Energy Storage Unit, 1/minute maximum with Models 210 and 211 auxiliary Energy Storage Units.

POLARITY - positive or negative.

STORED ENERGY - automatically selected by Programmer Network
Model 424 alone: 28.1 or 78.8 joules,
With Model 210 as well: 315 joules,
With both Models 210 and 211: 630 joules.

WAVESHAPES, IMPULSE: OPEN-CIRCUIT VOLTAGE AND SHORT-CIRCUIT CURRENT -
Exponential or linear rise, depending on Programmer
Exponential decay
te^{-at} form for 8 x 20 (PN 242, PN 247)

WAVESHAPES, OSCILLATORY and OTHER -
See applicable specifications on specific Programmer Networks.

ACCURACY -

Pulse virtual front durations:

$>$ 4uS	±10%
$\leq$ 4uS	±30%

All other pulse durations: ±20%

1.4.2 Programmer Network Output Pulse Characteristics

Table 1-1, following, lists pulse characteristics for a wide range of presently-available Programmer Networks.

TABLE 1-1

OUTPUT PULSE CHARACTERISTICS

PROGRAMMER NETWORK		ENERGY (joules)		PEAK POWER (kilowatts)	VOLTAGE (open-circuit)		CURRENT (short-circuit)	
Model	Mode	Stored	Max. Out	Max. Out	Peak or Plateau	Waveshape	Peak	Waveshape
PN 241	1	80	24.	23.	0-1.5 kV	1 kV/usec*	60 A	10 x 1000
	2		3.4	5.6	0-1.5 kV	10 x 1000	15 A	10 x 1000
PN 242	1	30	1.3	125.	0-1 kV	8 x 20	500 A	8 x 20
	2		.5	50.			200 A	
	3		.3	25.			100 A	
	4		.1	13.			50 A	
	5		.05	5.			20 A	
PN 243	1	80	4.5	188.	0-1.5 kV	1.2 x 50	500 A	<2 x 50
	2		2.0	75.			200 A	
	3		1.0	38.			100 A	
	4		.5	19.			50 A	
	5		.2	7.5			20 A	
PN 244	1	80	1.8	125.	0-1 kV	10 x 50	500 A	10 x 50
	2		.7	50.			200 A	
	3		.3	25.			100 A	
	4		.1	13.			50 A	
	5		.07	5.			20 A	
PN 245	1	30	4.8	15.	0-1.5 kV	10 kV/usec*	40 A	exponential rise, exponential decay (300 usec)
	2					5 kV/usec*		
	3					2 kV/usec*		
	4					1 kV/usec*		
	5					.5 kV/usec*		

*Underdamped step with linear rise to about 80% of peak open-circuit ("plateau") setting. Overshoots by about 25% of "plateau" setting. Exponential decay -- approx. 7500 usec PN 241, 900 usec PN 245.

TABLE 1-1 (con't)

OUTPUT PULSE CHARACTERISTICS

PROGRAMMER NETWORK		ENERGY (joules)		PEAK POWER (kilowatts)	VOLTAGE (open-circuit)		CURRENT (short-circuit)	
Model	Mode	Stored	Max. Out	Max. Out	Peak or Plateau	Waveshape	Peak	Waveshape
PN 246	1	28	5.4	19.	0-1.5 kV	10 kV/usec*	50 A	exponential rise, exponential decay (300 usec)
	2	30				5 kV/usec*		
	3					1 kV/usec*		
	4					.5 kV/usec*		
	5					.1 kV/usec*		
PN 247		30	11.	750.	0-1.5 kV	< 4 x 40	2000 A	8 x 20
PN 248**	1	80	11.	75.	0-1.5 kV	$<\overline{10}$ x >160	200 A	$<\overline{10}$ x >160
	2		14.	20.	0-800 V	$<\overline{10}$ x >560	100 A	$<\overline{10}$ x >560
PN 249+	1	315	43.	302.	0-800 V	4-5 x 200	1500 A	6 x 160
	2		16.	100.			500 A	
PN 250+	1	315	109.	94.	0-1.5 kV	1 kV/usec*	250 A	10 x 1000
	2		22.	25.	0-1 kV	10 x 1000	100 A	10 x 1000
PN 251++		630	200.	188.	0-1.5 kV	1 kV/usec*	500 A	10 x 1000

+Requires Model 210 Energy Storage Unit. Due to parasitic impedances, 249 may have "flat top" for ~40 microseconds before starting the exponential decay. Surge rate, 2/minute.

++Requires Models 210 and 211 Energy Storage Units. Surge rate, 1/minute.

*Underdamped step with linear rise to about 80% of peak open-circuit ("plateau") setting. Overshoots by about 25% of "plateau" setting. Exponential decay -- approx. 900 usec PN 246, 10 msec PN 250, 7 msec PN 251.

**Actual specifications are on time to crest rather than virtual front time (see section 1.3). This is indicated by $\overline{A}$ x B rather than A x B.

TABLE 1-1 (con't)

OUTPUT PULSE CHARACTERISTICS

PROGRAMMER NETWORK		ENERGY (joules)		PEAK POWER (kilowatts)	VOLTAGE (open-circuit)		CURRENT (short-circuit)	
Model	Mode	Stored	Max. Out	Max. Out	Peak or Plateau	Waveshape	Peak	Waveshape
PN 252	1	80		11.	0-1 kV	"10" x 1000*	45A	"15" x 600*
	2	80		11.	0-1 kV	"100" x 1000*	45A	"60" x 800*
PN 253	1	80	16	56.	0-1.5kV	100 kV/usec, all 5 modes: duration - 1000 usec	150A	<1 x 320
	2	80	11			500 usec		<1 x 240
	3	30	2.5			100 usec		<1 x 60
	4	30	1.4			50 usec		<1 x 40
	5	30	.6			20 usec		<1 x 20

* "A" x B means "A" is 10-90% risetime, rather than virtual front duration.

TABLE 1-1 (con't)

OUTPUT PULSE CHARACTERISTICS

PROGRAMMER NETWORK		ENERGY (joules)		PEAK POWER (kilowatts)	VOLTAGE (open-circuit)		CURRENT (short-circuit)	
Model	Mode	Stored	Max. Out	Max. Out	Peak or Plateau	Waveshape	Peak	Waveshape
PN 261		30	<.5	180.	0-6 kV	oscillatory .5 usec rise, 100 kHz	200 A (50 ohms parallel 50 uH)	oscillatory
PN 281		30	<.5	180.	0-6 kV	Same as 261	Same as PN 261	
PN 282**		30	6.	625.	0-2.5 kV	$<\overline{2} \times >10$ superimposed on ac line	1000 A min; 1200-1400 A typ.	4 us rise-time, >10 us time to 1/2 crest
PN 283	1 2	30	6	500	0-5 kV	5 kV/usec 2 kV/usec	100A	25 usec duration

**Actual specifications are on time to crest rather than virtual front time (see section 1.3). This is indicated by $\overline{A} \times B$ rather than A x B.

TABLE 1-1 (con't)

OUTPUT PULSE CHARACTERISTICS

PROGRAMMER NETWORK		ENERGY (joules)		PEAK POWER (kilowatts)	VOLTAGE (open-circuit)		CURRENT (short-circuit)	
Model	Mode	Stored	Max. Out	Max. Out	Peak or Plateau	Waveshape	Peak	Waveshape
PN 286	1	30	.2	40.	3.2 kV	10 kV/usec* +	50A	See note+
	2		.2	40.	3.2 kV	5 kV/usec* +		
	3		1.6	40.	3.2 kV	1 kV/usec* +		
	4		1.6	40.	3.2 kV	.5 kV/usec* +		
	5		1.5	38.	3 kV	.1 kV/usec* +		
PN 291**	1	630	76.	90.	1.2 kV (with extended range to 1.5 kV)	100 to 120 V/usec slope at 700V with 1200 open-circuit	300A	~10 x 1000
	2		20.	30.			100A	
	3		6.3	9.			30A	
	4		1.8	3.			10A	
	5		.9	1.5			5A	
	6		.2	.3			1A	

+ Durations are ~5 usec for 10 and 5 kV/usec; ~40 usec for 1 and .5 kV/usec; ~65 usec for .1 kV/usec. Durations the same for current, except ~45 usec for .1 kV/usec. All durations measured from start of wave to decay to 1/2 peak value.

* To obtain linear fronts, waves are quasi-square waves with 20-25% initial overshoots beyond peak open-circuit (plateau) voltages, except for .1 kV/usec which is roughly triangular. Undershoots range from 5 to 25%. Waves are linear to 3 kV except for .1 kV/usec, which is linear to 2.5 kV. NOTE: Multiply Model 424 digital and go/no go voltage readings X 2.

** Requires Models 210 and 211 Energy Storage Units, and Option I-424. Surge rate, 4/minute.

1.4.3 Monitor

Includes all waveforms, whether full or chopped.

DISPLAYS

Digital

Range	Display	Resolution	Accuracy for virtual front duration of >5 usec	Accuracy for virtual front duration of <5 usec
		Voltage*		
10 kV**	0-9.99 kV	10 V	± 3% rdg ± 1% range	±(3+kV/usec)% rdg ± 3% range
1 kV	0-1500 V	1 V	± 3% rdg ± 1% range	±(3+kV/usec)% rdg ± 3% range
100 V	0-139.9 V	0.1 V	± 3% rdg ± 1% range	NA+

Overrange indications: over 139.9 on 100V range, 1599 on 1 kV range.
Underrange indications: under 40 on 1 kV range, 0.4 on 10 kV range.

		Current	
1 kA++	0-1500 A	1 A	± 5% rdg ± 2% range
100 A	0-150 A	1 A	± 5% rdg ± 2% range

Range automatically selected by plug-in Programmer Network

* For short-circuit current I, maximum voltage readings are I/500 for >5 usec virtual front time; and I/50 for <5 usec virtual front time and for ≤10 usec time to crest. (Short at terminals.)

** 10 kV range supplied only with Programmer Networks which require it, such as the PN 261 and PN 282.

\+ Not applicable: in wave startup area, and accuracy limited by connectors, terminations, fixturing.

++ Peaks to 2000A with Programmer Networks like PN 247, via simple scaling.

Minimum readings	4% of range, V or I peak meter
Controls	voltage range selector, and on-off switch for each display

Go/No-Go

Go/No-Go indicators for voltage and current peaks, based on digital comparison with front panel switch settings for allowable maximum voltage to 1 kV, minimum current to 500 A.

Analog Outputs

Voltage and current	5V, full range
Output impedances	50 ohms
Application	Primarily for use with full impulse waves with >5 usec virtual front duration; such as 10x1000, 8x20, 10x50 etc.

1.4.4 Interlock Systems

There are two separate interlock systems within the Model 424, one of which is also suitable for the use in conjunction with auxiliary equipment such as the Model 450 Component Test Fixture.

1. Power Interlock System

   If the instrument is tilted more than about ten degrees off the vertical in any direction, the input AC to the entire instrument is automatically turned off and the Tilt/Power Interlock light becomes lit. This insures that components within the instrument which must be operated in the vertical position will not be required to function under less-than-optimum conditions.

   The power interlock system is also interrupted by removal of the Programmer Network, so that the instrument cannot be powered unless a Programmer Network is in place.*

2. Circuit Interlock System

   The circuit interlock system prevents charging the internal energy storage capacitors unless the following requirements are met:

   A. A Programmer Network must be plugged in.

   B. A link must exist between Out Lo and Measure Lo on the front panel.

* The interlock is also opened by a thermal cutout on the heat sink of the ± 15 V regulator circuitry.

Note

If Measure Lo is connected to Chassis via front panel link (or other means), as recommended, then connection to Out Lo of a scope return or other instrument connected to the third wire of the ac line input, may inadvertently complete the required Out Lo-Measure Lo connection.

C. When auxiliary equipment utilizing the External Adapter jack on the front panel is employed, closure of an external interlock switch such as the one incorporated in the Model 450 Component Test Fixture, is also required.

D. If the Model 424 has been outfitted with a high-voltage, multi-pin rear panel connector for use with the auxiliary Model 210 (and 211) Energy Storage Unit(s), and the cable to those unit(s) is disconnected, a special "keeper" cable must be connected between the multi-pin connector and the rear interlock phone jack to close the circuit interlock.

E. If the Model 424 is connected to the auxiliary Model 210, but an auxiliary Model 211 Energy Storage Unit is also supplied, the 210-211 cable connection must also be made.

If any of the above interlock requirements are not met, the green Charge Ready light will go out, and the Circuit Interlock light on the Model 424 panel will become illuminated. Model 424 Charge and Pulse operations are then inhibited.

1.4.5 Physical Specifications

OPERATING TEMPERATURE RANGE	10 to 50°C
DIMENSIONS	8-3/4" h x 19-1/2" d x 17" w (22.2 x 49.5 x 43.2 cm). (Some Programmer Networks, like the PN 282, protrude approximately 6" (15.2 cm) from the front panel, and must be shipped separately.)
WEIGHT	65-75 lbs. (29.3-33.8 kg), depending on options and Programmer Networks supplied.

1.5 Programmable/Readout Option P

Option P supplies programmability for Charge and Pulse operations in the KeyTek Model 424 Surge Generator/Monitor. Selection of remote operating mode is made via remote input command, causing the front-panel High Voltage light to flash continuously as a safety feature.

In addition to furnishing programmability, Option P also includes remote BCD outputs for resulting clamped peak voltage and current, as well as for voltage and current ranges. Auxiliary printers and other readouts can be used to generate hard copy whether surges are under manual or remote control.

Appropriate print command and data valid signals are included. They are generated only if all Model 424 normal operating requirements are satisfied: all circuit interlocks closed, optimum peak voltage range in use, pulse current exceeding front-panel preset limit and peak clamped voltage less than front-panel preset limit.

Via remote selection, the data valid and print command signals can be generated independent of peak voltage versus preset limit. This feature allows computer/calculator determination of voltage go/no go limits, particularly important when limits change as a function of remotely-controlled modifications of the pulse-forming-network configuration, including output currents.

1.5.1 Specifications, Inputs

REMOTE CONTROL	- enables the eight following inputs to take control, de-activates front-panel Charge and Pulse switches, and flashes High Voltage light continuously.
PULSE (+)	- duration greater than 1 msec generates approximately 5 sec Model 424 Charge function: following which, if PULSE ALLOW enabled, generates (+) Model 424 output pulse.
PULSE (-)	- same as PULSE (+), except generates (-) Model 424 output pulse.
PULSE ALLOW	- low for normal operation. Open or high to permit Charge but inhibit output Pulse until EXTERNAL PULSE.
EXTERNAL PULSE	- open or high for normal operation. Pulse 1 msec to 1 sec maximum, required to generate externally-synchronized Model 424 output pulse.

CURRENT SELECT	- low to select clamped peak current BCD outputs. High to select clamped peak voltage BCD outputs.
DATA VALID CONTROL	- low for DATA VALID to include voltage Go as a requirement; open or high for DATA VALID independent of voltage Go/ No Go.
PRINTER BUSY	- inhibits new PULSE (+) or PULSE (-) signal.
POLARITIES	- low or ground assertion except as noted.
LOADING	- one TTL LS load, +1 10K ohm pullup to +5.

1.5.2 Specifications, Outputs

PEAK CLAMPED OUTPUT VOLTAGE AND CURRENT	- 14 lines, 3 BCD digits plus overrange digit and sign (high for (-)).
VOLTAGE AND CURRENT DECIMAL POINT 1	- low for 100V range, i.e. XXX.X and 10A range i.e. XX.X
VOLTAGE DECIMAL POINT 2	- low for 10kV range, i.e. XX.XX

		V/I DP1	V DP2
10kV Range	XX.XX	High	Low
1000V Range	XXXX	High	High
100V Range	XXX.X	Low	High
1000A Range	XXXX	High	High
100A Range	-XXX	High	High
10A Range	-XX.X	Low	High

DATA VALID - low step indicates:

* BCD and range data stable and may be read,
* peak pulse current greater than set limit,
* peak pulse voltage less than set limit, (unless otherwise selected)
* on 100V range, peak less than 139.9V,
* on 1 kV range, peak between 40 to 1599V,
* on 10 kV range, peak above 0.4 kV,
* all circuit interlocks closed.