DEC STANDARD 123 REV. B

POWER CONTROL BUS STANDARD

DEC STD 123 - POWER CONTROL BUS STANDARD

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ABSTRACT: Defines the Digital power control bus function and its electrical and mechanical components.

APPLICABILITY: Design Engineers and System Installers are responsible for abiding by the requirements defined in this standard for all hardware released that interfaces with the power control bus.

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1 INTRODUCTION

Since 1972, Digital has used a standard 3-wire power control bus to control power. Its purpose is to have the bus controls, master switch, and sensor shutoff devices (such as overtemperature thermostats) turn on and off switched power in a predictable manner to a box, cabinet, or system of cabinets. Its original implementation was with ac power controllers, which used the bus for control and also allowed a single power entry to a cabinet, as required by DEC STD 119. It is now also used with other equipment such as battery backup and dc power controllers requiring this same type of control.

WARNING

The Digital power control bus cannot be relied on to remove hazardous voltages from the system.

1.1 PURPOSE

The purpose of this standard is to provide product designers and System Installers with information to design and connect equipment with the power control bus. It is not its purpose to define which equipment should use the bus.

1.2 SCOPE

This standard provides a specification of the power control bus and a description of its operation. It includes definitions, applications information, and descriptions of the components of the bus. It also includes configuration rules and specifications for power control buses. Design guidelines for ac power controllers are also included.

Note

Implementation of the Digital power control bus is intended to permit normal control of the power state of computers and certain peripheral devices. It is not intended to meet the requirements of National Fire Protection Association (NFPA) No. 75-7300 Emergency Power Controls in Computer Rooms. That specification requires an "Emergency Power Control Switch", located near the operator's panel and near the room EXIT, Note (cont'd)

that disconnects all power to the electronics and air conditioners in the room. Digital recommends that the user provide such switches and protective circuitry as part of site preparation. To avoid confusion, the master switch of the power control bus will not be labeled "Power ON-OFF" or "Emergency Power Off". It could be labeled "Run-Standby" or an equivalent.

2 DEFINITIONS

Refer to Figures 1 and 2 when reading the following definitions.

daisy chain - Two connectors parallel-wired on a power control device that allow for the continuation of the power control bus in a straight line method.

branching - Three or more connectors parallel-wired on a power control device that allow the power control bus to interface with several other devices.

bus control - A device that responds to signals from the power control bus to activate or deactivate a power switch.

master switch - A device that controls the state of the power request circuit.

power control bus - A network made up of a master switch, power control cables, bus controls, and sensor shutoff devices interconnected according to the set of configuration rules established by this standard.

power control cable - A 3-wire cable used to interconnect the sensor shutoff devices, the master switch, and the bus controls.

power controller - A device typically containing a bus control, power source inputs, load power distribution, and a power switch activated by the bus control.

power request circuit - An electrical loop consisting of a current source/sense element, power control cable, and master switch using pins 1 and 3 of the power control bus to activate the power switch.

power inhibit circuit - An electrical loop consisting of a current source/sense element, power control cable, and sensor shut off devices, using pins 2 and 3 of the power control bus. When activated, this circuit overrides the effect of the power request circuit.

power switch - A device, activated by the bus control, that supplies or removes power to a load.

repeater - A circuit that creates an additional power control bus. The circuit passes onto the additional bus the power request and power inhibit signals appearing on the first bus.

sensor shutoff device - A device, such as an overtemperature sensor, air sensor, or smoke detector, that controls the state of the power inhibit circuit.

sequencing - Delaying the power request signal before passing it to another bus control, also referred to as the delay bus.
SWITCHED POWER - Power that is activated or deactivated by the bus control.

system shield - A layer of electrically conductive material, enclosing a volume, that forms an electromagnetic boundary.

unswitched power - Power that is neither activated nor deactivated by the bus control. Unswitched power is present whenever source power is applied and the input circuit breaker is closed.

3 DESCRIPTION

3.1 PURPOSE OF A POWER CONTROL BUS

A power control bus provides a means of controlling the power state of a system from local or remote locations using low level, non-hazardous voltages.

A power control bus does not shut off all power to the equipment. For example, semiconductor memory refresh, clocks, and disks may remain on. A power control bus does not function as an emergency power off for the equipment. It does not remove power for the purpose of servicing equipment. Some hazardous circuits may remain energized. A power control bus may allow unexpected start-up, as in the case of operation by a self-resetting thermal sensor. The power control bus does not prevent fire, shock, injury, or function as a safety interlock.

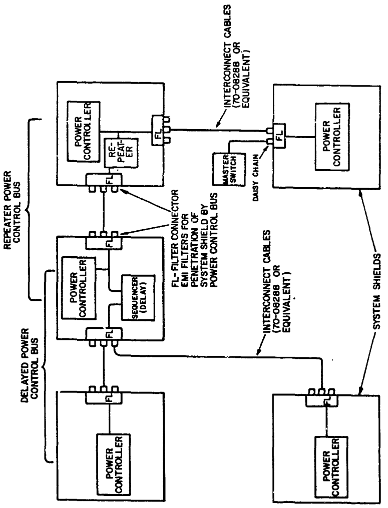

Figure 1. Power Control Bus Block Diagram

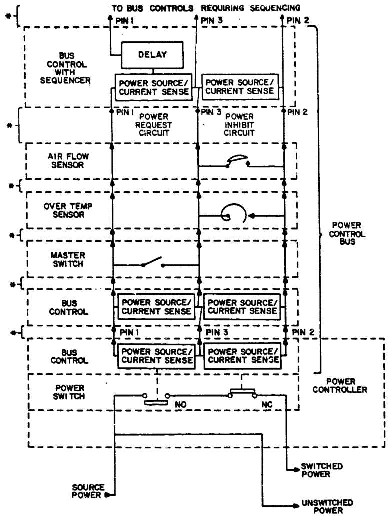

Figure 2. Power Control Bus System Interconnect

3.2 FUNCTIONAL DESCRIPTION OF POWER CONTROL BUS

A bus control both supplies and detects power in response to sensors and a master switch. The detected power is used to control a power switch.

If a sensor or master switch is open, a bus control must be capable of supplying all the leakage currents required by an entire system and interpret the condition as a high. If a sensor or master switch is closed, a bus control must supply current within specific limits and interpret the condition as a low.

3.3 PIN IDENTIFICATION

Pin 1 Power Request
Pin 2 Power Inhibit (formerly Emergency Shutdown)
Pin 3 Return (formerly Ground)

3.3.1 Pin 1 - Power Request

The state of Pin 1 is controlled by the master switch. Power is requested when the switch is closed, called a low on Pin 1.

3.3.2 Pin 2 - Power Inhibit (Formerly Emergency Shutdown)

The state of Pin 2 is controlled by sensor shut-off devices, any one of which may close to assert a low to inhibit power. Pin 2 shall not be asserted low during the course of normal operation to cause the removal of switched power.

3.3.3 Pin 3 - Return (Formerly Ground)

The states of Pin 1 and Pin 2 are referenced to Pin 3 (not to ground). Pin 3 may be grounded in old designs, but is not to be grounded in designs meeting this standard.

3.4 TRUTH TABLE FOR BUS LOGIC

Pin 1	Pin 2	Switched Power
High	High	OFF
Low	High	ON
High	Low	OFF
Low	Low	OFF

High = switch open
Low = switch closed

4 BUS CONTROL SPECIFICATION

The two circuits, power request and power inhibit, should be treated independently. Bus control units are self-powering, contain a power supply of 35 volts or less, and conform to the Truth Table.

Requirements For Pin 1 or 2, Referenced to Pin 3 Return

Interpreted as a Low:	Source current at least 5 mA but less than 25 mA with the bus voltage between 0 and +1.6 V.
Interpreted as a High:	Source current less than 1.0 mA and bus voltage more positive than +1.6 V.
Leakage Current:	Must sink less than 20 uA at a Vin of +40 V.
Open Circuit Voltage:	Shall be less than +35 volts when measured with a meter with at least 10 megohms input resistance.
Short Circuit Current:	Shall be at least 5 mA but less than 25 mA when shorted to return.
Transient Voltage:	A transition shall not cause a transient voltage on the power control bus of less than -0.7 volts or greater than +40 volts peak.

Note

The voltage to be interpreted as a high is dependent on the implementation and can range from 1.6 volts to 35 volts.

Figure 3 shows the boundaries for the allowed operations of the bus.

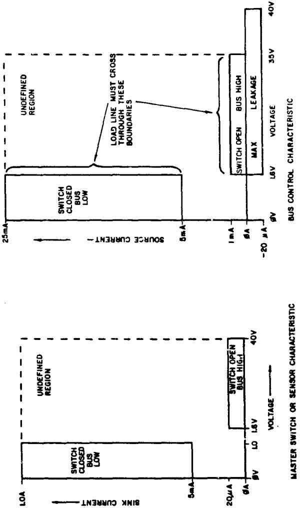

Figure 3. Boundaries for Allowed Bus Operations

4.1 LEAKAGE TO CHASSIS

Leakage to chassis for each device on the bus shall not exceed 0.5 mA at 40 V. To prevent the bus from floating to an abnormally high voltage, a resistor may be added between Pin 3 and chassis. A recommended resistor is a 47K 0.5 W ±5%, Digital Part No. 13-01761-00.

4.2 MASTER SWITCH OR SENSOR SHUTOFF DEVICES (TRANSMITTERS)

For Pin 1 or 2, Referenced to Pin 3 Return

Switch Open:	Must sink less than 20 uA at a Vin of +40 volts whether powered or unpowered.
Switch Closed:	Must have a voltage drop of less than or equal to 1.0 volts when sinking a current of 1000 mA.

4.3 POWER CONTROL BUS INTERCONNECTIONS

The power control bus has three wires. The connector on the power controller is a Digital Part No. 12-09350-03 housing with Digital Part No. 12-09379-00 contacts or the equivalent.

The connectors on the power control bus cables are Digital Part No. 12-09351-03 housings with Digital Part No. 12-09378-00 contacts or the equivalent. Drawing No. 70-08288 gives details of a typical cable.

4.4 EMI FILTERING PER DEC STD 103

No device or part of the power control bus may in itself contribute emission in excess of DEC STD 103 requirements. If the power control bus penetrates the system shield and does not attenuate the EMI it has picked up, it may degrade the EMI shield effectiveness. Thus, each wire of the power control bus must be filtered at the point of its penetration of the system shield.

Minimum common mode insertion loss required for each wire filter:

FREQUENCY	INSERTION LOSS
3 MHz	10 dB
30 MHz	30 dB
1000 MHz	30 dB

Note

Straight line interpolation is required between frequencies using semi-log plot.

A filter that meets these requirements is Digital Part No. 12-21099-01. This is a 3-wire filter with daisy chain capability.

4.5 SAFETY REQUIREMENTS

General safety requirements such as insulation, spacings, and enclosures may be found in DEC STD 119.

4.5.1 SELV Requirements

The power control bus is considered an operator-accessible circuit. All components, such as the master switch, power control cables, bus controls, and sensor shutoff devices must meet the SELV (Safety Extra Low Voltage) requirements of DEC STD 119.

4.5.2 Fault Protection

While operation of the power control bus may prevent or reduce equipment damage, its function is not a substitute for safety requirements found in DEC STD 119. It is not to be relied on to prevent fire, shock, casualty, or other safety hazards.

5 CONFIGURATION

All devices, the bus controls, master switch, and sensors, are connected in parallel on the 3-wire bus. Not all devices make use of all wires, but all three are routed to each device by the power control cable. The configuration of the system may be a straight line, with the bus daisy chained from one device to the other, or a branching connection, where one device forms a node to which several others connect.

The maximum configuration is limited by several factors: the total current from the bus controls that the sensor or master switch must carry, the maximum leakage current allowed on the system, the voltage at the master switch or sensor when considered a low, the voltage at the bus control when considered a low, and the resistance of the power control cable. These constraints lead to the following limitations on the configuration of the bus system.

5.1 BUS LOADING

The following configuration guidelines are based on the assumptions in subhead 5.1.2. The system engineer can come up with alternate configurations based on different conditions. In lieu of directions from the design engineer, field and manufacturing personnel should follow these rules.

5.1.1 Configuration Requirements

When configuring a system, the following rules must be met:

Rule 1. The maximum number of bus controls must not exceed 40.

The limiting factor of 40 bus controls is based upon each bus control in the low state sourcing 25 mA of current and the master switch or a sensor being limited to 1 ampere (40 X 25 mA = 1 ampere of sink current. Leakage current is not a limiting factor in the low state when applying rule 1.

Rule 2. In the low state, the voltage at the bus control must not exceed 1.6 volts.

There may be 40 bus controls supplying 25 mA for a total of 1 ampere. The sensor is allowed to have a 1.0 volt drop at 1 ampere. This limits the drop in the cables to 0.6 volts with 1 ampere flowing. From this information, the following formula was derived to describe the limits of an acceptable cabling configuration:

$$(L + 10) N \leq 480$$

The symbol definitions and derivation are shown in subhead 5.1.2.

Rule 3. The maximum number of sensors and bus controls on a single power control bus is limited to 50.

This rule is based upon each device being allowed to sink 20 microamperes or to source 1 milliampere in the high state ($\geq$ 1.6 V). This ratio of source current to sink current yields a maximum of 50 devices.

Refer to Figure 4 for the following example configuration.

(a) Number of bus controls = 7........................Meets Rule 1

(b) $(L + 10)\ N \leq 480$

L = 25 feet + 5 feet + 8 feet + 6 feet = 44 feet
N = 7

$(44 + 10)\ (7) = 378 \leq 480$..........................Meets Rule 2

(c) Number of bus controls and sensors = 14..........Meets Rule 3

```
S          S           S          S          M          S
|          |           |          |          |          |
|A         |A          |A         |A         |A         |A
B----------B-----------B          B----------B----------B----S
   5      /     5       \            5      /     6          A
        /25              \                 /
S ----- B                 \_______________/
                                 8
```

S = Sensor B = Bus Control M = Master Switch
A = 10 feet (see subhead 5.1.2)

Figure 4. Typical Control Bus System

5.1.2 Assumptions

The formula $R(L+A)IN \leq E$ was developed to determine the limits of an acceptable configuration, where

R = Cable resistance per foot

L = Cable length in feet between any two bus controls

A = Assumed maximum distance in feet between a bus control and either sensor or master switch within a cabinet

I = Maximum source current of any bus control (low state)

N = Number of bus controls

E = Interconnect voltage drop in volts due to cable resistance.

$R(L+A)IN \leq E$ can be reduced to $(L + 10)(N) \leq 480$ based on the following values:

R = 50 milliohms/foot
A = 10 feet
I = 25 milliamperes
E = 0.6 volts

These values were derived as follows:

The interconnect cable is assumed to be Digital Part No. 70-03288. This is 22 AWG wire, which has a resistance of .016 ohm/foot. Since the current path is twice the cable length, total resistance would normally be 2(.016) = .032 ohm/foot. However, the return conductor can carry twice the current due to contributions by both the power request and power inhibit circuits. This will result in twice the voltage drop along the return conductor. This is the equivalent of the return conductor being .032 ohms/foot and when added to the outgoing conductor resistance of .016 ohms/foot, gives an equivalent cable loop resistance of .048 ohms/foot. In the formula this resistance "R" is rounded to .050 ohms/foot.

The assumption was made that, within a single cabinet, the maximum length power control cable interconnecting the bus control with either a sensor or master switch is 10 feet. Therefore, 10 feet may be suubstituted for "A" in both the example and the formula.

Each bus control in the bus low state is limited to sourcing a maximum of 25 mA. Therefore, "I" becomes .025 amperes.

The maximum number of bus controls N is 40, based on the following assumptions. Each switch (sensor or master switch) is expected to handle a maximum of 1 ampere in the bus low state. Each bus control in that state is limited to sourcing 25 mA. The number of controls, N = Isw/Ibus = 1 amp/.025 amp = 40.

Any switch (sensor or master switch) is allowed a maximum voltage drop of 1 volt when closed. The voltage at the bus control must be no more than 1.6 volts under this condition to be interpreted as a low. This allows 0.6 volts for interconnect loss, which is assumed to be due to cable resistance. Therefore, "E" in the above formula = 0.6 volts.

6 IMPLEMENTATION

6.1 BRANCHING ABILITY

When designing power control bus devices, keep in mind that a device with a single connector will terminate that branch of the bus. In general, devices should have at least two connectors to allow daisy chaining. It is preferred, especially on power controllers, that three or more connectors be provided to permit branching.

6.2 AC POWER CONTROLLER DESIGN GUIDELINES

6.2.1 Input AC Connections

The controller will be specified with either a properly terminated input power cord, cord set, or field wiring terminals and strain relief that meet the requirements of DEC STD 119 and DEC STD 002. No primary circuit ac or other hazardous potential will be exposed when the device is fully assembled.

6.2.2 Filter

If an ac line filter is included, it will meet RF insertion losses for FCC Class A or Class B operation as required by DEC STD 103. Leakage current of the filter will meet the requirements of DEC STD 119.

6.2.3 Lamps

An ac lamp or lamps may be supplied to show the presence of ac. This lamp should be connected before the input protection so that anytime a hazardous voltage is present, the lamp will be illuminated.

6.2.4 Input Protection

The input lines will have a protective device, either a fuse or circuit breaker, to interrupt the ac in case of overload. The rating of the protective device will not be less than 125% of the unit loading. The protective device must have an interrupt rating of at least 1000 amps at rated voltage.

6.2.5 Contactor Rating

The contactor will have, as a minimum, an inductive load rating at operating voltage at least equal to the circuit protective device.

6.2.6 Switched Power Selector (Formerly Local-Remote Switch)

There may be a 3-position switch located on the power controller labelled "BUS, OFF, and ON". In the BUS position, the power control bus controls the operation of the switched power. In the OFF position, only that power controller is off and the controller will not respond to power control bus logic. In the ON position, the switched power from that controller only is distributed to its load regardless of the power request signal. If power inhibit is asserted, however, the controller must turn switched power off.

If the control switch is OFF or ON, the switch or wiring must be capable of passing the bus signals to other bus controls. The switch position must never affect the operation of another bus control.

6.2.7 Total Off

This is an optional feature on some power controllers. Its function is to cause the input breaker to trip off, via an auxiliary coil on the breaker, which removes both switched and unswitched power from the controller's output. The auxiliary coil of the breaker is usually powered from the bus control's power source. A normally open sensor that closes on an abnormal condition is used to activate total off. The sensor's contacts should have a current rating consistant with the current rating of the auxiliary coil of the breaker.

The total off connector at the power controller should be different from the power control bus to prevent accidental wiring errors.

To restore power after a total off, the breaker must be manually reset.

6.3 POWER BUS SEQUENCERS AND REPEATERS

6.3.1 Power Bus Sequencers

A power bus sequencer is a circuit that adds a delay to the power request line (Pin 1). It helps prevents excessive inrush currents by allowing several products, such as disk drives, to start sequentially.

The sequencer receives its logic signal from the Digital power control bus and transmits the delayed signal via another connector that uses the same type cable as the power control bus. The power inhibit is paralleled in the connectors so the inhibit function is not lost.

To provide the user with configuration information, the product specification should include the time delay and the driving capability of the sequencer. On the product it should be clear which connection is to the undelayed power control bus and which connection is for the delayed bus.

6.3.2 Power Bus Repeaters

A repeater is a circuit that creates an additional power control bus, passing on to that bus the power request and power inhibit signals appearing on the first bus. Because the power inhibit signal cannot be passed from the second bus to the first without special arrangements to keep the two busses from locking each other in an off condition, the use of such a circuit is not recommended.

REFERENCED STANDARDS

DEC STD 002	AC Power Wiring, Safety Grounding, Receptacle, and Electrical Rating Information Requirements
DEC STD 060	Design and Certification of Hardware Products to National and International Regulations and Standards
DEC STD 103	Electromagnetic Compatibility (EMC) Hardware Design Requirements
DEC STD 119	Digital Product Safety
DEC STD 186	Signal Integrity

Copies of these standards are available from Digital Standards Administration, ML03-2/E56, DTN: 223-9475.