

The logo for Artesyn Embedded Technologies. The word "ARTESYN" is in a large, bold, blue, sans-serif font with a white-to-blue gradient. A small "TM" trademark symbol is to its right. Below "ARTESYN", the words "EMBEDDED TECHNOLOGIES" are written in a smaller, blue, all-caps, sans-serif font. The background of the slide is a dark blue, abstract digital space with glowing blue squares and lines.

ARTESYNTM
EMBEDDED TECHNOLOGIES

Multi-Vendor Interoperation

Artesyn Embedded Technologies, Inc

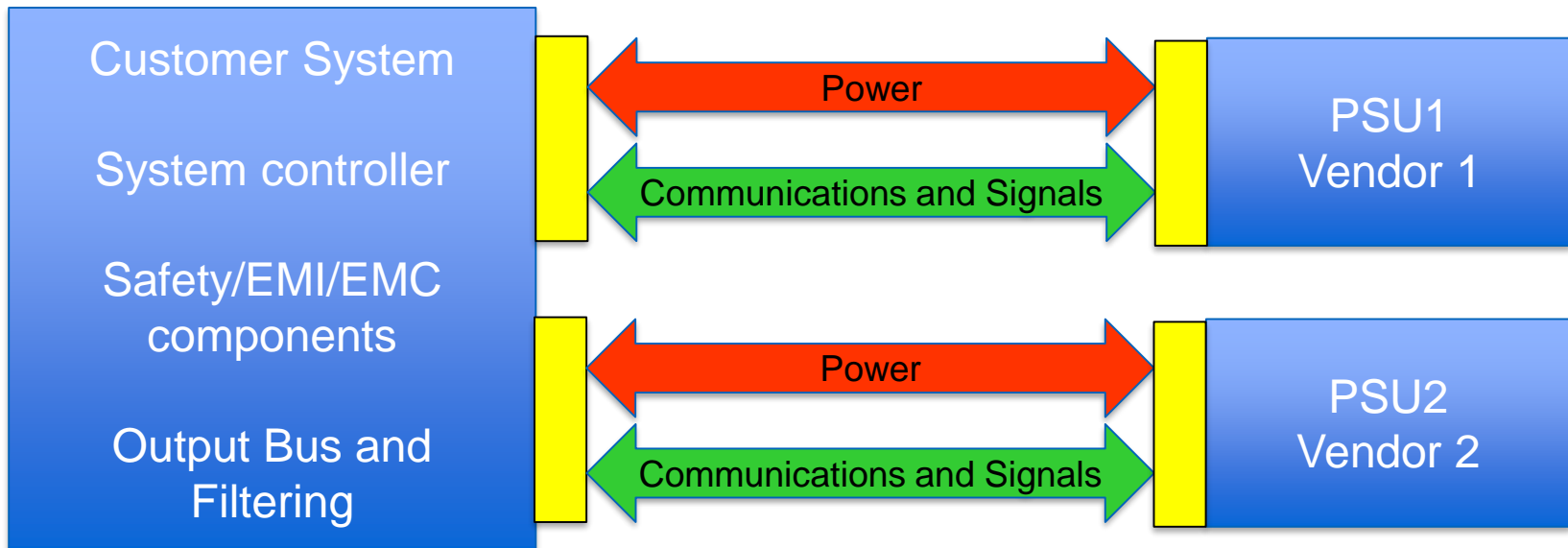
Objective

- Interoperation (Interop): To allow PSUs and/or other components such as Power Shelf, BBU, etc., from different vendors to function compatibly in the same system together
- True dual/multi vendor sourcing

Challenges

- Different vendor design approaches to:
 - Current sharing
 - Communications protocol and other shared signals
 - Control functionality differences such as dynamic response, start-up and shut down timing, fault handling, etc.
 - Mechanical design
- System comprised of multiple components:
 - PSUs, Controller
 - Need to function compatibly in any combination

Shared Signals and Components



- Current Sharing, Remote Sense, Digital Communications
- Filtering and protection components

Artesyn Solution - Specification

- Define parameters for interop specification beyond normal PSU specification
- Cooperate with other supplier(s) to exchange necessary information and material including:
 - Details needed to specify interop critical parameters
 - Interface circuit details
 - Digital communication details
 - Mechanical details
 - Samples including corner case samples

Artesyn Solution - Design

- Perform additional analyses and design tasks as needed to insure reliable interop during all conditions
- Artesyn advanced digital and analog design techniques used to emulate alternate vendor performance when required

Artesyn Solution - Testing

- Define and execute test program to insure reliable interop for all conditions including:
 - Steady state and dynamic conditions
 - Start-up, shut down, hot swap
 - Fault simulation
 - Temperature effects
 - Corner cases
 - Role swaps
- ATE Interop test program to be performed at each design phase

Additional Interop Requirements

Requirements beyond those normally specified and tested:

Specifications:

- Mechanical
- Electrical
- Digital Communications
- Current Sharing Details
- Output Response
- Safety and EMC/EMI

Interop Test Program – Mix and Match:

- Sharing Accuracy
- Dynamic Loading
- Redundancy/Hot swap
- Start-up/Shut down
- Fault Simulation

Interop Specifications

Requirements for interoperability beyond normal PSU specification:

- Mechanical
 - Mechanical outline with tolerances, materials, feature definition such as mounting, airflow direction
 - Connector definition including terminal assignments, short pin/long pin features, etc.
- Electrical
 - Definition of signal and interface circuit for all shared control signals
 - Definitions of output response and timing for start-up, shut down, dynamic and fault conditions
 - LED Response (Blinking Rates, Intensity, wavelength)
- Digital Communications
 - Communication architecture and spec
 - Synchronization turn on / turn off sequence
 - Firmware update compatibility requirements, if any
- Current Sharing
 - Current share interface circuit
 - Current share capture range setting
 - Current share signal vs. output current characteristic
 - Vout temperature coefficient magnitude and direction (drift)
 - Vout droop linearity (if droop sharing used)
 - Remote sense offset compensation
 - System distribution of bus resistances
- Safety and EMC/EMI
 - Distribution of filter components between PSU and shelf
 - Breaker/Fuse compatibility

Interop Test Program

Testing requirements for interoperability beyond normal PSU test program:

- **Current Sharing Accuracy and Redundancy – Mixed Vendors**
 - Measure the total output current of each PSUs and verify current sharing accuracy over line, load temperature.
 - Verify all corner cases including Vendor 1/Vendor 2 master/slave and with roles swapped
- **Start-up/Shut-down– Mixed Vendors**
 - Measure and verify output voltage, current share bus voltage and output current are stable during start up and shut down condition with mixed vendors' PSUs
 - Verify appropriate timing for start-up of multiple PSUs
- **Hot Swap**
 - Measure output response, current share bus voltage and output current from each PSU and verify current sharing capture and glitch free output response and logic operation during hot swap events
 - Verify all corner cases including Vendor 1/Vendor 2 master/slave and with roles swapped
- **Dynamic Load Sweep**
 - Verify current sharing accuracy and output stability/response over different dynamic loading conditions, duty cycle, remote sense offset, input voltage and temperatures to ensure acceptable interop performance at all conditions including corner cases and role swaps (master/slave)
- **Redundancy and Fault Simulation**
 - Verify output is stable and well regulated during all simulated fault conditions when redundancy is lost
 - Perform also for role swap condition
- **Safety and EMC/EMI**
 - Insure that EMC and EMI and safety requirements are met with all combinations of PSUs and other components (breakers, fuses, input and output filter and suppression devices, etc.)

Interop Test Program

- Example – Current Sharing Test
- Testing is extensive must be automated

Table 1. Sharing Accuracy for 1+1 @ 230Vac (UUT1 trimmed 12.024V; UUT2 trimmed to 11.976V)

% Load	Load (A)	Bus Voltage (V)	MICROCHIPART Artesyn Load (A) UUT1	MICROCHIPART Artesyn Loading (A) UUT2	Total Load (A)	Ishare_V (V)	Accuracy (Artesyn - Artesyn) (A)	3% Limit	Remarks
0%	0.00	12.249	0.53	0.02	0.55	0.232	0.51		No requirement
10%	4.13	12.230	2.89	1.62	4.51	0.664	1.27	2.06	PASS
20%	8.25	12.222	4.69	2.98	7.67	0.928	1.71	2.06	PASS
30%	12.38	12.215	7.22	5.63	12.85	1.271	1.59	2.06	PASS
40%	16.50	12.211	9.27	7.67	16.94	1.680	1.60	2.06	PASS
50%	20.63	12.207	11.34	9.75	21.09	2.089	1.59	2.06	PASS
60%	24.75	12.204	13.40	11.84	25.24	2.480	1.56	2.06	PASS
70%	28.88	12.201	15.56	13.80	29.36	2.884	1.76	2.06	PASS
80%	33.00	12.197	17.51	15.87	33.38	3.279	1.64	2.06	PASS
90%	37.13	12.195	19.51	17.89	37.40	3.685	1.62	2.06	PASS
100%	41.25	12.189	21.38	20.38	41.76	4.048	1.00	2.06	PASS

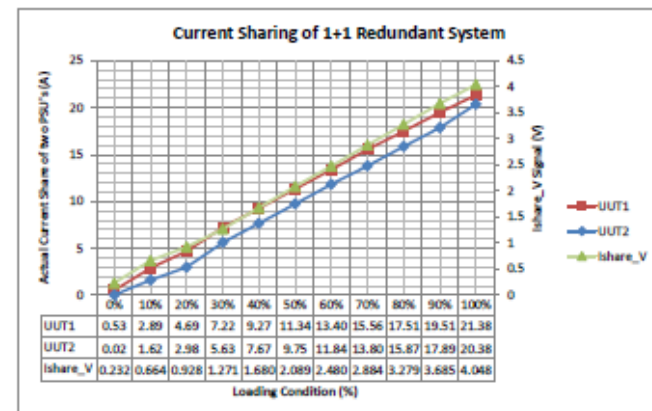


Figure 3. Current Sharing of Artesyn PSU's (Max and Min Vout Trim) in 1+1 Redundant System

Alternate Vendor Sample Requirements

Sample requirements to carry out interoperability test program:

- Normal production level samples for test at Proto stage
- PSU trimmed to max and min exit factory setting
- PSU trimmed to max and min Capture Range limit

Summary

Defining Interop Requirements upfront is the key to ensure smooth operation amongst multiple vendors.

Artesyn has extensive experience and capabilities related to PSU interop including:

- Specifications
- Design flexibility
- Automated Interop Testing

Thank You!