



Design Verification Plan and Report
24 Way Hybrid Connector System
Apex 150 Tin & Apex 2.8mm Tin Terminal Systems
PV Level

DVP NUMBER FCINPEL-24WayHybridPV,07-168	DEPT
PLAN DATE	PLAN ORIGINATOR F. Holub
CONCURRENCE	MANAGER APPVL R. Johannes
REPORT DATE 11/9/07	REPORTING ENGR F. Holub

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Procedure or Standard	Test Description	Timing		Quantity		Results				Acceptance Criteria	Notes	
		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.	Pass/Fail			
SAE/USCAR-2, revision 5 (Draft)												
5.9.5 Connector System Mechanical Tests Flow Chart												
	Seq. ID D											
5.4.1	Terminal- Connector Insertion/ Extraction											
	Apex 150 Terminals											
	Female- 16 AWG TXL											
	Insertion w/o removal of prev. term.	10/2/07	10/3/07	3	24	8.16	11.81	6.15	Pass	≤ 30N		
	Terminal push-thru	10/2/07	10/3/07	3	24				Pass	No push thru ≤ 50N		
	Removal w/wedge	10/4/07	10/5/07	2	16	102.00	106.00	100.00	Pass	≥ 70N		
	Removal w/o wedge	10/4/07	10/5/07	2	16	102.38	108.00	98.00	Pass	≥ 45N		
	Moisture conditioned removals	10/4/07	10/5/07	3	24	100.21	103.00	96.00	Pass	≥ 70N		
	Female- 22 AWG TXL											
	Insertion w/o removal of prev. term.	10/3/07	10/3/07	2	24	7.38	8.20	6.20	Pass	≤ 30N		
	Male- 16 AWG TXL											
	Insertion w/o removal of prev. term.	10/2/07	10/2/07	3	24	8.12	9.05	7.21	Pass	≤ 30N		
	Terminal push-thru	10/2/07	10/2/07	3	24				Pass	No push thru ≤ 50N		
	Removal w/wedge	10/4/07	10/5/07	2	16	115.25	124.00	112.00	Pass	≥ 70N		
	Removal w/o wedge	10/4/07	10/5/07	2	16	112.56	116.00	109.00	Pass	≥ 45N		
	Moisture conditioned removals	10/4/07	10/5/07	3	24	107.88	112.00	98.00	Pass	≥ 70N		
	Male- 22 AWG TXL											
	Insertion w/o removal of prev. term.	10/3/07	10/3/07	3	24	7.62	8.80	6.20	Pass	≤ 30N		
	Apex 2.8mm Terminals											
	Female- 12 AWG TXL											
	Insertion w/o removal of prev. term.	10/2/07	10/3/07	3	12	8.10	8.90	7.00	Pass	≤ 30N		
	Terminal push-thru	10/2/07	10/3/07	3	12				Pass	No push thru ≤ 50N		
	Removal w/wedge	10/4/07	10/5/07	2	8	114.88	124.00	108.00	Pass	≥ 90N		
	Removal w/o wedge	10/4/07	10/5/07	2	8	91.38	95.00	85.00	Pass	≥ 60N		
	Moisture conditioned removals	10/4/07	10/5/07	3	12	109.67	117.00	103.00	Pass	≥ 90N		
	Male- 12 AWG TXL											
	Insertion w/o removal of prev. term.	10/2/07	10/2/07	3	12	11.73	12.60	10.60	Pass	≤ 30N		
	Terminal push-thru	10/2/07	10/2/07	3	12				Pass	No push thru ≤ 50N		
	Removal w/wedge	10/4/07	10/5/07	2	8	125.25	129.00	122.00	Pass	≥ 90N		
	Removal w/o wedge	10/4/07	10/5/07	2	8	123.63	129.00	120.00	Pass	≥ 60N		
	Moisture conditioned removals	10/4/07	10/5/07	3	12	118.00	120.00	116.00	Pass	≥ 90N		



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		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.	Pass/Fail		
	Seq. ID G										
5.4.2	Connector-Connector Engage/ Disengage										
	Mate with primary lock (with terminals)	10/11/07	10/16/07	15	360	49.95	57.64	44.80	Pass	≤ 75N	
	Unmate with primary lock (without terminals)	10/11/07	10/16/07	5	0	247.34	252.12	241.87	Pass	≥ 110N	
	Unmate without primary lock (without terminals)	10/11/07	10/16/07	5	0	26.78	28.62	24.59	Pass	≤ 75N	
	Unlatching force	10/11/07	10/16/07	5	0				Pass	≤ 70N	
	Seq. ID H										
5.4.4	Polarization Feature Effectiveness										
	Incorrect orientation mating										
	Pol A to Pol A- 90° rotated	9/10/07	9/10/07	1	24				Pass	No mating with 220N applied force.	
	Pol A to Pol A- 180° rotated	9/10/07	9/10/07	1	24				Pass		
	Pol E to Pol E- 180° rotated	9/10/07	9/10/07	1	24				Pass		
	Mismatched polarization mating										
	Male Pol A to female Pol E- 0° rotated	9/10/07	9/10/07	1	24				Pass		
	Male Pol E to female Pol A- 0° rotated	9/10/07	9/10/07	1	24				Pass		
	Male Pol A to female Pol E- 180° rotated	9/10/07	9/10/07	1	24				Pass		
	Seq. ID E										
5.4.5	Misc. Components Engage/ Disengage										
	CPA										
	Pre-stage to locked (unmated connectors)	9/12/07	9/20/07	10	0				Pass	≥ 60 N	
	Fully removed	9/12/07	9/20/07	10	0				Pass	≥ 30N	
	Male wedge (TPA)										
	Pre-stage to locked	10/18/07	10/22/07	10	0	34.09	38.77	29.88	Pass	≥ 15N	
	Locked to pre-stage	10/18/07	10/22/07	10	240	39.05	44.01	27.92	Pass	≤ 60N	
	Fully removed	10/18/07	10/22/07	10	240	84.60	110.00	55.00	Pass	≥ 25N	
	Female wedge (TPA)										
	Pre-stage to locked	9/12/07	9/20/07	10	240	26.56	32.47	23.22	Pass	≤ 60N	
	Locked to pre-stage	9/12/07	9/20/07	10	240	35.50	40.00	30.00	Pass	≤ 60N	
	Fully removed	9/12/07	9/20/07	10	240	43.50	51.00	35.00	Pass	≥ 25N	
	Male Retainer										
	Removal	9/25/07	9/28/07	10	240	295.70	310.00	275.00	Pass	≥ 110N	
	Female Retainer										
	Removal	9/12/07	9/20/07	10	240	176.30	187.00	166.00	Pass	≥ 110N	



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Procedure or Standard	Test Description	Timing		Quantity		Results			Acceptance Criteria	Notes
		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.		
	Female Slider									
	Force to defeat pre-lock w/o male connector	10/9/07	10/9/07	10	0	227.4	238.0	221.0	Pass	≥ 220N
	Force to remove slide from housing (off back)	10/9/07	10/9/07	10	0	360.8	384.0	337.0	Pass	≥ 220N
	Force to remove slide from housing (off front, no pre-lock)	10/9/07	10/9/07	10	0	181.7	188.0	174.0	Pass	≥ 110N
	Seq. ID F									
5.4.7	Connector-Connector Audible Click									
	Unconditioned	10/8/07	10/8/07	8	0	62.49	66.60	59.50		For info only. All data is in decibels (C scale).
	Conditioned	10/12/07	10/12/07	8	0	62.81	71.70	58.60		For info only. All data is in decibels (C scale).
	Seq. ID I									
5.4.8	Connector Drop Test									
	Male connector									
	Orientation 1	9/11/07	9/11/07	10	0				Pass	**see below
	Orientation 2	9/11/07	9/11/07	10	0				Pass	**see below
	Orientation 3	9/11/07	9/11/07	10	0				Pass	**see below
	Female connector									
	Orientation 1	9/11/07	9/11/07	10	0				Pass	**see below
	Orientation 2	9/11/07	9/11/07	10	0				Pass	**see below
	Orientation 3	9/11/07	9/11/07	10	0				Pass	**see below
	Seq. ID J									
5.4.9	Cavity Damage Susceptibility									
	Male wedge seating	9/21/07	9/21/07	5	5				Pass	Must not seat ≤ 80N
	Apex 150 male terminal removal w/wedge	9/21/07	9/21/07	5	5	113.20	118.00	110.00	Pass	≥ 85N
	Apex 2.8mm male terminal removal w/wedge	9/21/07	9/21/07	5	5	126.40	130.00	124.00	Pass	≥ 90N
	Female wedge seating	9/21/07	9/21/07	5	5				Pass	Must not seat ≤ 80N
	Apex 150 female terminal removal w/wedge	9/21/07	9/21/07	5	5	104.80	110.00	103.00	Pass	≥ 85N
	Apex 2.8mm female terminal removal w/wedge	9/21/07	9/21/07	5	5	113.80	115.00	112.00	Pass	≥ 90N



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Procedure or Standard	Test Description	Timing		Quantity		Results			Acceptance Criteria	Notes
		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.		
5.4.10	Terminal/ Cavity Polarization									
	Apex 150 terminals									
	Male connector									
	Terminal rotated 90°	10/23/07	10/24/07	3	10				Pass	> 15N
	Terminal rotated 180°	10/23/07	10/24/07	3	10				Pass	> 15N
	Terminal rotated 270°	10/23/07	10/24/07	3	10				Pass	> 15N
	Female connector									
	Terminal rotated 90°	10/23/07	10/24/07	3	10				Pass	> 15N
	Terminal rotated 180°	10/23/07	10/24/07	3	10				Pass	> 15N
	Terminal rotated 270°	10/23/07	10/24/07	3	10				Pass	> 15N
	Seq. ID L									
5.7.2	Mounting Feature Mechanical Strength									
	Force direction 1	10/8/07	10/8/07	5	0				Pass	Force to break mounting feature > 50N.
	Force direction 2	10/8/07	10/8/07	5	0				Pass	
	Force direction 3	10/8/07	10/8/07	5	0				Pass	
	Force direction 4	10/8/07	10/8/07	5	0				Pass	
5.9.6	Connector System Electrical Tests Flow Chart									
	Seq. ID M									
5.4.6	Vibration-Mechanical Shock									Coupled-to-engine profile
5.1.9	Discontinuity	9/18/07	9/24/07	5	120				Pass	no loss > 1µs
	Apex 150 terminal									
5.3.1	Pre-test dry circuit	9/17/07	9/17/07	10	160	1.293	1.885	0.935	Pass	≤ 10.0 mΩ
5.3.1	Post-test dry circuit	9/25/07	9/25/07	5	80	1.159	1.940	0.910	Pass	≤ 10.0 mΩ
5.3.2	Post-test voltage drop	9/27/07	9/27/07	5	80	1.356	1.967	1.026	Pass	≤ 10.0 mΩ
	Apex 2.8mm terminal									
5.3.1	Pre-test dry circuit	9/17/07	9/17/07	10	80	0.354	0.425	0.265	Pass	≤ 5.0 mΩ
5.3.1	Post-test dry circuit	9/25/07	9/25/07	5	40	0.484	0.550	0.385	Pass	≤ 5.0 mΩ
5.3.2	Post-test voltage drop	9/27/07	9/27/07	5	40	0.573	1.077	0.452	Pass	≤ 5.0 mΩ
5.1.8	Visual inspection	9/27/07	9/27/07	10	240				Pass	**see below



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Procedure or Standard	Test Description	Timing		Quantity		Results			Pass/Fail	Acceptance Criteria	Notes
		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.			
	Seq. ID N										
5.6.1	Thermal Shock										125°C maximum
5.1.9	Discontinuity	9/26/07	10/1/07	5	120				Pass	no loss > 1µs	
	Apex 150 terminal										
5.3.1	Pre-test dry circuit	9/24/07	9/24/07	5	80	1.129	1.550	0.920	Pass	≤ 10.0 mΩ	
5.3.1	Post-test dry circuit	10/1/07	10/2/07	5	80	1.441	1.875	1.190	Pass	≤ 10.0 mΩ	
5.3.2	Post-test voltage drop	10/4/07	10/4/07	5	80	1.877	2.700	1.456	Pass	≤ 10.0 mΩ	
	Apex 2.8mm terminal										
5.3.1	Pre-test dry circuit	9/24/07	9/24/07	5	40	0.312	0.430	0.220	Pass	≤ 5.0 mΩ	
5.3.1	Post-test dry circuit	10/1/07	10/2/07	5	40	0.539	0.770	0.450	Pass	≤ 5.0 mΩ	
5.3.2	Post-test voltage drop	10/4/07	10/4/07	5	40	0.626	1.051	0.460	Pass	≤ 5.0 mΩ	
5.1.8	Visual inspection	10/4/07	10/4/07	10	240				Pass	**see below	
	Seq. ID O										
5.6.2	Temperature Humidity Cycling										125°C maximum
	Apex 150 terminal										
5.3.1	Pre-test dry circuit	9/7/07	9/7/07	5	80	1.257	1.395	1.035	Pass	≤ 10.0 mΩ	
5.3.1	Post-test dry circuit	10/5/07	10/5/07	5	80	1.772	2.080	1.445	Pass	≤ 10.0 mΩ	
5.3.2	Post-test voltage drop	10/8/07	10/8/07	5	80	2.386	4.220	1.676	Pass	≤ 10.0 mΩ	
5.5.1	Isolation resistance	11/8/07	11/8/07	10	240				Pass	≥ 100MΩ	
5.4.1	Male terminal-connector extraction	10/9/07	10/9/07	3	24				Pass	≥ 50N	
5.4.1	Female terminal-connector extraction	10/9/07	10/9/07	3	24				Pass	≥ 50N	
	Apex 2.8mm terminal										
5.3.1	Pre-test dry circuit	9/7/07	9/7/07	5	40	0.355	0.385	0.310	Pass	≤ 5.0 mΩ	
5.3.1	Post-test dry circuit	10/5/07	10/5/07	5	40	0.849	1.325	0.565	Pass	≤ 5.0 mΩ	
5.3.2	Post-test voltage drop	10/8/07	10/8/07	5	40	0.905	1.428	0.584	Pass	≤ 5.0 mΩ	
5.5.1	Isolation resistance	11/8/07	11/8/07	10	240				Pass	≥ 100MΩ	
5.4.1	Male terminal-connector extraction	10/9/07	10/9/07	3	12				Pass	≥ 50N	
5.4.1	Female terminal-connector extraction	10/9/07	10/9/07	3	12				Pass	≥ 50N	
5.1.8	Visual inspection	10/9/07	10/9/07	10	240				Pass	**see below	



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		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.	Pass/Fail		
	Seq. ID P										
5.6.3	High Temperature Exposure										125°C maximum
	Apex 150 terminal										
5.3.1	Pre-test dry circuit	8/21/07	8/21/07	5	80	1.204	1.330	1.070	Pass	≤ 10.0 mΩ	
5.3.1	Post-test dry circuit	10/8/07	10/8/07	5	80	1.837	2.375	1.355	Pass	≤ 10.0 mΩ	
5.3.2	Post-test voltage drop	10/9/07	10/9/07	5	80	2.037	4.351	1.040	Pass	≤ 10.0 mΩ	
	Apex 2.8mm terminal										
5.3.1	Pre-test dry circuit	8/21/07	8/21/07	5	40	1.204	1.330	1.070	Pass	≤ 5.0 mΩ	
5.3.1	Post-test dry circuit	10/8/07	10/8/07	5	40	0.802	1.190	0.520	Pass	≤ 5.0 mΩ	
5.3.2	Post-test voltage drop	10/9/07	10/9/07	5	40	0.971	1.389	0.600	Pass	≤ 5.0 mΩ	
5.1.8	Visual inspection	10/9/07	10/9/07	10	240				Pass	**see below	

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		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.	Pass/Fail			
5.9.7 Connector System Environmental Test Flow Chart												
Fluid Resistance data is from 14 Way Hybrid testing performed in 2005.												
Seq. ID Q												
5.6.4 Fluid Resistance												
	Pre-test isolation resistance	6/8/05	6/8/05	8	112					Pass	≥ 100MΩ	
Gasoline												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Diesel Fuel												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Engine oil												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Ethanol												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Power steering fluid												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Automatic transmission fluid												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Engine coolant												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Brake fluid												
5.5.1	Isolation resistance	6/8/05	7/5/05	1	14					Pass	≥ 100MΩ	
5.1.8	Visual inspection	7/5/05	7/5/05	1	14					Pass	No ingress of fluid	
Seq. ID R & S												
Temperature Humidity Cycling/ Submersion/ Pressure/Vacuum Leak												
	Pre-test isolation resistance	9/11/07	9/11/07	10	240					Pass	≥ 100MΩ	125°C maximum
5.5.1	Post-submersion isolation resistance	10/9/07	10/9/07	10	240					Pass	≥ 100MΩ	
	Pressure	10/10/07	10/10/07	10	240					Pass	No bubbles	28kPa
	Vacuum	10/10/07	10/10/07	10	240					Pass	No ingress of fluid	
5.5.1	Post- pressure/ vacuum isolation resistance	10/10/07	10/10/07	10	240					Pass	≥ 100MΩ	



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		Start	Compl.	Conn.	Term.	Avg.	Max.	Min.	Pass/Fail		
	Seq. ID T & U										
	High Temperature Exposure/ Submersion/ Pressure Vacuum Leak										125°C maximum
	Pre-test isolation resistance	8/24/07	8/24/07	10	240				Pass	≥ 100MΩ	
5.5.1	Post-submersion isolation resistance	10/10/07	10/10/07	10	240				Pass	≥ 100MΩ	
	Pressure	10/11/07	10/11/07	10	240				Pass	No bubbles	28kPa
	Vacuum	10/11/07	10/11/07	10	240				Pass	No ingress of fluid	
5.5.1	Post- pressure/ vacuum isolation resistance	10/11/07	10/11/07	10	240				Pass	≥ 100MΩ	

