SPECIFICATIONS FOR GENERAL PURPOSE DESK-TOP ANALOG COMPUTER

1. GENERAL DESCRIPTION

1.1 Reliability, accuracy and operating convenience shall be paramount considerations in the design of the equipment comprising the computer as outlined herein. The computer is to be completely transistorized to insure the best reliability, stability and extreme compactness. So that it shall be suitable for desk-top use, the computer when fully expanded shall weigh no more than one hundred (100) pounds and shall be no greater in size than 16" W x 23" H x 16" D.

1.2 One each computer, in accordance with Section 2.

1.3 (Up to twenty) operational amplifiers, in accordance with Section 3.

1.4 (Up to twenty-four) precision potentiometers in accordance with Section 4.

1.5 (Up to nine) multipliers in accordance with Section 5.

1.6 (Up to eighteen) unipolar X^2 DFG, in accordance with Section 6.

1.7 One comparator (if required) in accordance with Section 7.

1.8 (Up to two) function switches, in accordance with Section 8.

1.9 One each reference supply, in accordance with Section 9.

1.10 One each power supply, in accordance with Section 10.

1.11 Patching elements, in accordance with Section 11.

2. COMPUTER - To contain the following features:

2.1 The computer shall be pre-wired to accommodate up to twenty operational amplifiers and twenty-four precision potentiometers. It shall also be pre-wired to accept interchangeably the following additional computing components:

2.1.1 (Up to eighteen) integrator networks (Nine Dual Networks)

2.1.2 (Up to nine) quarter-square multipliers.

2.1.3 (Up to nine) X^2 diode function generators.

2.1.4 (Up to nine) variable diode function generators.

2.1.5 (Up to nine) Log or one-half Log X diode function generators.

2.2 Computer shall also be pre-wired to accommodate (up to one) comparator and two function switches.

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2.3 All computing components shall plug into the front of the computer to allow for quick and easy interchangeability, replacement and servicing.

2.4 Control Panel

2.4.1 Mode Selection. The following computer mode controls shall be available at the computer control panel.

2.4.1.1 Reset. This mode shall restore problem to initial conditions.

2.4.1.2 Hold. This mode shall hold problem solution.

2.4.1.3 Operate. This mode shall place computer in operate condition.

2.4.2 Readout

2.4.2.1 A current sensitive meter shall be provided which may be used as a null meter with .1% accuracy and as a voltmeter with 2% accuracy. When used as a voltmeter, it shall have the following meter ranges: ±30 volts, ±10 volts, ±3 volts, ±1 volt, ±0.3 volts, ±0.1 volt.

2.4.2.2 A voltmeter jack shall be provided for use as an input to the voltmeter when being used as a null meter or voltmeter.

2.4.2.3 It shall be possible through the use of no more than one patch cord to read any output voltage in the computer on the voltmeter and to null it against the null pot.

2.4.2.4 It shall be possible to select and readout on the voltmeter the output of each operational amplifier (1 thru 20), plus (+) reference voltage, and minus(-) reference voltage without patching.

2.4.2.5 An amplifier output jack shall be provided so that amplifier outputs, selected without patching, are available at all times for metering, recording, etc.

2.4.3 Coefficient Potentiometer Setting - It shall be possible to accurately set any coefficient potentiometer within the system without patching.

2.4.4 Amplifier Balance - It shall be possible to select the stabilizer output of each operational amplifier and monitor it on the meter (2.4.2.1) to allow accurate balancing without patching.

2.4.5 Power On-Off Switch - The control panel shall contain a switch to turn on and off primary power to the computer.

2.5 A visual overload alarm shall be provided which shall indicate whenever an operational amplifier is overloaded.

2.6 All power supply voltages are to be supplied by bus bars. It shall be possible to remove any power supply voltage from any component by merely unplugging the proper taper pin from a bus bar carrying that voltage behind the component.

2.7 All operational components and power supplies are to be of a plug-in type.

2.8 The computer patching area shall be color-coded as follows:

2.8.1 Green - Input

2.8.2 Red - Output

2.8.3 Yellow - Potentiometer

2.8.4 Black - Ground

3. AMPLIFIERS

3.1 All operational amplifiers shall be uncommitted. That is, shall be capable of being used as either integrators, summers, or high-gain amplifiers, depending upon the patching utilized.

3.2 Each amplifier shall have an overload indicator tied to a central overload alarm which will indicate any excessive departure of the summing point voltage from the zero.

3.3 Output current shall be twenty milliamps at plus-minus ten volts.

3.4 Bandwidth shall be 200 KC minimum.

3.5 Phase shift of a standard inverter at twenty volts peak-to-peak and one-thousand cycles per second shall be no more than 0.1^{o}.

3.6 After balancing by the normal procedure the offset voltage measured at the amplifier summing junction shall be no more than twenty microvolts maximum.

3.7 Drift of a gain one integrator shall not exceed 50 microvolts per second maximum.

3.8 Integrating capacitors shall be accurate to within plus minus .1%.

3.9 The dynamic amplitude error of a standard inverter at ten volts peak-to-peak at 1,000 cycles per second shall be no greater than .06% typical and .1% maximum.

4. POTENTIOMETERS

4.1 Shall be 10-turn 5000 OHM (carbon) potentiometers with adjusting knobs.

4.2 Shall have push-button switching to allow rapid setting of coefficients without patching.

4.3 Resolution shall be (.025%) typical.

4.4 Approximately one out of every two potentiometers shall be ungrounded.

4.5 All inputs shall be uncommitted.

5. MULTIPLIERS

5.1 All multipliers shall be of the quarter-square type.

5.2 The maximum static multiplying error shall not exceed $\pm$0.4% of full scale (20 volts full scale).

5.3 Phase shift shall be less than 0.28^{o} when multiplying $\pm$10 volts D-C by 20 volts peak-to-peak at 1000 CPS.

5.4 The maximum dynamic amplitude error when multiplying $\pm$10 volts D-C by 20 volts peak-to-peak at 1000 CPS shall be $\pm$0.25% of full scale.

5.5 The unit shall be completely solid state.

5.6 All necessary terminations shall be brought to the patch panel to enable the operator to use these units for performing multiplication and division.

6. X^2 DFG

6.1 Shall be a completely solid state fixed diode function generator.

6.2 When properly interconnected with one or more operational amplifiers it shall be capable of performing the following operations:

6.2.1 Yield an X^2 output with the input X varying voth plus and minus in sign.

6.2.2 Yield the square root of X with the input X varying both plus and minus in sign.

6.2.3 Yield outputs of $(X_1)^2$ and $(X_2)^2$ with inputs X_1 and X_2 which are unipolar and of opposite sign.

6.2.4 Yield outputs of the square root of X_1 and square root of X_2 with both inputs X_1 and X_2 unipolar and of opposite sign.

6.3 Phase shift and dynamic error shall be equivalent to the multiplier as outlined in Section 5 above.

6.4 There shall be at least seven segments per quadrant used to approximate the X^2 function.

6.5 The maximum static error shall be no greater than plus minus 0.4% of full scale. The typical static error shall be no greater than plus minus 0.2% of full scale.

7. COMPARATOR

7.1 The comparator shall compare a variable input voltage to an arbitrary fixed voltage and cause a switching operation to be performed.

7.2 The comparator shall contain at least one double pole, double throw relay.

7.3 A differential amplifier shall be furnished as a part of the comparator.

7.4 Each comparator shall have an input range of plus minus 10 volts.

7.5 Switching time shall be no greater than 10 milliseconds maximum.

7.6 Sensitivity (minimum change in input voltage required to cause switching action in either direction) shall be no greater than three millivolts.

7.7 The relay contacts shall be capable of handling at least two amperes at 30 volts for non-inductive loads.

8. FUNCTION SWITCHES

8.1 Shall be single pole, double throw, center off, switches for performing manual switching operations.

8.2 Switch contacts shall be capable of handling at least one ampere at 120 volts for resistive loads.

9. REFERENCE

9.1 Accurate ±10 volt reference supplies of 50 milliamperes capacity shall be furnished.

9.2 On the patch panel there shall be at least three parallel terminations for positive (+) reference and three for negative (-) reference.

10. POWER SUPPLY

10.1 A transistorized power supply shall be furnished which is capable of operating from 100 to 125 volts, 50 to 60 cycles per second without affecting the accuracy of the computing components.

10.2 This supply shall have sufficient capacity to supply the necessary power to the computer when it is completely expanded.

11. PATCHING ELEMENTS

11.1 Feedback Resistors (Quantity Required)

11.1.1 They shall be 100K OHMS ±.1% wire-wound resistors.

11.1.2 Each resistor shall be supplied in a molded plug designed for patching between the summing junction and output terminations of any operational amplifier.

11.1.3 It shall be possible to parallel feedback resistors by plugging one plug on top of another plug.

11.2 Input Resistors (Quantity Required)

11.2.1 Input resistors shall be 10K OHMS or 100K OHMS ± .1% epoxy-incapsulated, wire-wound resistors.

11.2.2 Each resistor shall have a male end to plug into any jack on the computer and a female end to accept a patch cord or another input resistor.

11.3 Diodes (Quantity Required)

11.3.1 Each Unit shall be a silicon diode incapsulated in the same manner as the input resistors.

11.3.2 Maximum inverse voltage shall be at least 25 volts.

11.3.3 Maximum inverse current shall be at least .025 microamperes at 10 volts. Minimum forward current shall be at least 3 milliamps at 1 volt.

11.4 Multiples (Quantity Required)

11.4.1 Each multiple to provide a six-hole, off the patch panel tie point for interconnecting patch cords or increasing the output holes of various computing components.

11.5 Patch Cords (Quantity Required)

11.5.1 To be flexible, insulated and of various lengths with both ends terminated in plugs.

11.5.2 They shall be color coded as to their length.

11.5.3 Their plugs shall fit all jacks used in the computer.

11.6 High Speed Repetitive Operation System

11.6.1 Shall permit computer to be operated in either real time or high speed repetitive operation.

11.6.2 Shall be capable of producing compute times from 20 to 500 milliseconds per solution. Reset time shall be ten milliseconds. The HSRO shall be capable of cycling solutions at least 33 times a second.

11.6.3 Shall have switch control of solution times at fixed values of 20, 50, 100, and 200 milliseconds per solution. Vernier control to obtain solution times between fixed values shall also be available.

11.6.4 Timing unit shall be completely solid state.

11.6.5 Shall have "slave" system to allow control of two or more computers in either real time or repetitive operation mode.

11.6.6 Shall have automatic time scale change of 500 to 1 from real time to repetitive operation which may be accomplished simultaneously on all integrators from mode control buttons on control panel.

11.6.7 Shall utilize high speed electro-mechanical relays to cycle computer between reset and operate modes.

11.7 Pre-Patch Panel

11.7.1 Construction

The computing console shall accept a removable pre-patch panel. All computing components shall terminate inputs and outputs on this pre-patch panel. Construction shall be such as to eliminate possibility of "open" connections due to loose or partial insertion of patch cords. The pre-patch panel shall be constructed so that it can be modified to conform to changes in the number and type of computing components in the computing console. This shall be accomplished by adding or replacing component blocks on the pre-patch panel as required by the new computer component configuration without any changes or additions to systems wiring. The pre-patch panel shall be at least 16-25/64 in width and 12-23/33 in height in order to allow the programmer proper access to, and vision of, the pre-patch panel connections.

11.7.2 Color-coding of pre-patch panel--To be color-coded as follows ...

11.7.2.1 Green--input

11.7.2.2 Red--output

11.7.2.3 Yellow--potentiometer

11.7.2.4 Black--ground

11.7.2.5 White--integrator networks

11.7.2.6 Tan--switching and non-linear components