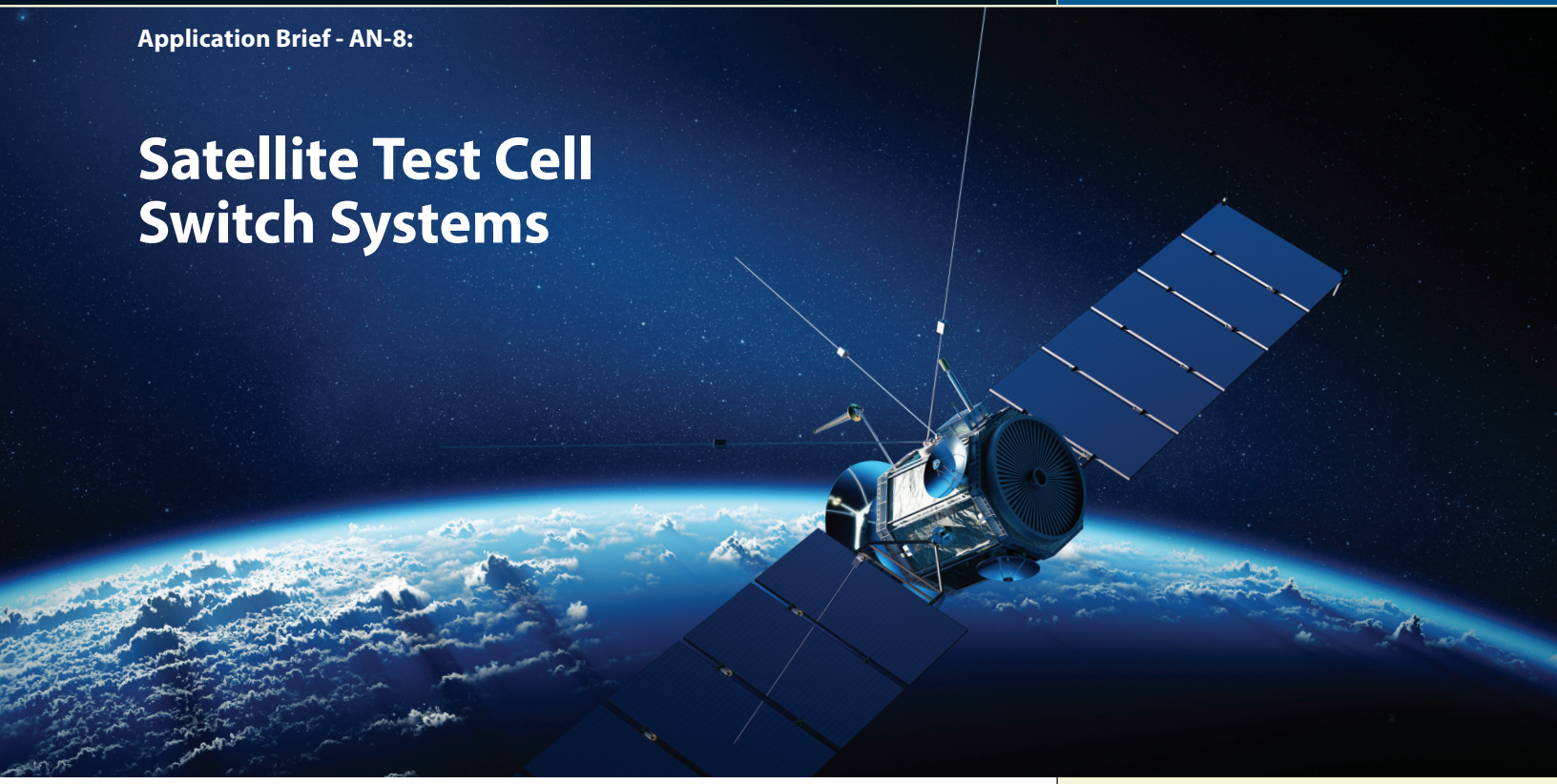
Precision 464kC Switch Matrix System

Application Brief - AN-8:

Satellite Test Cell Switch Systems

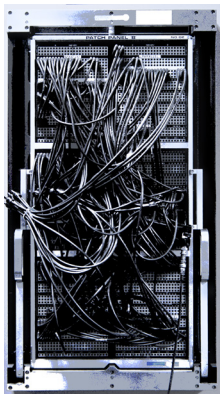


Introduction

A large manufacturer building satellites for commercial, space and defense applications recently updated their instrumentation control room to replace their legacy manual patch panels. This premier facility produces sophisticated satellites for many applications including TV and radio, GPS constellations, air/sea/space communications and war fighter tactical communications. The satellites are tested for vibration and environmental factors to validate their design and to make sure they can endure the harsh conditions of the launch and subsequent orbit in space.

The facility has a central instrumentation and control room for operating three test cells each containing a multi-axis shaker table. Signal conditioning, data acquisition, control, display and other recording and analysis assets were allocated to the test cells via old manual patch panels. The patch panels, which took days to configure, were difficult to verify and were prone to faulty connections and human error. Inputs and outputs to the patch panel were connected at different locations in the building, creating large ground loops that imparted 60 Hertz noise on the acquired data along with unacceptable DC errors.

An automated switch system where multiple test configurations could be saved and downloaded from a host computer was highly desired to save setup time and reduce costly testing errors. Solid-state switching technology was preferred for its reliability and differential input buffers were required to eliminate errors due to multiple ground sources. This application note outlines how these objectives were met by the Precision 464kC solid state switch matrix system.



Manually Configured Patch Panel

Computer controlled analog signal switching replaces tedious manual patch panels

Precision Switch systems are reliable solid-state switch matrix systems providing computer-controlled connections between any input and any output.

Program switch setups, store them, download them and verify them using a host computer.

Configure up to a 256 x 256 switch system. Larger systems can be built by bussing two or more systems together.

464kC High Density Programmable Switch Matrix

Solution

The customer required a computer controlled 768 x 512 solid-state switch matrix capable of organizing measurement signal and data flow logistics between the hundreds of input and output channels. In selecting the architecture of the switch system, four criteria of primary importance were considered; a) maintaining the highest analog fidelity of the switched signal, b) reliability and dependability of the switch system, c) ease of use to assist in day-to-day operations and d) scalability and expandability for future upgrades. After evaluating several proposals against these criteria, the manufacturer selected the Precision Filters' 464kC High Density Programmable Switch Matrix as the best solution to meet their needs.

Analog Fidelity

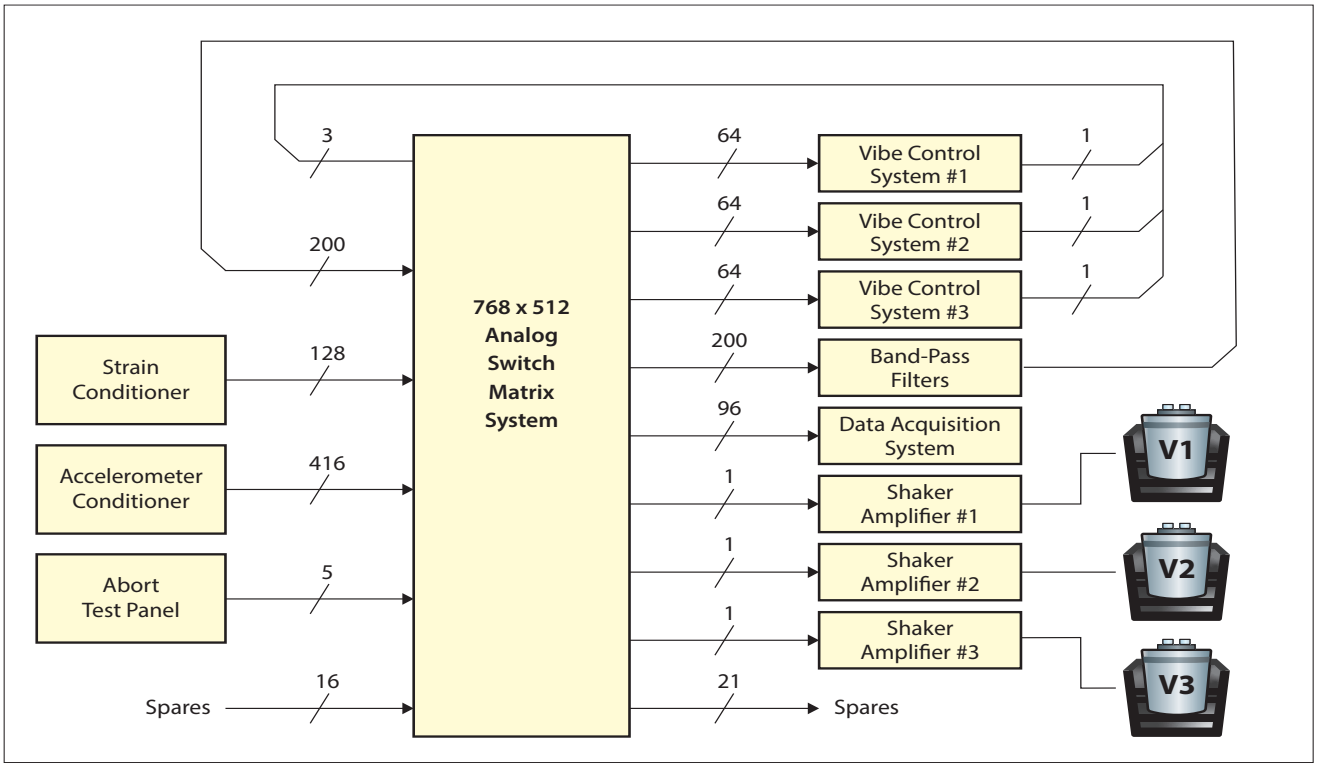
Precision Filters 464kC utilizes a 3-stage non-blocking architecture to form the equivalent of a 256 x 256 rectangular coordinate switch matrix (65,536 cross points) in a single 10U chassis. The 3-stage switching architecture provides a 63% reduction in cross points which translates not only to a smaller physical chassis size, but shorter input to output signal paths. The shorter paths mean lower capacitance, less crosstalk and higher bandwidth compared to a traditional rectangular coordinate design. Precision Filters' 464kC topology optimizes bussing of signals inside the chassis by using internal connection planes without requiring external bussing cables.

One key attribute of the 464kC is the use of high impedance (10 MΩ) differential buffers for each of the 256 inputs. The differential buffers properly reference each input signal to its point of origin while the high common mode rejection (CMR) reduces noise pick-up on the long input wires. The use of differential buffers is especially important when both the input and output devices are single ended (grounded low) signals. If these signals are connected using patch panel cables or relay switching, large ground loops would be created resulting in high power line related noise signals or hum in the measurement data.

Other switch system attributes include 0.02% amplitude accuracy through any input to output switch path, 0.2 degree channel to channel phase match, 1.3 MHz signal bandwidth and less than 25 μV_{RMS} noise while maintaining better than –90 dB channel to channel crosstalk.

Reliability and Dependability

Dependability and reliability are paramount as each switch system is a crucial link in the signal path of every measurement channel in the satellite test operation. The use of solid-state switches rather than electromechanical relays not only improves initial reliability in the early stages of deployment but becomes an even greater advantage later in the service life of the switch. Over time, mechanical relay systems exhibit an increasing rate of contact and coil related failures.



Block Diagram of 768 x 512 Satellite Control Room Switch System

Ease of Use

A simple and intuitive graphical user interface (GUI) controls the 464kC switch matrix. The main GUI selection screen presents a spreadsheet type matrix consisting of columns and rows with each switch output channel represented by one cell. Programming of the switch is as simple as clicking the mouse on one of the output cells and then selecting an input from a drop-down list. Factory default names (In 1, In 2, Out 1, Out 2 etc.) are easily changed to any user defined name up to 32 characters long. Output channels color assignments provide an intuitive visual association of channel groupings such as "Shaker control channels in Red" "Vibration Channels in Blue" "Bridge Channels in Green" that is similar to some manual patch panel configurations.

Given the frequent change-over of test articles in the test cells, it is important that an operator preparing for a subsequent test can program the switch and name the input channels off line without disrupting a test currently in process. The 464kC GUI accomplishes this by saving the current configuration to a standard comma separated variable (CSV) file format. Off line edits are easily done using Excel or any CSV file manager and imported back to the 464kC GUI as the active configuration.

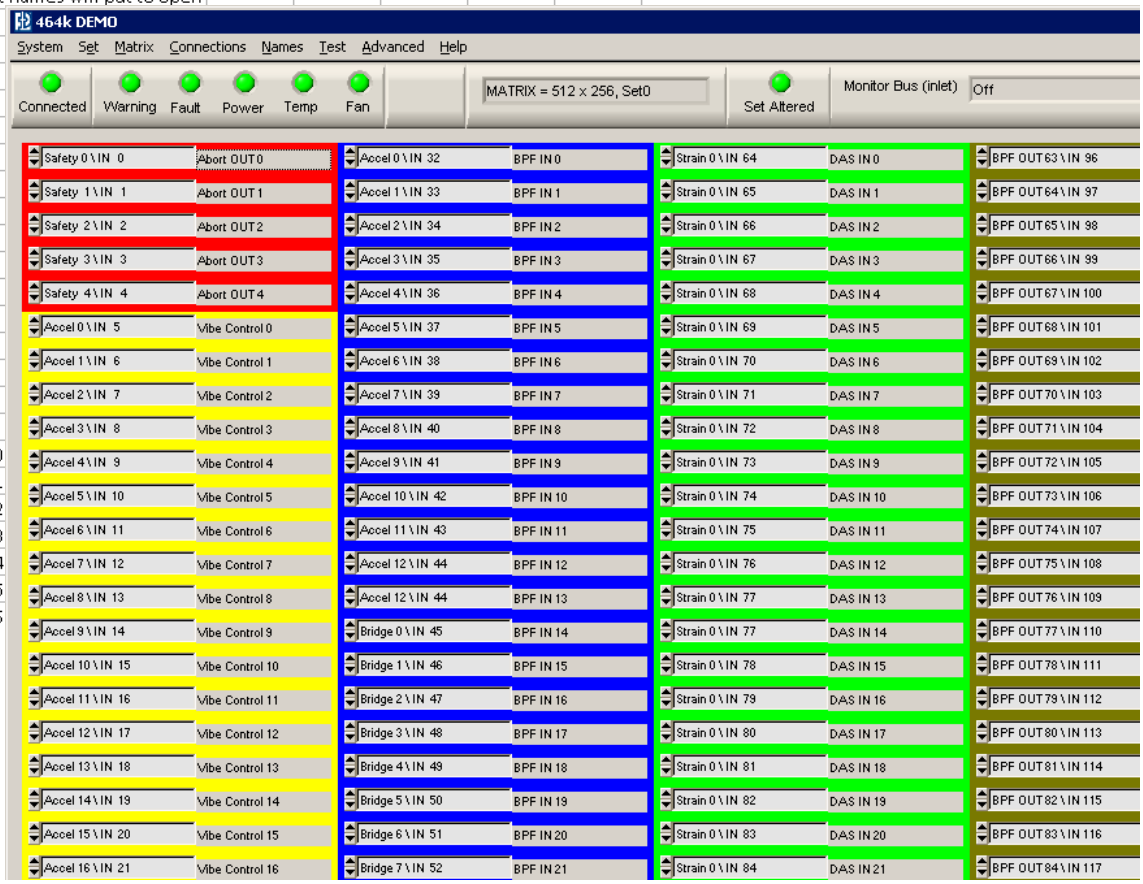
Several other usability features are built in to the GUI to simplify the day-to-day operations of large test operations.

- Output Monitor architecture allows simple monitoring of any output channel in the system via a single connector without disrupting any output signals or removing any output cables.
- Input Monitor architecture allows simple monitoring of any input channel in the system via a single connector without disrupting any input signals or removing any input cables.
- An internal 16 kHz test tone can be applied to any channel input. This allows quick verification of the switch path and provides a useful test signal for downstream devices attached to the 464kC outputs.

Scalability and Expandability

It was important at the testing facility that the switch purchased for todays "Phase 1" requirement of 768 inputs by 512 outputs be easily expandable for future requirements of 1024 or 1280 inputs. To accomplish this the 464kC architecture uses 256 x 512 building blocks to expand the switch in 256 input channel increments. Each 256 input channel expansion may be easily upgraded in the field by adding additional building blocks to the existing hardware.

	A	B	C	D	E	F	G	H	I	J
1	464k-GUI Set File Ver. 1.1									
2	Total Matrices=2									
3	Note: Unrecognized inlet/outlet names will put to open									
4	Inlet	*	Outlet							
5	Safety 0	*	Abort OUT 0							
6	Safety 1	*	Abort OUT 1							
7	Safety 2	*	Abort OUT 2							
8	Safety 3	*	Abort OUT 3							
9	Safety 4	*	Abort OUT 4							
10	Accel 0	*	Vibe Control 0							
11	Accel 1	*	Vibe Control 1							
12	Accel 2	*	Vibe Control 2							
13	Accel 3	*	Vibe Control 3							
14	Accel 4	*	Vibe Control 4							
15	Accel 5	*	Vibe Control 5							
16	Accel 6	*	Vibe Control 6							
17	Accel 7	*	Vibe Control 7							
18	Accel 8	*	Vibe Control 8							
19	Accel 9	*	Vibe Control 9							
20	Accel 10	*	Vibe Control 10							
21	Accel 11	*	Vibe Control 11							
22	Accel 12	*	Vibe Control 12							
23	Accel 13	*	Vibe Control 13							
24	Accel 14	*	Vibe Control 14							
25	Accel 15	*	Vibe Control 15							
26	Accel 16	*	Vibe Control 16							



The Main GUI Section Screen with User-Defined Colored Coded Groups, Descriptive Channel Names and the Corresponding CSV File

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Precision 464kC Switch Matrix System

Prove It and Document It

The Precision 464kC was designed with the philosophy that a switch matrix and its programmed configuration is of little use if you can't prove it and document it. This is especially important with a switch system having 24,000 possible switch connections. If only one of the connections is faulty, it could corrupt critical satellite vibration test data.

The extensive built-in self-test capabilities allow full parametric factory acceptance test "FAT" of the entire system including all switch paths, while the quicker "Go/No-Go" test verifies and documents only the active switch paths in the present configuration. The fully automated tests confirm opening and closing of switches, crosstalk of the switch path to other outputs and the switch path input to output gain accuracy. A diagnostic report isolates problems to the board level for quick replacement or service. Test reports are saved as text documents and can be used to supplement quality and validity reports for the overall measurement system.

Conclusion

Precision Filters' 464kC High Density Programmable Switch Matrix solution provides the customer with a quick and easily verifiable error-free configuration in minutes, allowing for greater test throughput while improving data quality. Input/output switch configurations are easy to program, store and recall for quick automated setup, eliminating costly misconnections.

The balanced differential input buffers eliminate noise pickup problems and correctly reference the signal inputs to their corresponding ground. The built-in Go/No-Go test feature automatically verifies run-time setup by checking each programmed connection using a direct input-to-output measurement. The 464kC FAT routines measure switch system parametrics, including gain, offset, crosstalk and open/short, in situ to verify performance and provides full test reports.

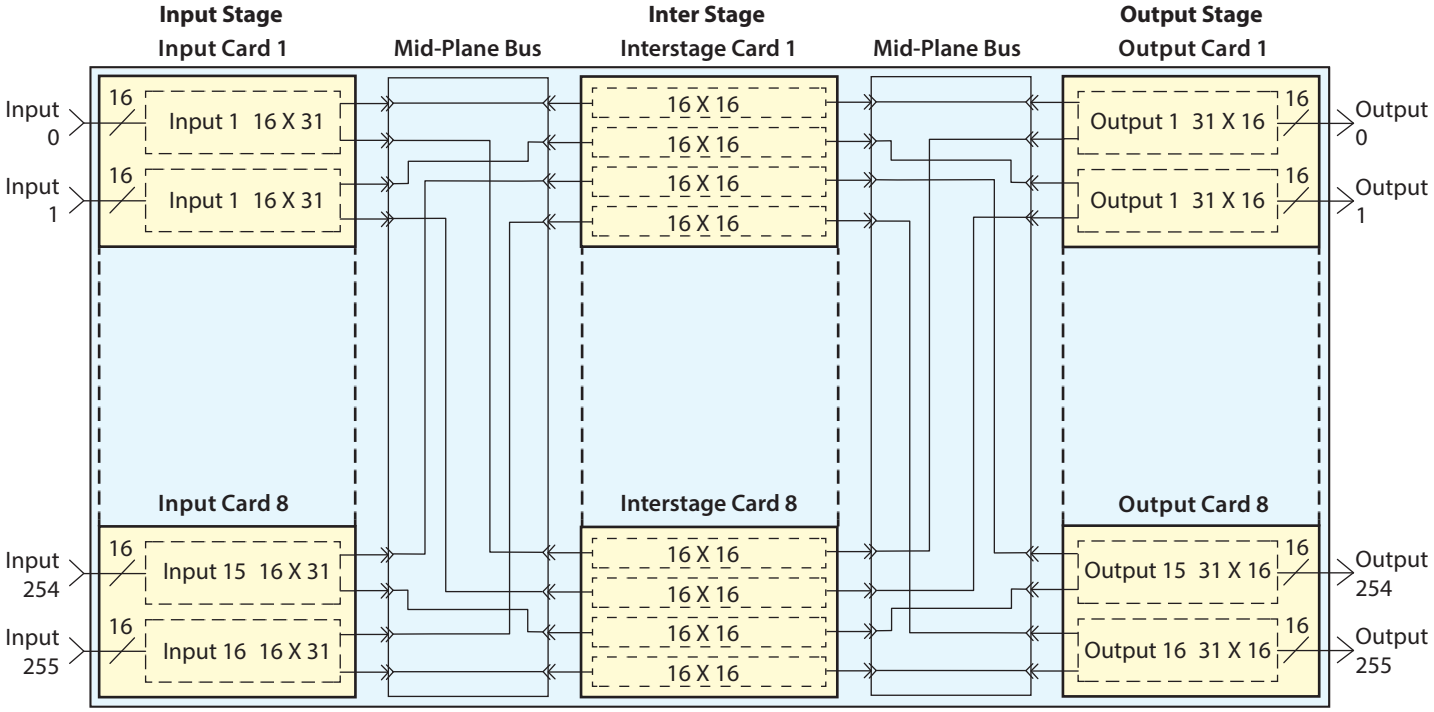
Summary:

Cost Savings: Automates signal connections and reduces costly testing errors.

Ease of Use: Programmable from a saved configuration or host computer. Store unlimited configurations on host.

Reliability: Solid-state switches are more reliable. Built in self-test verifies setup and operation with reports.

Data Quality: Buffered switches reduce errors due to multiple ground sources.



Block Diagram of a 3-Stage 256 x 256 Non- Blocking Switch Chassis

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