SECTION I
INTRODUCTION AND DESCRIPTION

1-1. INTRODUCTION.

1-2. This manual contains operation and maintenance data on the QRD Series, fast-programmable power supplies, manufactured by Raytheon Company, Sorensen Operation, Norwalk, Conn. Its purpose is to familiarize the user with unit functions, to introduce the varied configurations to which the unit is convertible and to provide sufficient maintenance data to assure long operating life. Note that the series consists of 7 models in the 30- and 80-watt classes with outputs ranging to 60 Vdc. Differences in models will be highlighted where required.

1-3. Six major sections form the manual divisions. Section I contains a description of the Series and its features, a tabular listing of complete unit specifications, and a set of characteristic curves. Details on initial inspections and checkout procedures are given in Section II. Operating instructions, including methods for adapting units to various applications, comprise Section III. Sections IV and V provide the principles of operation and maintenance procedures, respectively. A replacment parts list, Section VI, concludes the manual.

1-4. DESCRIPTION.

1-5. Designed for either bench use or rack mounting (para 1-23), a typical QRD fast-programmable power supply provides a precisely regulated d-c output, adjustable over a wide range. It operates from any of three nominal a-c inputs and, in addition, exhibits extremely fast programming-time characteristics as well as rapid response to transients, both load and line. (For a complete tabulation of standard-programming specifications, refer to Table 1-1. Fast-programming characteristics which are unique or which differ from standard-programming specifications are listed in Table 1-2.)

1-6. All semiconductors used in the QRD are silicon types and contribute significantly to the unit ambient-temperature characteristics. High-dissipation transistors are mounted to a cast aluminum-alloy heatsink; low-dissipation devices are located on a plug-in printed-circuit board. Cooling is by convection. Mechanical design permits easy component accessibility, with no sacrifice in unit size (see Figure 1-4).

1-7. Other mechanical features include a human-engineered front panel that mounts all operating controls and indicators used in normal operation. These include two dual-tandem potentiometers which give fine and coarse control over the output voltage and current range, a volt-ammeter with selector switch, an input-power switch and a power-on light. In addition, fluted-nut, miniature binding posts from which the output may be taken are situated on the front panel. At the rear, a mode-selector terminal board and the input fuse holder are mounted directly below the heatsink. By manipulating terminal-board links, the unit may be selected to such applications as fast and standard voltage-mode programming, fast and standard current-mode programming, parallel operation and remote sensing. A set of output terminals is also provided on the board.

1-8. OPERATING MODES. QRD Models have two basic operating modes, constant voltage and constant current. In the former, the output voltage is regulated at the front-panel selected or programmed value, and the output current varies with the load. In constant-current operation, the output-current is regulated at the selected value while the output voltage varies as a function of load.

1-9. AUTOMATIC CROSSOVER. The automatic-crossover system enables the unit to transfer operating modes as a function of load requirements. If, for example, load current attempts to increase above the setting of the current-adjust control, the unit will switch operation automatically from the voltage to current mode. If the load requirements are lowered, return to the voltage mode will occur automatically.

	QRD MODELS							
	ALL	15-2	30-1	40-.75	60-.5	20-4	40-2	60-1.5
INPUT								
Voltage Ranges (Vac)	105-125 200-240 210-250							
Frequency Range (Hz)	48-440							
Phase	1							
Max.Current (Aac)								
at 115 Vac		0.95	0.95	0.95	0.95	2.3	2.3	2.3
at 230 Vac		0.5	0.5	0.5	0.5	1.15	1.15	1.15
Power Factor (1)		0.86	0.86	0.86	0.86	0.78	0.78	0.78
Efficiency (%) (1)		35	35	35	35	42	42	45
OUTPUT								
Voltage Mode								
Range (Vdc)		0-15	0-30	0-40	0-60	0-20	0-40	0-60
Coarse Adj.Range	Full Range							
Fine Adj.Range (mV)		150	300	400	600	200	400	600
Resolution (typical) (mV)		1.5	3.0	4.0	6.0	2.0	4.0	6.0
Output Current Range at 55°C (2) (Adc)		0-2	0-1	0-.75	0-.5	0-4	0-2	0-1.5
Current Mode								
Current Range	(See Volt.Mode)							
Coarse Adj.Range	Full Range							
Fine Adj.Range (mA)		30.0	15.0	12.0	8.0	60.0	30.0	25.0
Resolution (typical) (μA)		300	150	120	80	600	300	250
Voltage Compliance	Full Volt.Range							
Current/Volt.Crossover Static (typical)	See Fig.1-2							

(1) At nominal input and full rated output.
(2) For derating characteristics, see Figure 1-1.

Table 1-1. Unit Specifications (Sheet 1 of 4)

	QRD MODELS							
	ALL	15-2	30-1	40-.75	60-.5	20-4	40-2	60-1.5
PERFORMANCE (3)								
Voltage Mode								
Regulation (4)	±0.005% or ±0.75 mV (5)							
PARD (Ripple) (6)								
50 to 60 Hz Input								
Max. RMS Volt. (μV) (10Hz-7MHz bandwidth)	200							
Max. P-P Volt. (mV) (0-25 MHz bandwidth)	3							
PARD (Ripple)								
400 Hz Input								
Typical RMS Volt. (μV)	500							
Typical P-P Volt. (mV)	10							
Transient Response (7) (μs)	50							
Output Impedance	R + JωL							
Low Frequencies (f < 1KHz)								
R (mohms)		0.4	1.5	2.5	6.0	0.25	1.0	2.0
L (μh)		0.5	1.2	2.0	3.0	0.4	0.8	1.5
Output impedance at 100 KHz is less than 0.2 ohms and at 600 KHz is less than 1.0 ohms.								
Temperature Coefficient	(0.015% + 200 μV)/°C							
Drift (8) (typical)	0.025% E_o (9)							
Remote Error Sensing Compensation (max)	1 volt/load lead							

(3) Output performance specifications are valid at rear terminals only.
(4) For a combined full line swing and a no load-to-full load (or full load-to-no load) change.
(5) Whichever is greater.
(6) With chassis ground tied to input ground.
(7) For a step load change, no load to full load or full load to no load, and recovery to within a ± 10 mV band.
(8) 8 hours after warm up at constant line voltage, load and ambient temperature.
(9) E_o is the output voltage.

Table 1-1. Unit Specifications (Sheet 2 of 4)

	QRD MODELS							
	ALL	15-2	30-1	40-.75	60-.5	20-4	40-2	60-1.5
Remote Prog. Coefficient								
Resistance	100±.5 ohms/volt							
Volt. Signal	1 volt/volt							
Overload Protection	Crossover to Current Mode							
Output Voltage Turn-On, Turn-Off Overshoots	None							
Max. Capacitive Load	Any							
Current Mode Regulation(10)	±(.01% + β)							
β (μA)		125	125	125	125	250	250	250
PARD (Ripple) 50 to 60 Hz Input(6)								
Max. RMS Current (μA) (10Hz-7MHz bandwidth)		150	150	150	150	400	300	300
Max. P-P Current (mA) (0-25 MHz bandwidth)	2							
PARD (Ripple) 400 Hz Input								
Typical RMS Ripple (μA)	100							
Typical P-P Current (mA)	8							
Transient Response	See Note 11.							
Output Impedance	See Fig. 1-3(12)							
Temperature Coefficient	(.015% + 50μA)/°C							
Drift(8) (Typical)	(0.1%+50μA)							

(10) For a combined full line swing and load change of short circuit to E max (or E max to short circuit) and recovery to a ±1% band.
(11) Function of $R_L C_o$ time constant (R_L = load resistance, C_o = value of output capacitor C19).
(12) Characteristic is typical for a Model 20-4. Typical curves for other specific models will be supplied upon request.

Table 1-1. Unit Specifications. (Sheet 3 of 4)

	QRD MODELS							
	ALL	15-2	30-1	40-.75	60-.5	20-4	40-2	60-1.5
Remote Prog. Coefficient Resistance (ohms/A) Signal (volts/A)		500 0.5	1000 1.0	1330 1.33	2000 2.0	250 0.25	500 0.5	667 0.67
Accuracy	± 10%							
Overload Protection	Crossover to Voltage Mode							
Output Current Turn-On, Turn-Off Overshoots	None							
MISCELLANEOUS Ambient Temp Range	-20 to +71°C(2)							
Series Operation	Max. 200 Vdc System Output							
Parallel Operation	Master-Slave							
Cooling	Convection							
Isolation Voltage to Grd Input Output	 1000 Vdc 200 Vdc							
Dimensions	See Fig. 1-4							
Weight (lb)		12.5	12.5	12.5	12.5	19.25	19.25	19.5
Meters- Voltage Range (Vdc) Current Range (Adc)		0-15 0-3	0-30 0-1.5	0-50 0-1	0-60 0-.6	0-25 0-5	0-50 0-2.5	0-80 0-2
Accuracy	±3%							

Table 1-1. Unit Specifications (Sheet 4 of 4)

	QRD MODELS							
	ALL	15-2	30-1	40-.75	60-.5	20-4	40-2	60-1.5
OUTPUT								
Current/Volt. Crossover	See Fig. 1-5							
Crossover Time								
Volt.-to-Cur. Mode (typ)	280 μs							
Cur.-to-Volt. Mode (typ)	160 μs							
PERFORMANCE(1)								
Voltage Mode								
PARD (Ripple)(2)								
50-60 Hz Input								
Max. RMS Volt. (μV) (10Hz-7MHz bandwidth)	300							
Typical P-P (mV) (0-25 MHz bandwidth)	8							
PARD (Ripple)								
400 Hz Input								
Typical RMS Volt. (mV)	1							
Typical P-P Volt. (mV)	20							
Transient Response(3)	70 μs							
Output Impedance (f < 600KHz)	R + JωL							
R (milliohms)		0.4	1.5	2.5	6.0	0.25	1.0	2.0
L (μh)		0.7	2.0	3.3	8.0	0.6	1.1	2.7
Prog. Time (10-90%)	See Fig. 1-6 and Para 1-18							
0-E max (typ) (μs)	25							
E max-0 (typ) (μs)	10							

(1) Output performance specifications are valid at rear terminals only.
(2) With chassis ground tied to input ground.
(3) For a step change no load to full load or full load to no load and recovery to within a ±10 mV band.

Table 1-2. Fast-Programming Specifications (Sheet 1 of 2)
(which are unique or which differ from standard specifications)

	QRD MODELS							
	ALL	15-2	30-1	40-.75	60-.5	20-4	40-2	60-1.5
Sinusoidal Freq.Response Gain (Eo/E in): Phase Shift: Max.Capacitive Load	See Note 4 Equivalent to R-C lag network where R = value of R47 or of external programming resistance and C = value of C17. 0.02 μF(5)							
Current Mode PARD (Ripple)(2) 50-60 Hz Input Max.RMS Current (μA) (10Hz-7MHz bandwidth)		300	300	300	300	800	600	600
Typical P-P Current (mA) (0-25 MHz bandwidth)	2							
PARD (Ripple) 400 Hz Input Typical RMS Current (μA)		300	300	300	300	800	600	600
Typical P-P Current (mA)	8							
Transient Response (typ)(6) E max. to 0 (μs) 0 to E max. (μs)		150 40	160 45	350 60	700 250	150 40	150 200	250 400
Output Impedance (typ)	1/(jωC)							
C (μF)		0.35	0.18	0.16	0.07	0.4	0.18	0.16
Output Current Overshoot Turn on Turn off Programming Time 0 - I max (10-90% points) I max - 0 (90-10% points) Sinusoidal Freq.Response Max.Frequency	None above 30% I max. Function of load current, output voltage at less than 30% I max. None 800 μs 200 μs $850 \frac{I_{max}}{I_{pp}}$ Hz							

(4) Max.Frequency, with average output voltage equal to (E max/2), is approximately (230/Epp)KHz.(Ref: Para 1-19 & Fig.1-7).
(5) For additional details, write or call Raytheon Co., Sorensen Operation.
(6) For a step load change of E max to short circuit or short circuit to E max, and recovery to a ± 1% band.

Table 1-2. Fast-Programming Specifications (Sheet 2 of 2)
(which are unique or which differ from standard specifications)

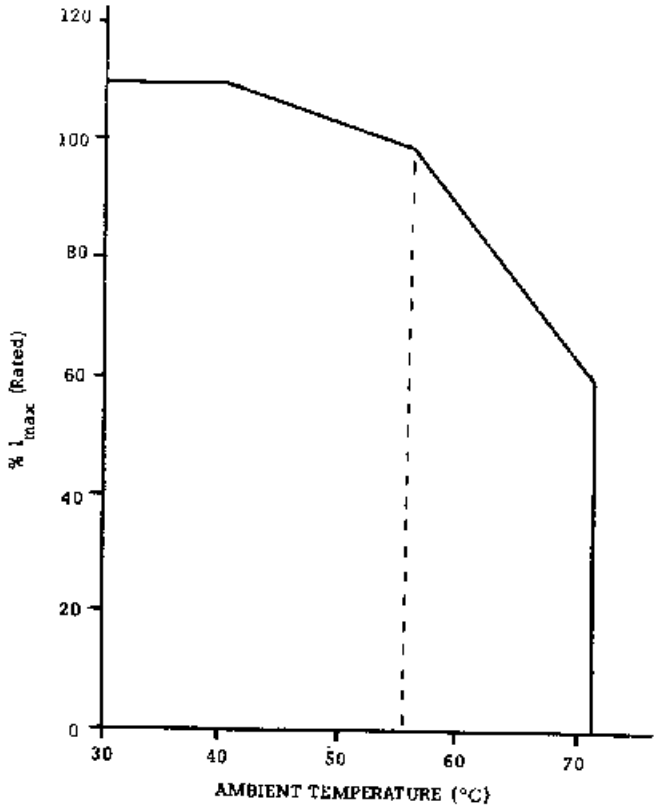


Figure 1-1. Current Derating Characteristics

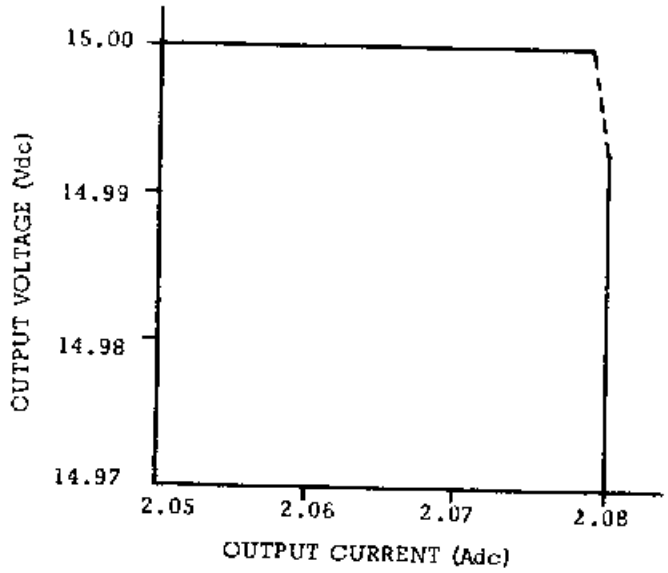
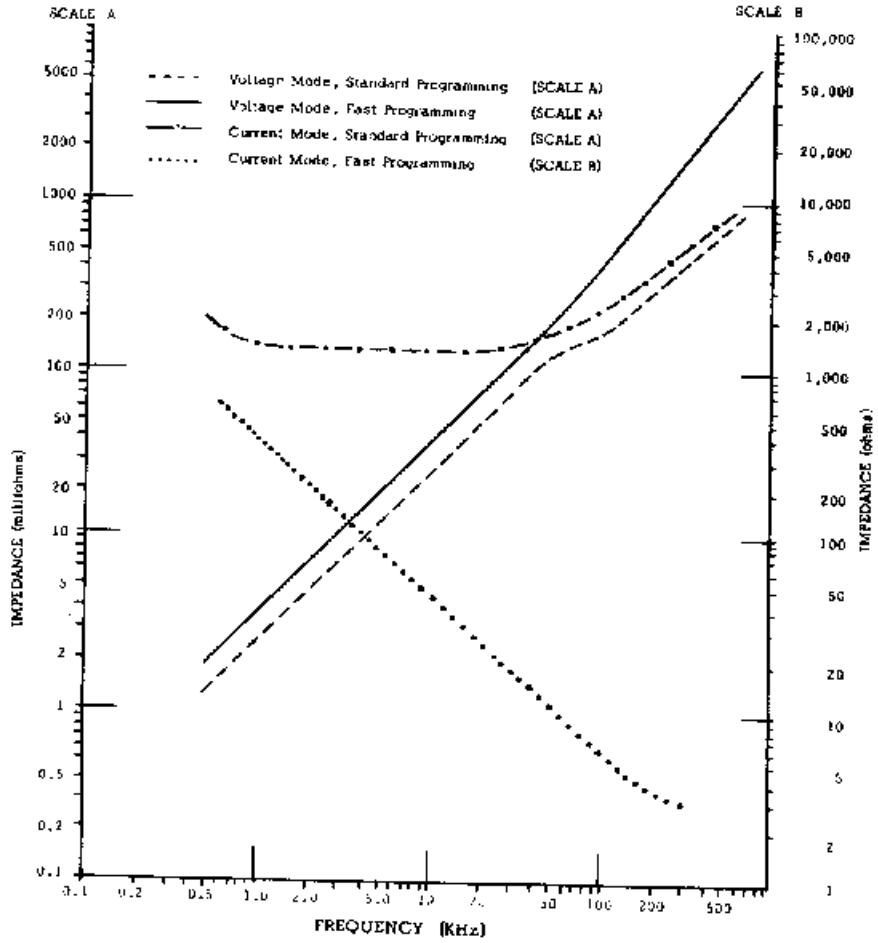
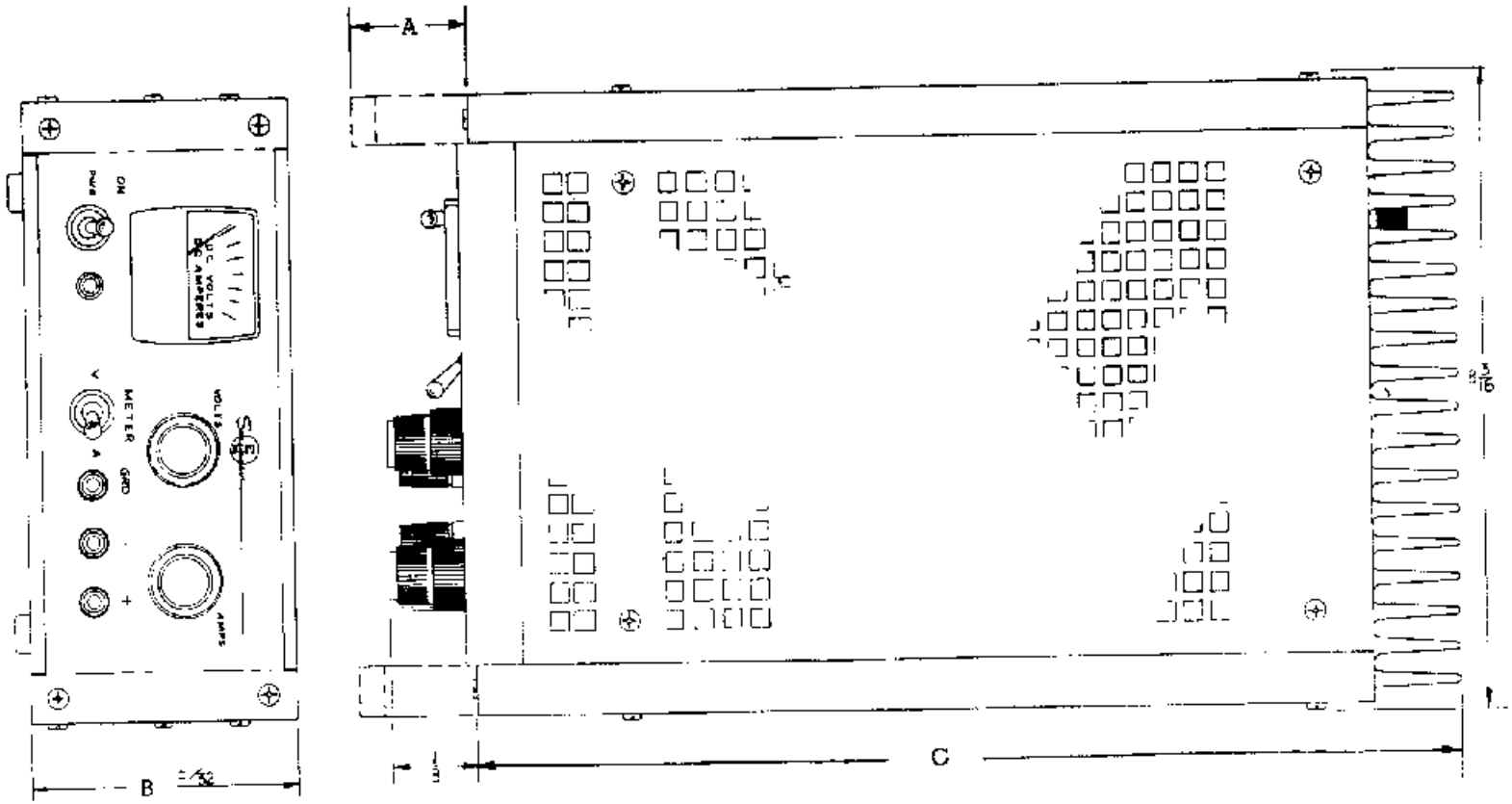


Figure 1-2. Typical Crossover Characteristics (Model QRD 15-2)

Figure 1-3. Output Impedance (Log-Log Plot) (Model QRD 20-4)





	QRD MODELS						
	15-2	20-4	30-1	40-.75	40-2	60-.5	60-1.5
A	1-1/2	1-3/4	1-1/2	1-1/2	1-3/4	1-1/2	1-3/4
B	3-15/32	5-7/32	3-15/32	3-15/32	5-7/32	5-7/32	5-7/32
C	12-3/4	13	12-3/4	12-3/4	13	12-3/4	13

Note: All dimensions are in inches.

Figure 1-4. Outline Dimensions.