

(2019.11.01 Revised)

Comparison Evaluation of Power Inductors



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V. Environmental tests



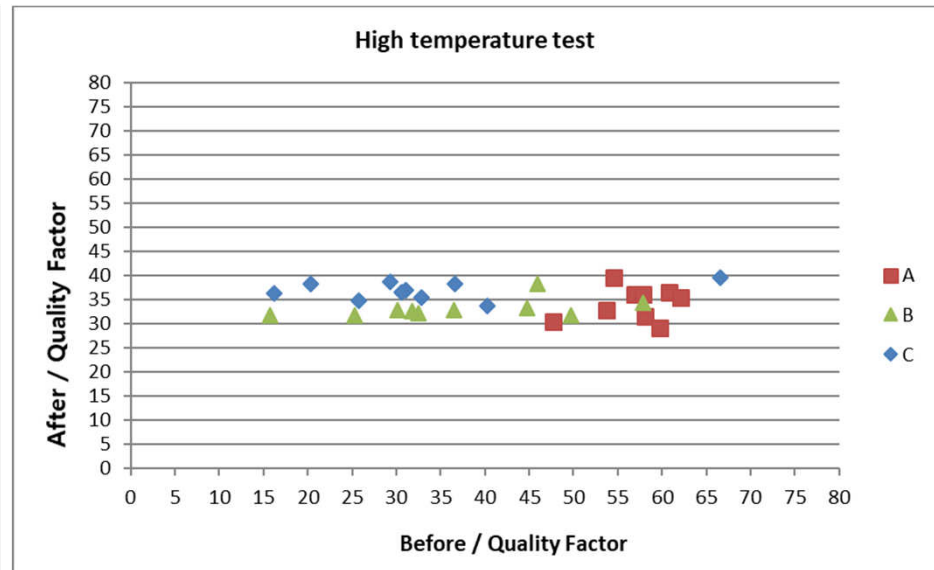
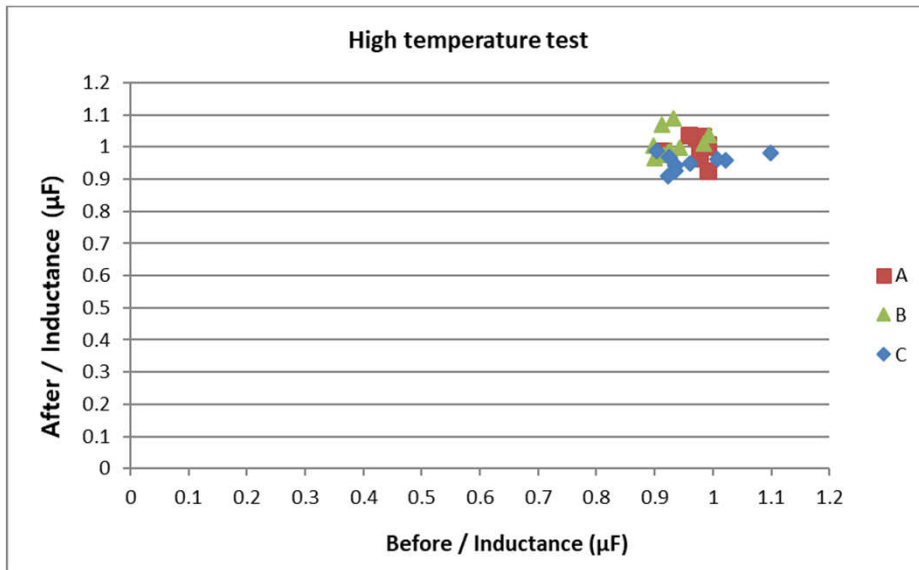
Environmental test conditions

- **Test:**

- High temperature test: $(125 \pm 2) \text{ }^\circ\text{C}$, 500 hr
- Low temperature test: $(-40 \pm 2) \text{ }^\circ\text{C}$, 500 hr
- High temperature and high humidity operation test:
 $(85 \pm 2) \text{ }^\circ\text{C}$, $(85 \pm 3) \text{ \% R.H.}$, 1000 hr
- Thermal shock test: $(125 \pm 2) \text{ }^\circ\text{C}$, $(-40 \pm 2) \text{ }^\circ\text{C}$, each 15 min., 500 cycles
- Vibration test: (min 10 Hz, max 55 Hz), 1.52mm
(min 55 Hz, max 500 Hz), 98 m/s^2
each 2 hr/X,Y,Z

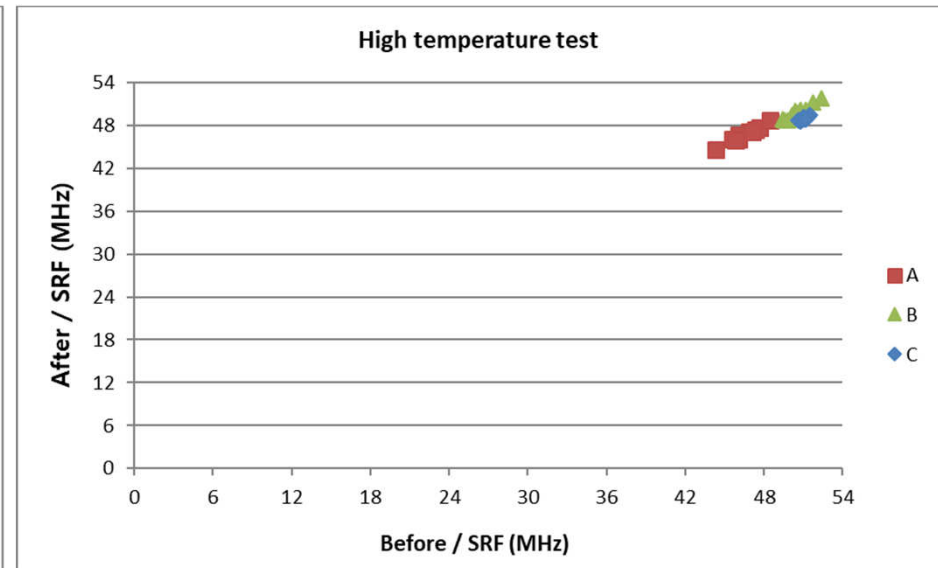
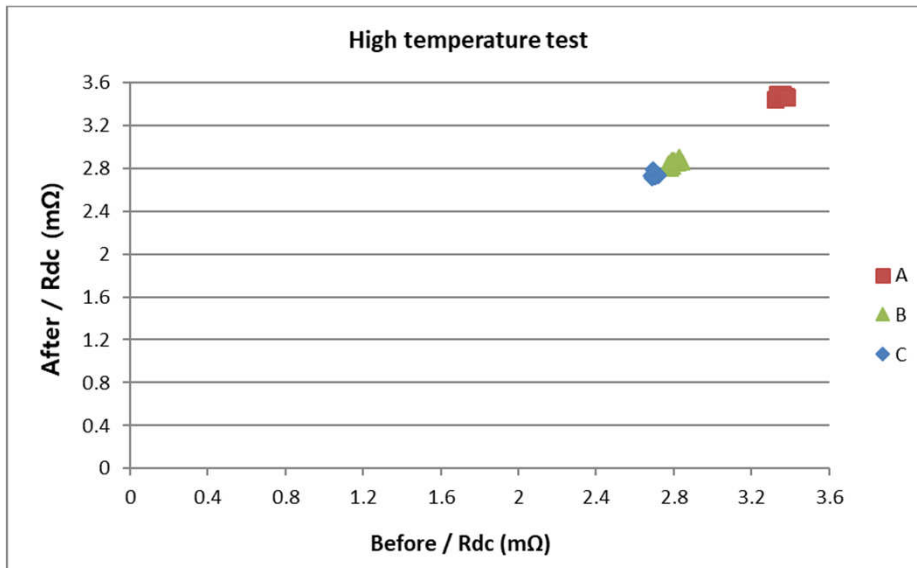
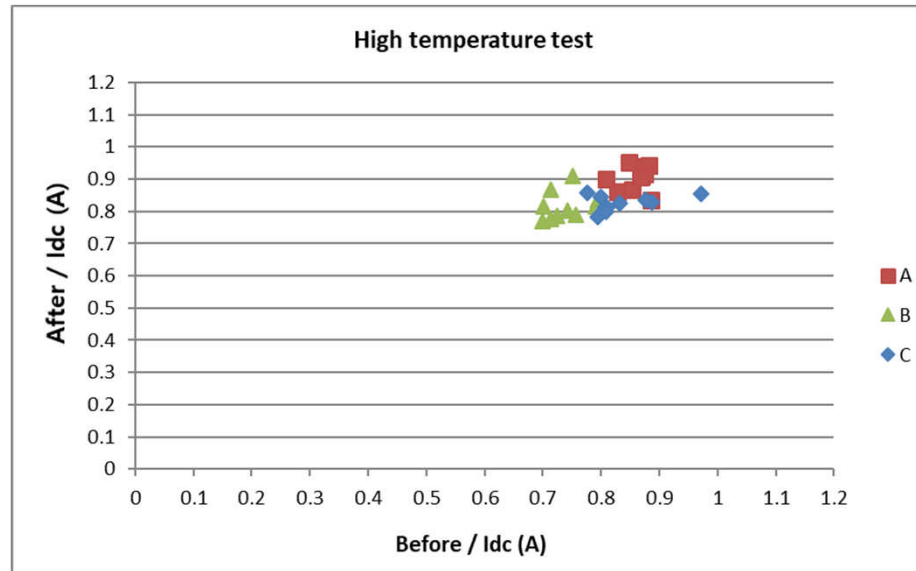
Summary

High temp. test



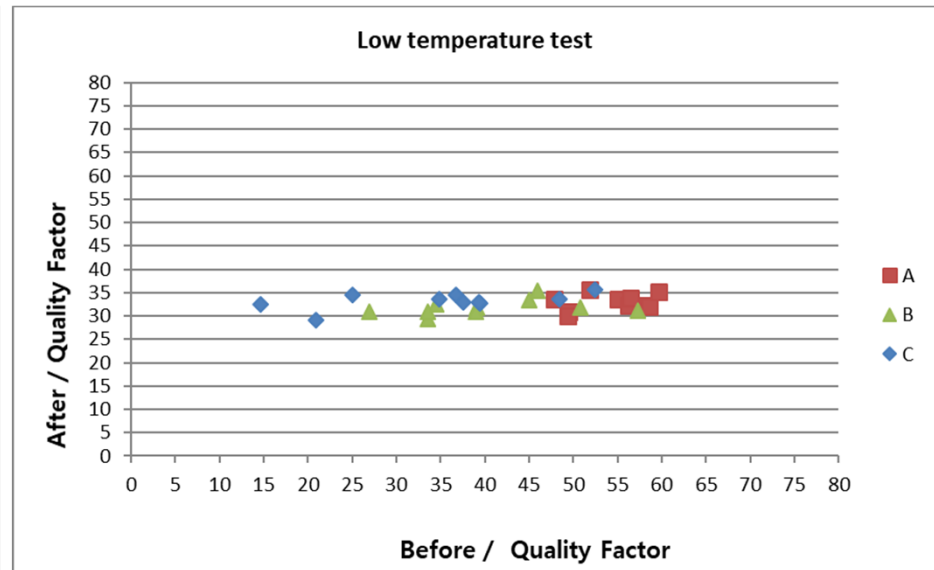
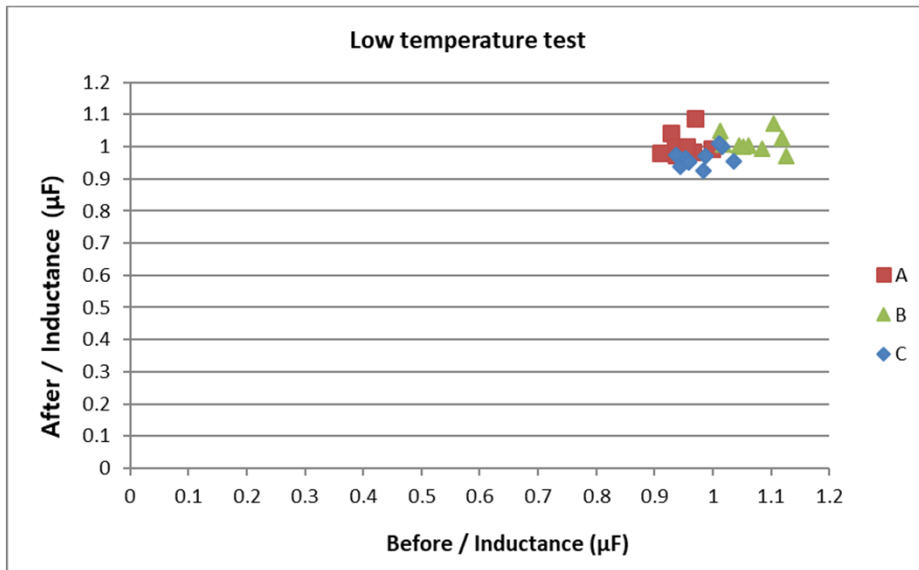
Summary

High temp. test



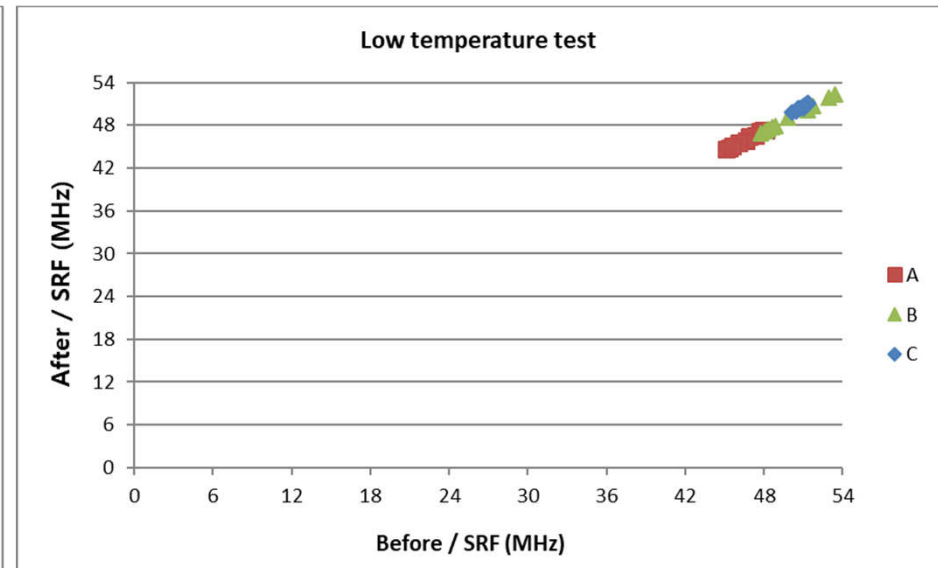
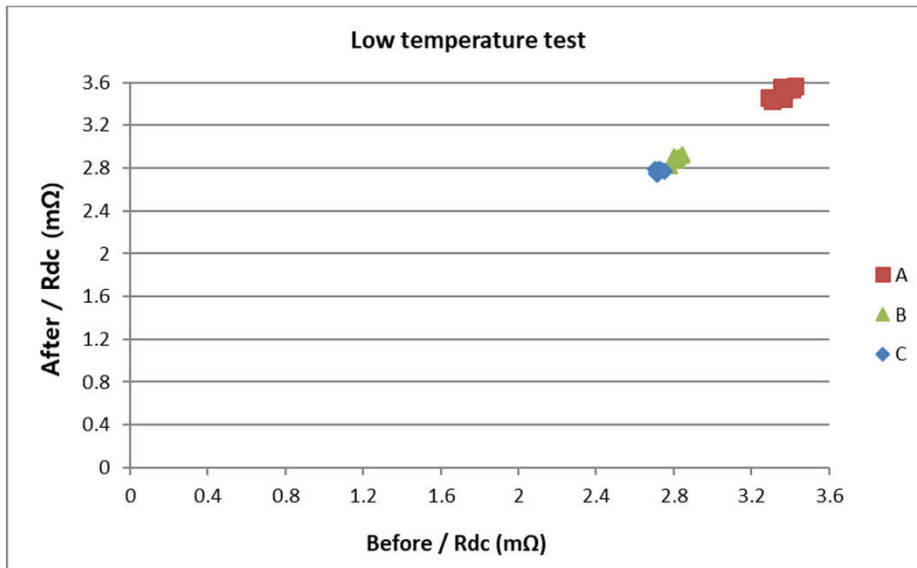
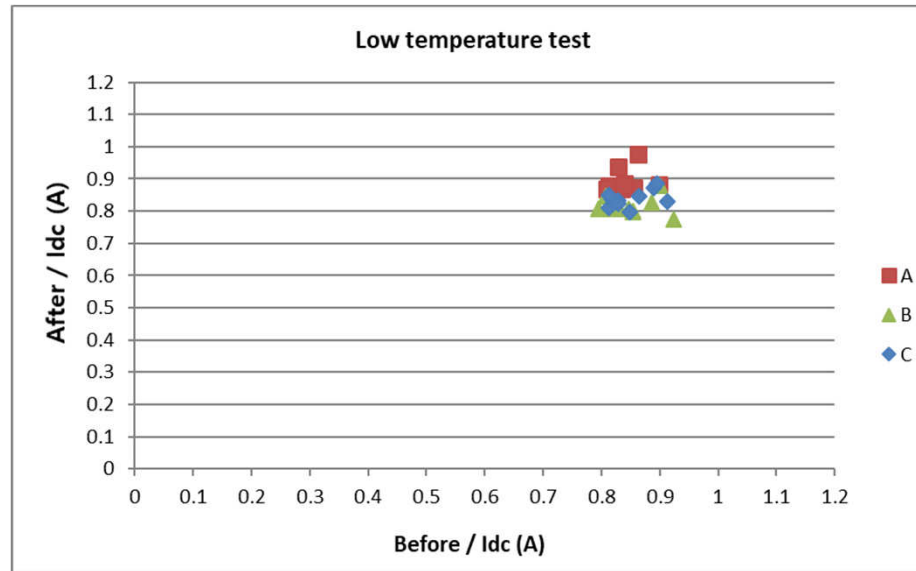
Summary

Low temp. test



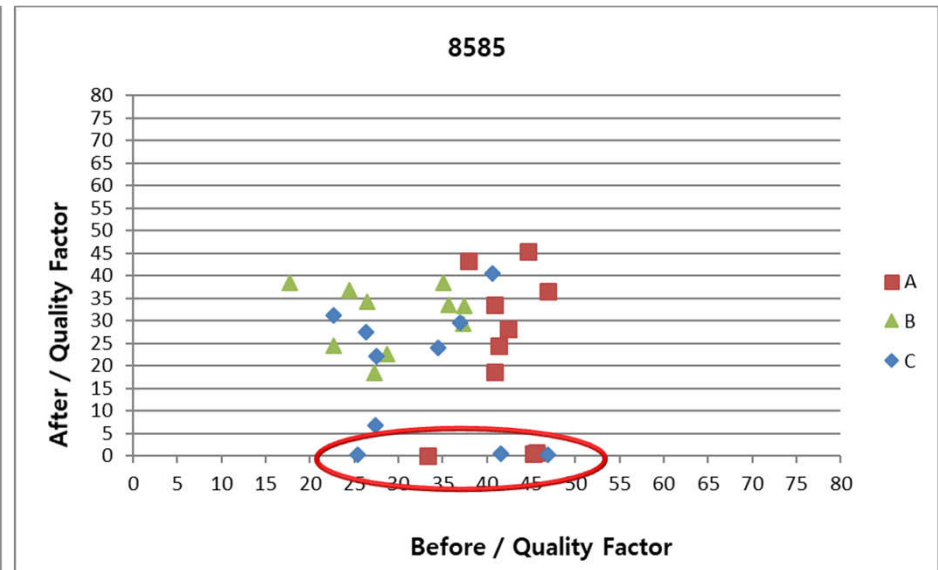
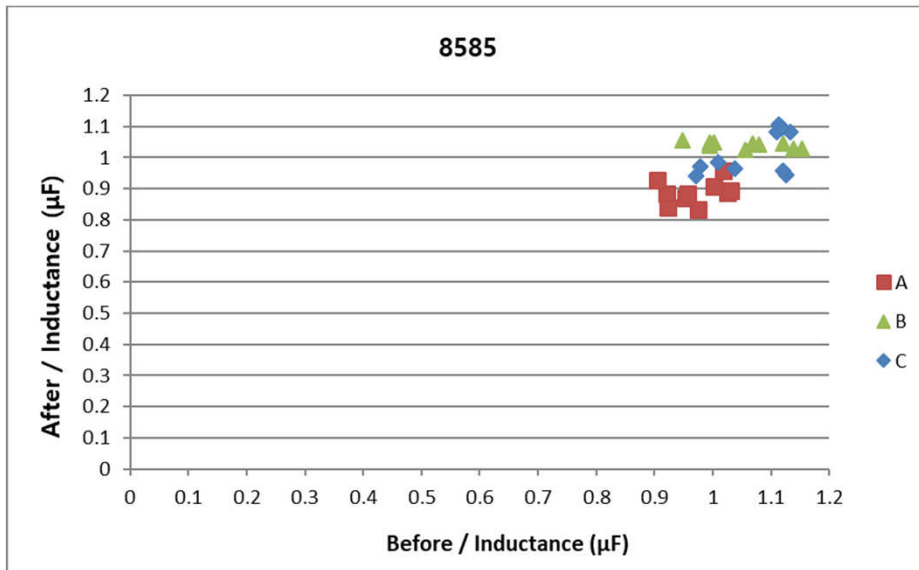
Summary

Low temp. test



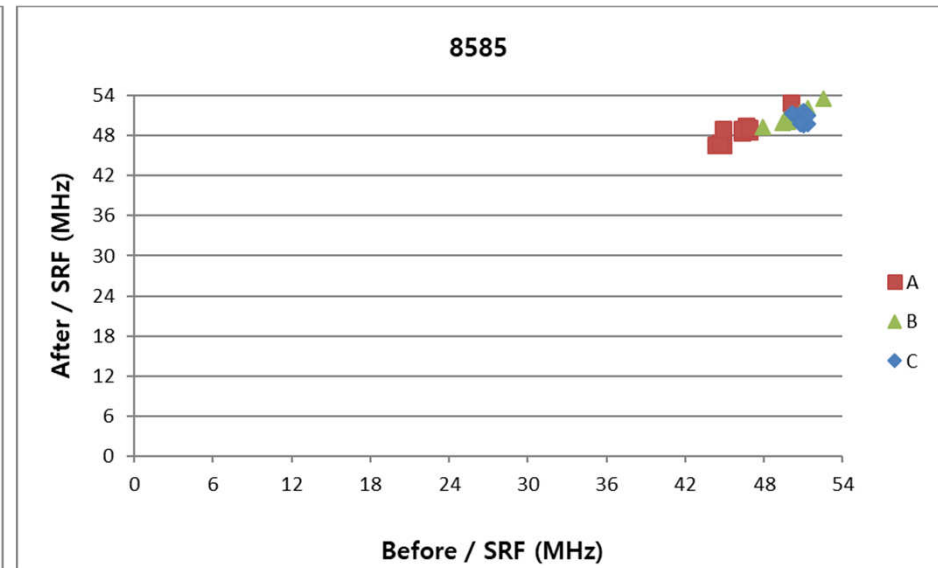
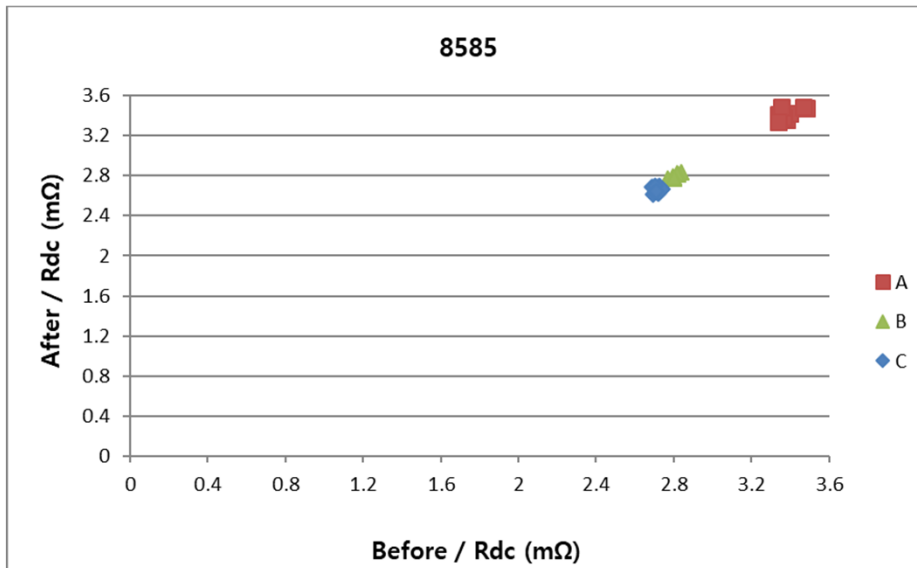
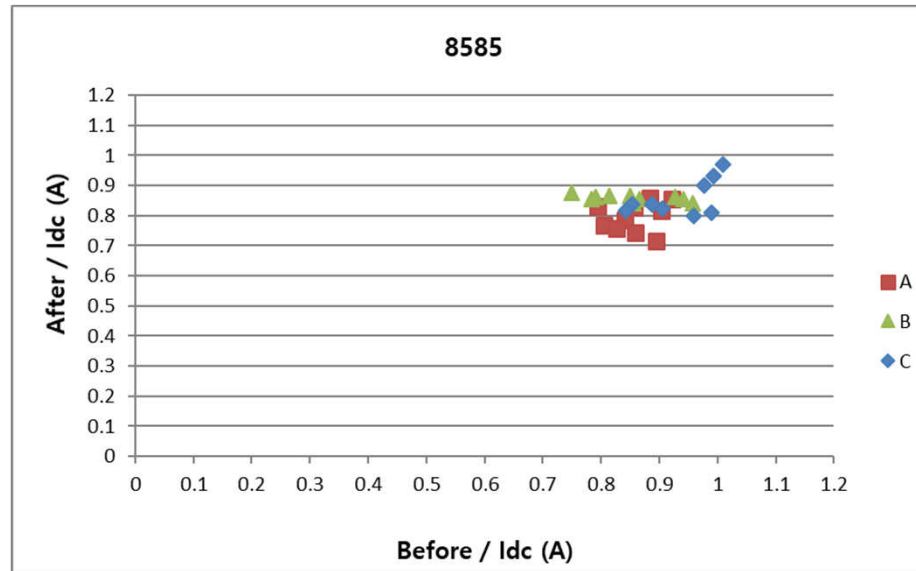
Summary

High temp. & high humidity



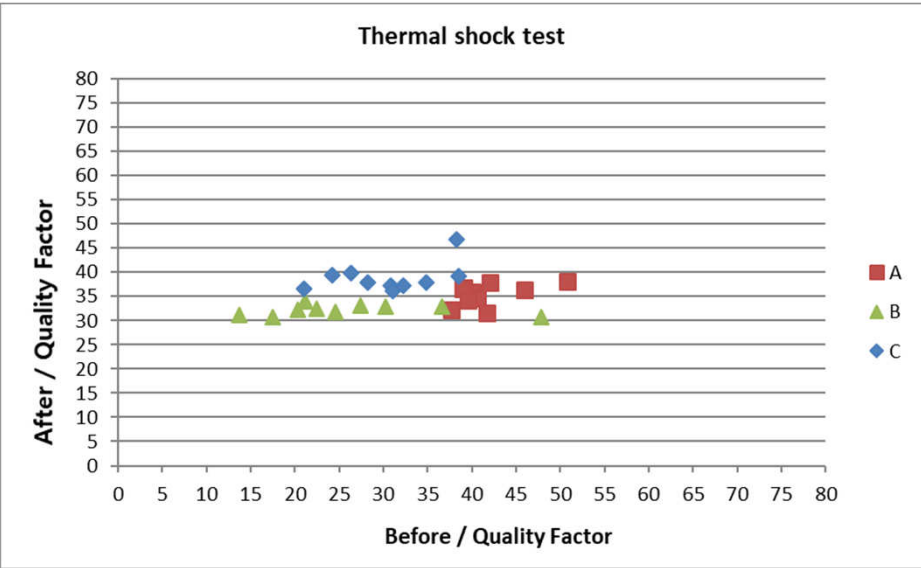
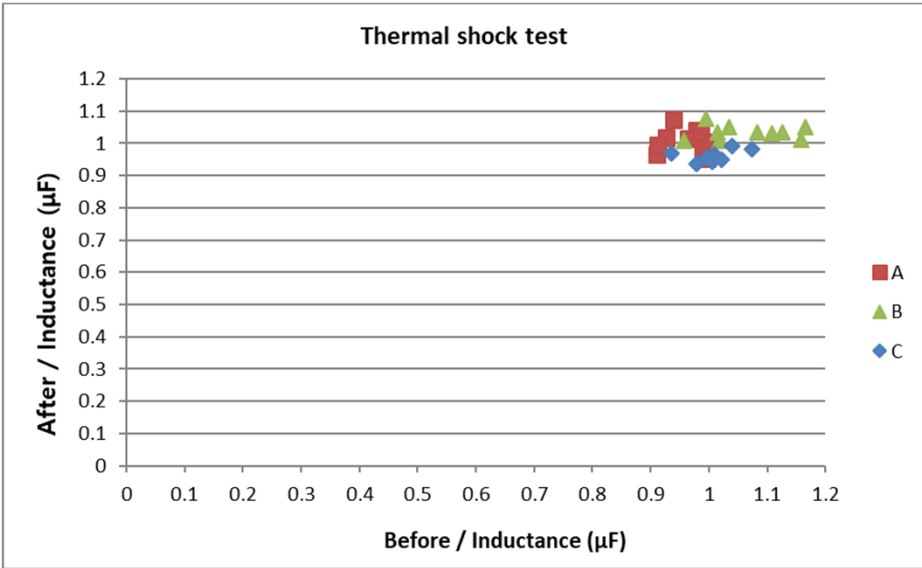
Summary

High temp. & high humidity



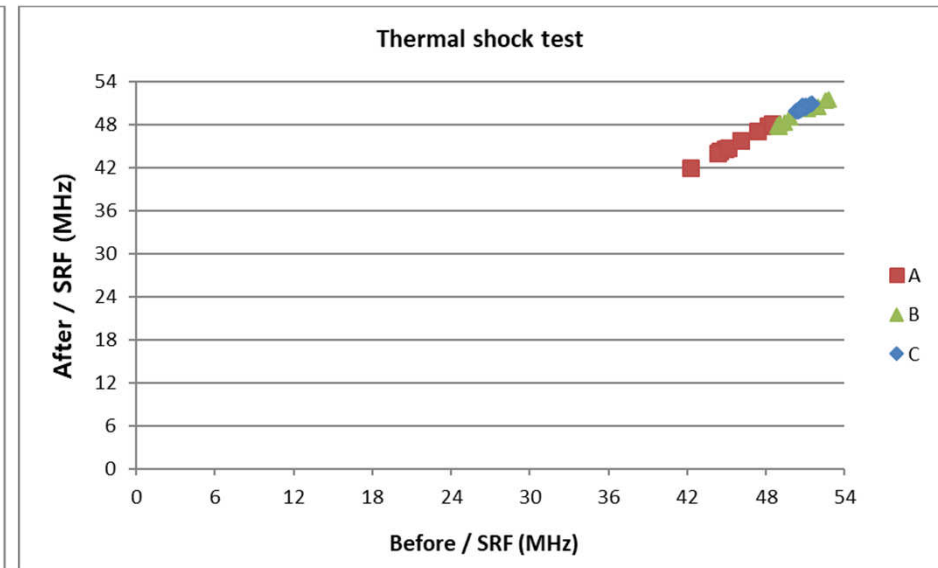
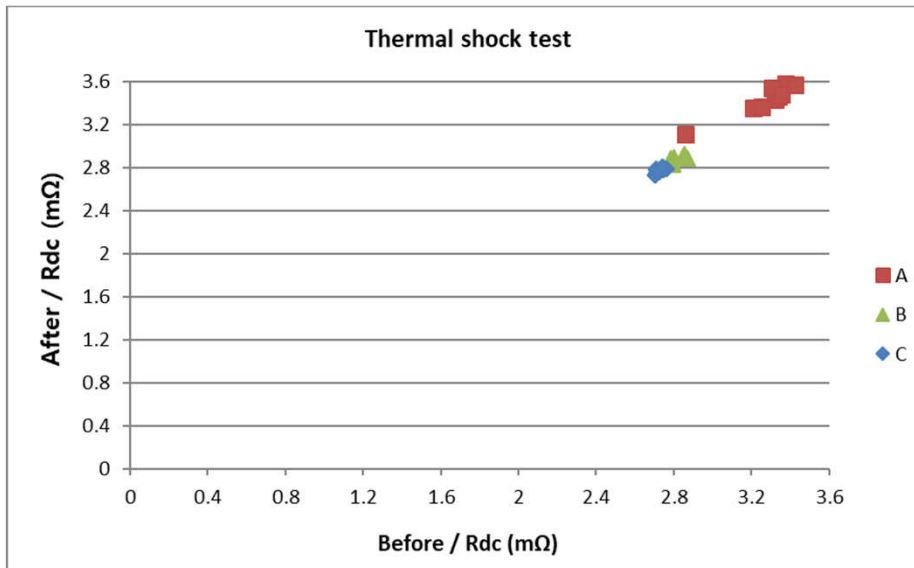
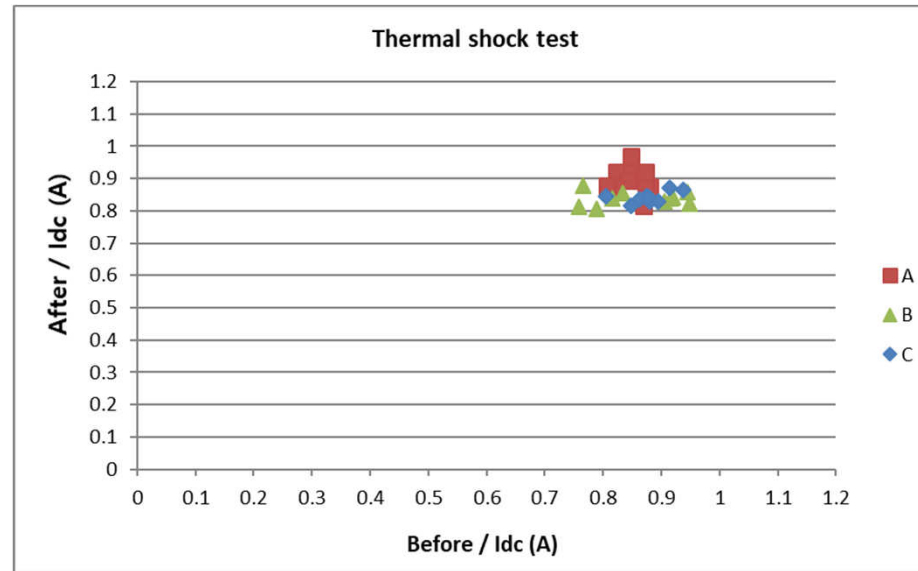
Summary

Thermal shock



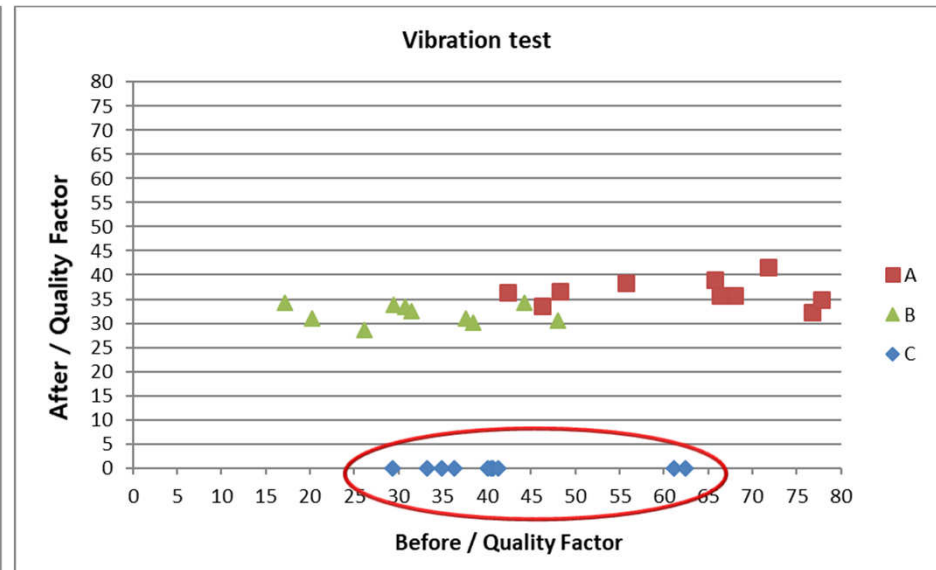
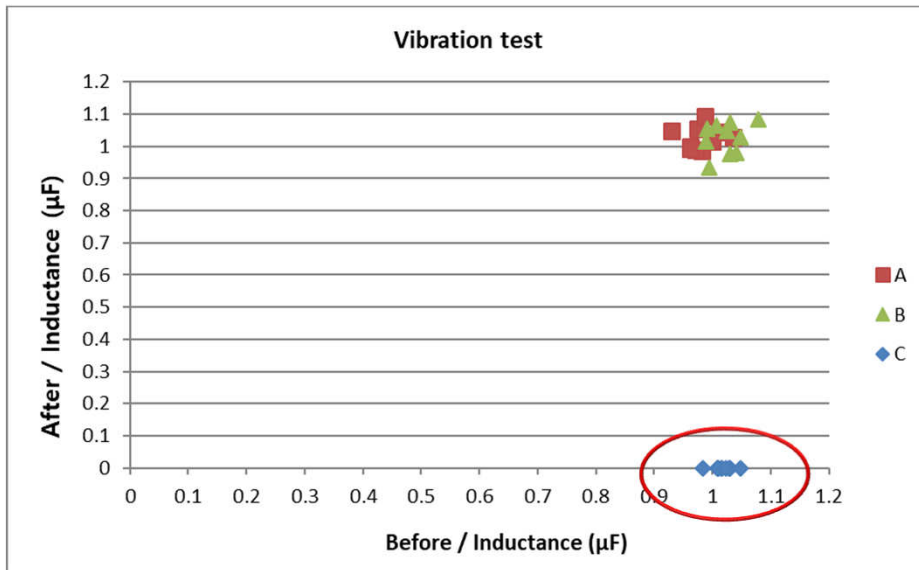
Summary

Thermal shock



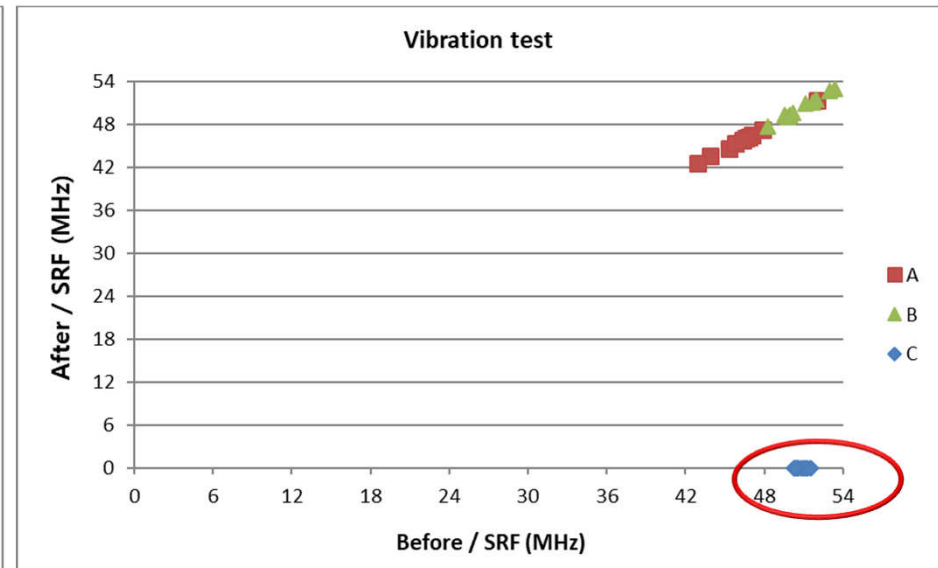
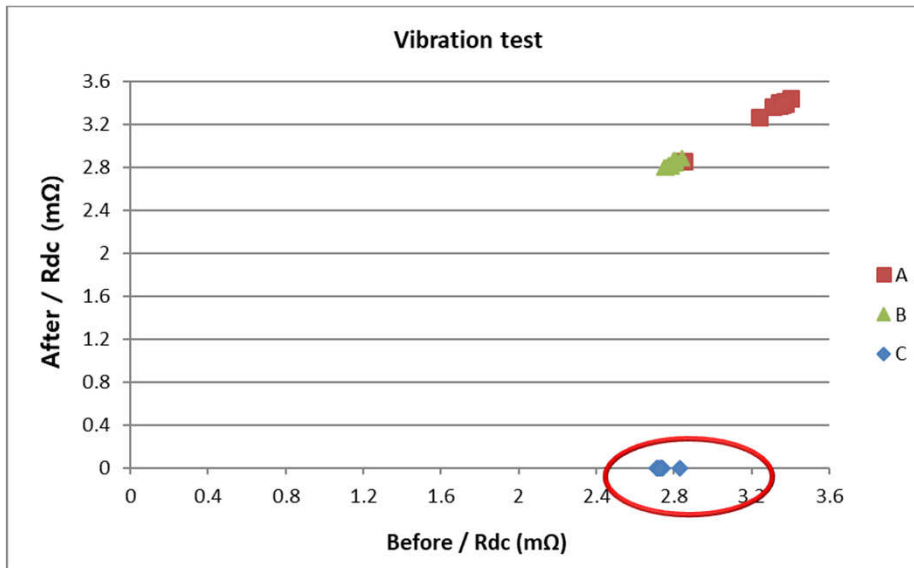
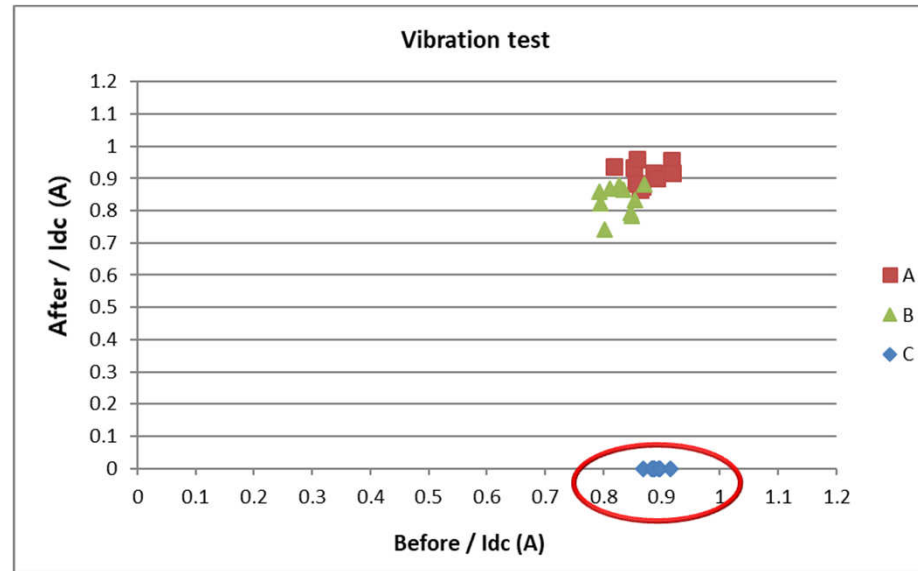
Summary

Vibration test



Summary

Vibration test



High temperature test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	0.97	1.03	0.06	56.90	36.20	-0.57	0.87	0.94	0.07	3.36	3.48	0.03	47.38	47.38	0.00
#2	0.98	1.00	0.03	57.90	36.00	-0.61	0.87	0.91	0.04	3.32	3.45	0.04	46.09	46.09	0.00
#3	0.98	0.97	-0.01	58.10	31.60	-0.84	0.83	0.86	0.04	3.33	3.47	0.04	44.36	44.60	0.01
#4	0.98	1.03	0.05	59.70	29.10	-1.05	0.88	0.94	0.07	3.34	3.46	0.03	46.86	47.12	0.01
#5	0.96	1.04	0.07	54.50	39.60	-0.38	0.85	0.95	0.11	3.34	3.47	0.04	46.09	46.60	0.01
#6	0.99	1.01	0.02	60.80	36.60	-0.66	0.88	0.91	0.04	3.38	3.47	0.03	45.59	46.09	0.01
#7	0.95	9.64	0.90	86.20	31.90	-1.70	0.85	0.89	0.04	3.33	3.49	0.04	47.64	47.64	0.00
#8	0.99	1.00	0.01	62.10	35.40	-0.75	0.87	0.91	0.04	3.36	3.49	0.04	45.84	45.84	0.00
#9	0.99	0.92	-0.07	53.70	32.90	-0.63	0.89	0.84	-0.06	3.37	3.47	0.03	47.12	47.12	0.00
#10	0.91	0.99	0.07	47.70	30.50	-0.56	0.81	0.90	0.10	3.38	3.47	0.02	48.43	48.70	0.01
Average	0.97	1.86	0.11	59.76	33.98	-0.78	0.86	0.91	0.05	3.35	3.47	0.03	46.54	46.72	0.00

* Test condition: 1 MHz

High temperature test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	0.91	1.07	0.15	30.10	32.90	0.09	0.71	0.87	0.18	2.79	2.80	0.01	50.36	49.97	-0.01
#2	0.93	1.09	0.14	45.90	38.20	-0.20	0.75	0.91	0.17	2.82	2.85	0.01	50.75	50.17	-0.01
#3	0.99	1.04	0.04	32.50	32.30	-0.01	0.79	0.83	0.05	2.80	2.82	0.01	49.40	48.83	-0.01
#4	0.94	1.00	0.06	57.80	34.30	-0.69	0.74	0.80	0.07	2.80	2.88	0.03	49.59	48.64	-0.02
#5	0.98	1.01	0.03	15.70	31.80	0.51	0.79	0.82	0.03	2.85	2.86	0.00	52.35	51.74	-0.01
#6	0.90	0.96	0.07	31.80	32.70	0.03	0.70	0.77	0.09	2.83	2.90	0.03	51.74	51.15	-0.01
#7	0.93	0.99	0.06	25.30	31.80	0.20	0.72	0.78	0.08	2.77	2.82	0.02	50.17	49.40	-0.02
#8	0.92	0.97	0.06	49.70	31.80	-0.56	0.71	0.78	0.08	2.77	2.85	0.03	50.56	49.78	-0.02
#9	0.92	0.99	0.06	36.50	32.90	-0.11	0.76	0.79	0.04	2.79	2.87	0.03	49.78	48.64	-0.02
#10	0.90	1.01	0.11	44.80	33.20	-0.35	0.70	0.82	0.14	2.80	2.87	0.02	51.15	50.17	-0.02
Average	0.93	1.01	0.08	37.01	33.19	-0.11	0.74	0.82	0.09	2.80	2.85	0.02	50.58	49.85	-0.01

* Test condition: 100 kHz

High temperature test	Inductance (μF)			Quality Factor			Idc (A)			Rdc ($\text{m}\Omega$)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	1.02	0.96	-0.07	36.60	38.30	0.04	0.89	0.83	-0.07	2.71	2.73	0.01	50.80	48.57	-0.05
#2	0.92	0.91	-0.01	16.20	36.40	0.55	0.79	0.78	-0.01	2.70	2.74	0.01	50.80	48.74	-0.04
#3	0.96	0.95	-0.01	31.10	37.00	0.16	0.83	0.83	-0.01	2.72	2.73	0.00	50.98	49.07	-0.04
#4	0.90	0.99	0.09	66.60	39.50	-0.69	0.78	0.86	0.10	2.68	2.73	0.02	50.63	48.74	-0.04
#5	1.01	0.96	-0.05	30.60	36.50	0.16	0.88	0.83	-0.05	2.70	2.72	0.01	51.16	48.90	-0.05
#6	0.92	0.97	0.05	40.30	33.70	-0.20	0.80	0.84	0.05	2.69	2.71	0.01	51.51	49.42	-0.04
#7	0.94	0.94	0.01	32.80	35.40	0.07	0.81	0.81	0.01	2.69	2.74	0.02	50.80	48.74	-0.04
#8	0.94	0.94	0.01	20.30	38.20	0.47	0.81	0.81	0.00	2.72	2.74	0.01	50.98	48.90	-0.04
#9	0.93	0.93	-0.01	25.70	34.90	0.26	0.81	0.80	-0.01	2.70	2.72	0.01	51.34	49.07	-0.05
#10	1.10	0.98	-0.12	29.30	38.80	0.24	0.97	0.86	-0.13	2.69	2.79	0.03	51.16	48.90	-0.05
Average	0.96	0.95	-0.01	32.95	36.87	0.11	0.84	0.83	-0.01	2.70	2.73	0.01	51.02	48.90	-0.04

* Test condition: 100 kHz

Low temperature test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	0.93	1.04	0.11	47.90	33.60	-0.43	0.83	0.94	0.12	3.40	3.55	0.04	47.90	47.38	-0.01
#2	0.95	0.98	0.04	49.50	30.80	-0.61	0.83	0.87	0.04	3.41	3.54	0.04	47.64	47.12	-0.01
#3	1.00	0.99	-0.01	51.90	35.60	-0.46	0.90	0.88	-0.02	3.37	3.53	0.04	45.34	44.85	-0.01
#4	0.97	0.98	0.02	49.40	29.90	-0.65	0.86	0.87	0.02	3.36	3.45	0.03	47.38	46.60	-0.02
#5	0.94	0.97	0.04	58.40	32.30	-0.81	0.83	0.87	0.04	3.29	3.46	0.05	46.86	46.35	-0.01
#6	0.94	0.99	0.05	55.10	33.50	-0.64	0.84	0.89	0.05	3.30	3.43	0.04	46.60	45.84	-0.02
#7	0.94	1.00	0.07	56.20	32.30	-0.74	0.81	0.88	0.07	3.41	3.53	0.03	46.09	45.59	-0.01
#8	0.97	1.09	0.11	56.50	33.90	-0.67	0.86	0.98	0.12	3.43	3.57	0.04	45.09	44.60	-0.01
#9	0.91	0.98	0.07	58.60	32.00	-0.83	0.81	0.87	0.07	3.36	3.55	0.06	48.16	47.38	-0.02
#10	0.96	1.00	0.04	59.70	35.10	-0.70	0.84	0.88	0.05	3.37	3.51	0.04	45.59	45.09	-0.01
Average	0.95	1.00	0.05	54.32	32.90	-0.65	0.84	0.89	0.06	3.37	3.51	0.04	46.67	46.08	-0.01

* Test condition: 1 MHz

Low temperature test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	1.06	1.00	-0.06	34.50	32.50	-0.06	0.82	0.81	-0.02	2.80	2.87	0.03	47.71	46.80	-0.02
#2	1.02	1.01	-0.01	33.60	30.30	-0.11	0.83	0.81	-0.03	2.81	2.87	0.02	51.74	50.75	-0.02
#3	1.13	0.97	-0.16	39.10	31.90	-0.23	0.92	0.77	-0.19	2.78	2.82	0.02	49.78	49.02	-0.02
#4	1.04	1.00	-0.04	39.00	30.90	-0.26	0.85	0.81	-0.05	2.84	2.93	0.03	51.34	50.17	-0.02
#5	1.05	1.00	-0.05	50.80	31.70	-0.60	0.85	0.80	-0.07	2.81	2.87	0.02	48.08	47.16	-0.02
#6	1.12	1.03	-0.09	45.00	33.40	-0.35	0.89	0.83	-0.07	2.82	2.90	0.03	48.83	47.89	-0.02
#7	1.10	1.07	-0.03	45.90	35.40	-0.30	0.90	0.88	-0.03	2.84	2.92	0.03	52.96	51.94	-0.02
#8	1.08	0.99	-0.09	57.30	31.20	-0.84	0.85	0.80	-0.07	2.81	2.90	0.03	53.37	52.35	-0.02
#9	1.02	1.01	-0.01	27.00	31.00	0.13	0.79	0.81	0.02	2.79	2.88	0.03	48.27	47.52	-0.02
#10	1.01	1.05	0.03	33.50	30.90	-0.08	0.81	0.85	0.04	2.80	2.91	0.04	48.64	47.71	-0.02
Average	1.06	1.01	-0.05	40.57	31.92	-0.27	0.85	0.81	-0.05	2.81	2.89	0.03	50.07	49.13	-0.02

* Test condition: 100 kHz

Low temperature test	Inductance (μF)			Quality Factor			Idc (A)			Rdc ($\text{m}\Omega$)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	0.94	0.94	-0.01	36.80	34.60	-0.06	0.81	0.81	0.00	2.71	2.78	0.03	50.11	49.76	-0.01
#2	0.96	0.95	0.00	25.00	34.40	0.27	0.83	0.83	0.00	2.73	2.77	0.02	51.16	50.80	-0.01
#3	0.99	0.97	-0.02	39.50	32.80	-0.20	0.86	0.85	-0.02	2.71	2.79	0.03	51.34	50.98	-0.01
#4	1.02	1.00	-0.02	39.40	32.90	-0.20	0.89	0.87	-0.02	2.72	2.74	0.01	50.98	50.45	-0.01
#5	1.01	1.01	0.00	48.40	33.60	-0.44	0.90	0.89	-0.01	2.71	2.78	0.03	51.34	51.16	0.00
#6	0.95	0.96	0.01	37.60	32.90	-0.14	0.82	0.84	0.02	2.71	2.75	0.01	50.63	50.28	-0.01
#7	0.94	0.97	0.04	52.50	35.60	-0.47	0.81	0.85	0.04	2.74	2.78	0.02	50.80	50.45	-0.01
#8	1.04	0.96	-0.08	34.80	33.60	-0.04	0.91	0.83	-0.10	2.73	2.79	0.02	50.98	50.63	-0.01
#9	0.96	0.95	-0.01	14.70	32.50	0.55	0.83	0.82	-0.01	2.76	2.77	0.01	50.45	49.93	-0.01
#10	0.98	0.93	-0.06	20.90	29.20	0.28	0.85	0.80	-0.07	2.75	2.77	0.01	50.63	50.45	0.00
Average	0.98	0.96	-0.02	34.96	33.21	-0.05	0.85	0.84	-0.02	2.72	2.77	0.02	50.84	50.49	-0.01

* Test condition: 100 kHz

High temp. high humidity	Inductance (μF)				Quality Factor				Idc (A)				Rdc (m Ω)				SRF (MHz)			
	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)
#1	0.95	0.95	0.87	-0.10	40.90	66.20	33.40	-18.3	0.84	0.86	0.79	-0.07	3.34	3.35	3.44	0.03	46.35	47.61	49.82	0.07
#2	0.96	0.94	0.90	-0.07	33.30	68.20	0.14	-99.6	0.86	0.85	0.81	-0.06	3.38	3.42	3.36	-0.01	46.60	47.90	49.51	0.06
#3	0.92	0.91	0.88	-0.04	42.40	69.70	28.20	-33.4	0.80	0.81	0.77	-0.05	3.35	3.51	3.39	0.01	46.86	47.38	48.70	0.04
#4	0.90	0.92	0.93	0.02	40.90	65.20	18.70	-54.3	0.80	0.82	0.83	0.04	3.48	3.51	3.48	0.00	46.35	47.64	48.96	0.05
#5	0.92	0.94	0.84	-0.10	44.60	71.30	45.40	1.8	0.83	0.85	0.76	-0.09	3.36	3.57	3.37	0.00	50.05	51.16	52.88	0.05
#6	1.02	0.95	0.93	-0.10	45.60	69.30	0.72	-98.4	0.90	0.86	0.82	-0.11	3.40	3.50	3.42	0.01	44.36	45.34	46.60	0.05
#7	1.00	1.01	0.91	-0.11	46.90	69.10	36.50	-22.2	0.89	0.90	0.72	-0.25	3.37	3.55	3.38	0.00	44.85	45.59	46.60	0.04
#8	1.02	0.98	0.96	-0.06	37.90	69.20	43.30	12.1	0.88	0.88	0.86	-0.03	3.47	3.53	3.52	0.01	44.60	45.84	46.86	0.05
#9	1.03	0.96	0.94	-0.10	45.30	68.30	0.61	-98.6	0.92	0.87	0.90	-0.03	3.36	3.51	3.48	0.04	46.86	47.84	47.44	0.01
#10	0.97	0.94	0.83	-0.17	41.40	79.00	24.50	-40.8	0.86	0.85	0.74	-0.16	3.34	3.40	3.34	0.00	44.85	47.38	48.96	0.08
Average	0.97	0.95	0.90	-0.08	41.92	69.55	23.15	-44.8	0.86	0.85	0.80	-0.08	3.38	3.48	3.42	0.01	46.17	47.37	48.63	0.05

* Test condition: 1 MHz

* 500시간 시험 후: 모든 시료에 녹 발생

1000시간 시험 후: 모든 시료에 녹이 발생하였으나 500시간 후에 관찰했을 때와 비슷함

※QF値に異常が発生している

High temp. high humidity	Inductance (μF)				Quality Factor				Idc (A)				Rdc (m Ω)				SRF (MHz)			
	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)
#1	0.99	0.96	1.04	0.04	17.70	28.90	38.30	53.8	0.78	0.78	0.85	0.08	2.79	2.82	2.79	0.00	49.78	49.59	50.68	0.02
#2	1.12	1.01	1.05	-0.07	26.50	28.10	34.20	29.1	0.93	0.82	0.86	-0.07	2.77	2.81	2.77	0.00	49.40	48.83	49.97	0.01
#3	0.99	1.00	1.05	0.05	35.70	25.60	33.40	-6.4	0.79	0.81	0.86	0.08	2.84	2.86	2.83	0.00	50.75	50.17	51.54	0.02
#4	1.06	1.01	1.02	-0.03	28.70	28.80	22.50	-21.6	0.85	0.83	0.84	-0.02	2.79	2.83	2.77	-0.01	50.17	49.78	51.15	0.02
#5	1.14	1.04	1.03	-0.11	35.10	32.30	38.40	9.4	0.94	0.86	0.85	-0.10	2.82	2.86	2.81	0.00	52.55	52.14	53.58	0.02
#6	1.00	1.03	1.05	0.04	24.50	30.10	36.80	50.2	0.81	0.85	0.87	0.06	2.80	2.82	2.78	-0.01	49.78	49.59	50.75	0.02
#7	1.08	1.03	1.04	-0.03	27.30	29.00	18.30	33	0.87	0.85	0.86	-0.01	2.80	2.81	2.77	-0.01	49.59	49.40	50.36	0.02
#8	1.07	1.02	1.04	-0.02	37.40	29.00	33.30	-11	0.85	0.84	0.87	0.02	2.80	2.81	2.78	-0.01	49.97	49.78	50.95	0.02
#9	0.95	0.95	1.06	0.10	37.30	29.50	29.30	-21.5	0.75	0.77	0.88	0.15	2.82	2.86	2.82	0.00	51.34	50.95	52.14	0.02
#10	1.15	1.09	1.03	-0.12	22.70	33.20	24.50	7.9	0.96	0.91	0.84	-0.14	2.80	2.84	2.78	-0.01	47.89	47.89	49.21	0.03
Average	1.06	1.02	1.04	-0.01	29.29	29.45	30.90	5.5	0.85	0.83	0.86	0.00	2.80	2.83	2.79	-0.01	50.12	49.81	51.03	0.02

* Test condition: 100 kHz

* 500시간 시험 후: 외관 변화 없음

1000시간 시험 후: #1, #2, #5 시료의 모서리 부분 위주로 약간의 녹 발생

High temp. high humidity	Inductance (μ F)				Quality Factor				Idc (A)				Rdc (m Ω)				SRF (MHz)			
	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)	Before	Mid	After	Change rate (%)
#1	1.04	0.99	0.96	-0.08	34.50	40.70	23.90	-30.7	0.91	0.86	0.82	-0.10	2.72	2.72	2.64	-0.03	50.45	48.40	50.98	0.01
#2	0.98	0.98	0.97	-0.01	26.40	35.10	27.40	3.8	0.85	0.85	0.84	-0.02	2.69	2.73	2.61	-0.03	50.98	48.90	49.59	-0.03
#3	1.01	0.97	0.98	-0.03	46.90	30.40	0.26	-99.5	0.89	0.84	0.83	-0.06	2.72	2.79	2.63	-0.04	51.34	49.93	49.76	-0.03
#4	0.97	0.97	0.94	-0.03	27.50	31.20	22.10	-19.6	0.84	0.85	0.82	-0.03	2.72	2.81	2.68	-0.01	50.80	49.79	49.65	-0.02
#5	1.13	1.00	0.94	-0.19	27.40	29.90	6.85	-75	0.96	0.88	0.80	-0.20	2.70	2.80	2.64	-0.02	50.98	48.40	50.45	-0.01
#6	1.11	1.06	1.08	-0.03	22.70	25.10	29.80	31.2	0.98	0.94	0.91	-0.08	2.73	2.74	2.69	-0.01	50.80	47.57	50.01	-0.02
#7	1.12	0.95	1.02	-0.10	25.40	33.00	0.15	-99.5	0.99	0.83	0.82	-0.21	2.74	2.74	2.67	-0.03	50.98	48.57	51.69	0.01
#8	1.13	1.13	1.13	0.00	37.00	36.90	31.40	-15.1	1.01	0.98	0.99	-0.02	2.69	2.78	2.63	-0.02	51.34	47.24	50.49	-0.02
#9	1.11	1.09	1.08	-0.03	40.60	32.40	40.00	-1.5	1.00	0.96	9.55	0.90	2.71	2.79	2.71	0.00	50.80	49.04	50.31	-0.01
#10	1.12	1.04	1.06	-0.06	41.60	21.90	0.45	-98.9	0.99	0.91	0.95	-0.05	2.71	2.80	2.64	-0.03	50.11	48.40	51.34	0.02
Average	1.07	1.02	1.02	-0.06	33.00	31.66	18.23	-44.8	0.94	0.89	1.73	0.01	2.71	2.77	2.65	-0.02	50.86	48.62	50.43	-0.01

* Test condition: 100 kHz

* 500시간 시험 후: #4, #6, #7, #9 시료의 pin 부분에 녹 발생, #10 시료 모서리 부분 깨짐
1000시간 시험 후: #3, #5 시료를 제외한 모든 시료에 녹 발생, #7 시료 모서리 부분 깨짐

※QF値に異常が発生している

Thermal shock test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	0.93	1.02	0.09	45.90	36.30	-0.26	0.82	0.92	0.11	3.32	3.43	0.03	48.16	47.90	-0.01
#2	0.98	1.04	0.06	50.80	38.10	-0.33	0.85	0.92	0.07	3.38	3.58	0.06	44.85	44.60	-0.01
#3	0.99	0.98	-0.01	40.00	36.00	-0.11	0.88	0.87	-0.01	3.34	3.46	0.04	47.38	47.12	-0.01
#4	0.97	1.02	0.05	39.10	36.70	-0.07	0.84	0.89	0.06	3.21	3.36	0.04	44.50	44.36	0.00
#5	0.91	0.97	0.06	42.10	37.90	-0.11	0.82	0.88	0.06	3.34	3.49	0.04	48.43	48.16	-0.01
#6	1.00	1.01	0.01	40.70	34.70	-0.17	0.87	0.89	0.01	3.31	3.54	0.07	44.36	44.11	-0.01
#7	0.91	1.00	0.08	37.70	32.30	-0.17	0.81	0.88	0.08	3.36	3.48	0.04	46.09	45.84	-0.01
#8	1.00	0.95	-0.05	41.70	31.60	-0.32	0.87	0.82	-0.07	2.86	3.11	0.08	42.22	41.98	-0.01
#9	0.99	1.04	0.05	39.00	36.60	-0.07	0.87	0.92	0.05	3.43	3.57	0.04	45.09	44.85	-0.01
#10	0.94	1.07	0.12	39.60	34.20	-0.16	0.85	0.97	0.12	3.25	3.37	0.03	46.09	45.84	-0.01
Average	0.96	1.01	0.05	41.66	35.44	-0.18	0.85	0.90	0.05	3.28	3.44	0.05	45.72	45.48	-0.01

* Test condition: 1 MHz

Thermal shock test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	1.00	1.08	0.08	24.60	31.90	0.23	0.77	0.88	0.13	2.80	2.90	0.03	49.02	47.71	-0.03
#2	1.01	1.03	0.02	21.20	33.90	0.37	0.82	0.84	0.03	2.80	2.84	0.02	48.83	47.89	-0.02
#3	1.08	1.03	-0.05	30.20	32.80	0.08	0.91	0.83	-0.09	2.79	2.84	0.02	49.02	48.08	-0.02
#4	1.02	1.01	-0.01	27.40	33.20	0.17	0.79	0.81	0.02	2.80	2.83	0.01	49.78	49.02	-0.02
#5	1.11	1.03	-0.08	20.30	32.20	0.37	0.92	0.84	-0.09	2.79	2.88	0.03	51.94	50.56	-0.03
#6	1.16	1.01	-0.14	36.60	32.80	-0.12	0.95	0.82	-0.15	2.85	2.91	0.02	52.75	51.54	-0.02
#7	1.13	1.04	-0.09	22.40	32.40	0.31	0.92	0.84	-0.09	2.85	2.93	0.03	50.95	50.17	-0.02
#8	1.03	1.05	0.02	17.50	30.80	0.43	0.83	0.85	0.02	2.78	2.84	0.02	49.40	48.27	-0.02
#9	0.96	1.01	0.05	13.70	31.10	0.56	0.76	0.81	0.07	2.87	2.89	0.01	51.15	50.17	-0.02
#10	1.17	1.05	-0.11	47.80	30.80	-0.55	0.94	0.86	-0.10	2.86	2.90	0.01	52.55	51.34	-0.02
Average	1.07	1.03	-0.03	26.17	32.19	0.19	0.86	0.84	-0.03	2.82	2.88	0.02	50.54	49.47	-0.02

* Test condition: 100 kHz

Thermal shock test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	1.01	0.97	-0.04	32.30	37.30	15.5	0.88	0.85	-0.03	2.71	2.75	0.01	50.98	50.28	-0.01
#2	1.04	0.99	-0.05	26.30	39.80	51.3	0.91	0.87	-0.05	2.77	2.79	0.01	51.51	50.98	-0.01
#3	1.00	0.95	-0.05	30.90	37.30	20.7	0.88	0.84	-0.05	2.71	2.79	0.03	51.34	50.80	-0.01
#4	1.00	0.96	-0.04	34.90	37.90	8.6	0.86	0.83	-0.03	2.75	2.78	0.01	50.45	50.11	-0.01
#5	0.94	0.97	0.04	28.20	38.00	34.8	0.80	0.85	0.05	2.70	2.73	0.01	50.28	49.93	-0.01
#6	1.07	0.98	-0.09	24.20	39.40	62.8	0.94	0.86	-0.08	2.70	2.73	0.01	50.80	50.28	-0.01
#7	0.98	0.94	-0.04	21.00	36.50	73.8	0.85	0.82	-0.04	2.72	2.76	0.01	50.98	50.63	-0.01
#8	1.01	0.94	-0.07	38.50	39.10	1.6	0.88	0.83	-0.06	2.72	2.76	0.01	50.80	50.63	0.00
#9	1.01	0.96	-0.05	38.30	46.80	22.2	0.88	0.84	-0.04	2.71	2.78	0.03	50.45	49.93	-0.01
#10	1.02	0.95	-0.08	31.10	36.10	14.2	0.90	0.83	-0.08	2.74	2.81	0.02	50.63	50.11	-0.01
Average	1.01	0.96	-0.05	30.57	38.82	26.9	0.88	0.84	-0.04	2.72	2.77	0.02	50.82	50.37	-0.01

* Test condition: 100 kHz

Vibration test	Inductance (μF)			Quality Factor			Idc (A)			Rdc ($\text{m}\Omega$)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	0.96	1.00	4.2	42.30	36.50	-13.1	0.89	0.92	0.03	3.37	3.40	0.01	52.01	51.45	-0.01
#2	0.98	0.99	1	46.20	33.60	-27.2	0.86	0.86	0.00	3.40	3.45	0.01	43.87	43.63	-0.01
#3	1.01	1.04	3	68.00	35.80	-47.4	0.92	0.96	0.04	3.34	3.37	0.01	47.90	47.38	-0.01
#4	0.93	1.05	12.9	71.80	41.70	-41.9	0.82	0.94	0.12	3.34	3.41	0.02	47.12	46.60	-0.01
#5	0.98	1.06	8	65.70	39.10	-40.5	0.85	0.94	0.09	3.37	3.40	0.01	46.86	46.35	-0.01
#6	0.97	0.99	2.1	48.30	36.70	-24	0.87	0.88	0.01	3.31	3.37	0.02	45.34	44.60	-0.02
#7	0.96	0.99	3.1	76.70	32.20	-58	0.86	0.89	0.03	3.24	3.27	0.01	46.60	46.09	-0.01
#8	1.04	1.03	-1	77.80	34.90	-55.1	0.92	0.92	0.00	3.37	3.41	0.01	45.84	45.34	-0.01
#9	0.99	1.09	10.1	55.70	38.30	-45	0.86	0.96	0.11	2.85	2.86	0.00	42.92	42.68	-0.01
#10	1.00	1.01	10	66.40	35.70	-46.2	0.89	0.90	0.01	3.36	3.39	0.01	46.35	45.84	-0.01
Average	0.98	1.02	4.1	61.89	36.45	-41.1	0.87	0.92	0.05	3.30	3.33	0.01	46.48	46.00	-0.01

* Test condition: 1 MHz

Vibration test	Inductance (μF)			Quality Factor			Idc (A)			Rdc ($\text{m}\Omega$)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	0.99	0.93	-6.1	17.20	34.30	51	0.80	0.74	-0.08	2.84	2.89	0.02	51.94	51.54	-0.01
#2	1.04	0.98	-5.8	26.10	28.70	10	0.85	0.78	-0.08	2.81	2.84	0.01	51.15	50.95	0.00
#3	0.99	1.02	3	30.80	33.30	8.1	0.80	0.82	0.03	2.76	2.80	0.02	49.59	49.40	0.00
#4	1.05	1.03	-1.9	20.20	30.90	53	0.85	0.83	-0.03	2.78	2.82	0.02	49.78	49.02	-0.02
#5	1.03	0.98	-4.9	29.50	33.90	14.9	0.85	0.79	-0.07	2.81	2.87	0.02	52.96	52.75	0.00
#6	1.03	1.05	1.9	38.40	30.10	-21.6	0.84	0.86	0.03	2.79	2.82	0.01	53.37	52.96	-0.01
#7	1.03	1.07	3.9	37.60	30.90	-17.8	0.83	0.88	0.06	2.75	2.80	0.02	49.97	49.40	-0.01
#8	1.01	1.06	5	31.50	32.50	3.2	0.81	0.87	0.07	2.77	2.82	0.02	50.17	49.59	-0.01
#9	0.99	1.06	6	48.00	30.60	-36.3	0.79	0.86	0.08	2.80	2.87	0.03	51.74	51.15	-0.01
#10	1.08	1.08	0.00	44.20	34.30	-22.4	0.87	0.88	0.01	2.81	2.85	0.02	48.27	47.71	-0.01
Average	1.02	1.03	1	32.35	31.95	-1.2	0.83	0.83	0.00	2.79	2.84	0.02	50.89	50.45	-0.01

* Test condition: 100 kHz

Vibration test	Inductance (μF)			Quality Factor			Idc (A)			Rdc (m Ω)			SRF (MHz)		
	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)	Before	After	Change rate (%)
#1	1.03	0.84	-18.5	61.20	26.90	-56	0.90	0.77	-0.16	2.71	2.63	-0.03	50.63	62.20	0.19
#2	0.98	0.93	-5.1	62.50	27.00	-56.8	0.87	0.83	-0.04	2.71	2.62	-0.04	50.98	55.00	0.07
#3	1.03	0.68	-33.4	36.30	13.20	-63.6	0.90	0.63	-0.43	2.74	2.64	-0.04	51.34	67.45	0.24
#4	1.02	0.88	-13.7	29.30	17.90	-38.9	0.89	0.77	-0.15	2.74	2.63	-0.04	50.28	54.25	0.07
#5	1.02	0.70	-31.4	34.90	14.20	-59.3	0.89	0.63	-0.42	2.72	2.63	-0.04	50.80	64.15	0.21
#6	1.01	0.91	-9.9	33.20	16.60	-50	0.89	0.77	-0.15	2.74	2.62	-0.05	51.16	51.40	0.00
#7	1.05	0.71	-32.4	40.70	17.30	-57.5	0.92	0.64	-0.43	2.74	2.63	-0.04	50.45	62.95	0.20
#8	1.01	0.42	-58.4	40.50	6.20	-84.7	0.88	0.40	-1.22	2.83	2.63	-0.08	50.63	109.10	0.54
#9	1.01	0.85	-15.8	40.10	17.10	-57.4	0.88	0.75	-0.17	2.73	2.63	-0.04	50.45	57.55	0.12
#10	1.02	0.54	-60.8	41.30	13.50	-67.3	0.90	0.50	-0.80	2.73	2.64	-0.03	51.51	77.45	0.33
Average	1.02	0.75	-26.5	42.00	16.99	-59.6	0.89	0.67	-0.40	2.74	2.63	-0.04	50.82	66.15	0.20

* Test condition: 100 kHz

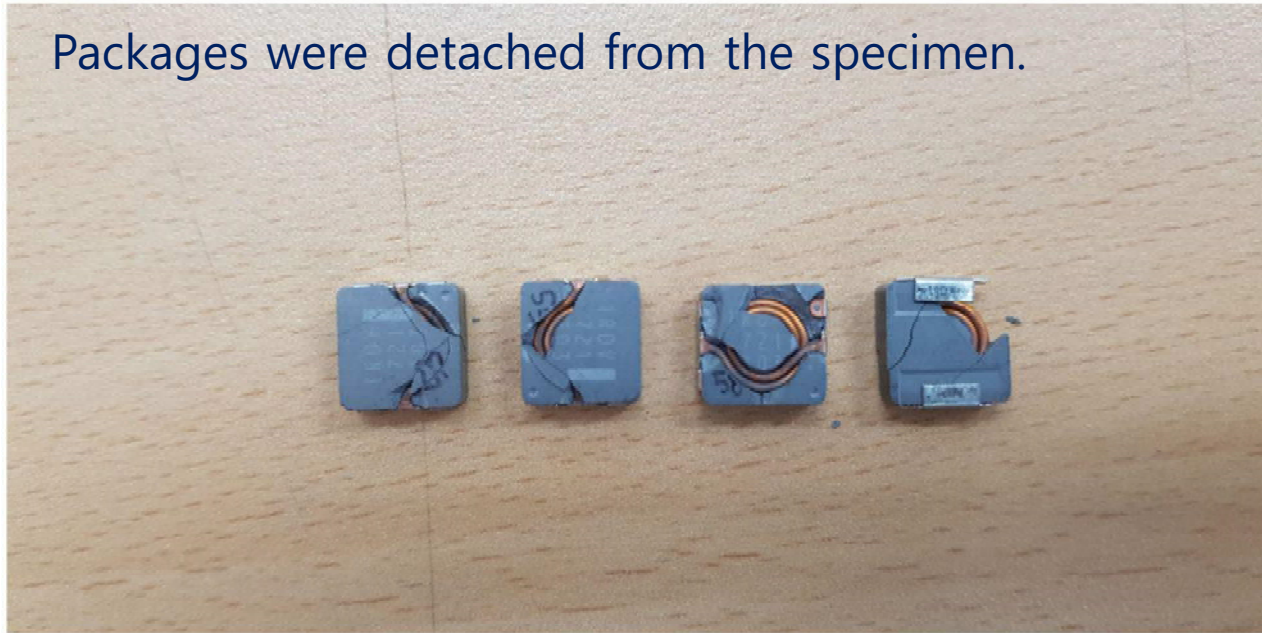
- In the case of sample C, all the specimen got fractured during vibration test (Z-axis).

Please refer picture on the next page.

※試験後、サンプルは全て破壊/クラックが発生している。そして、インダクタンス値は規格オーバーしている。

<2 types of failures sample C after vibration test>

Packages were detached from the specimen.

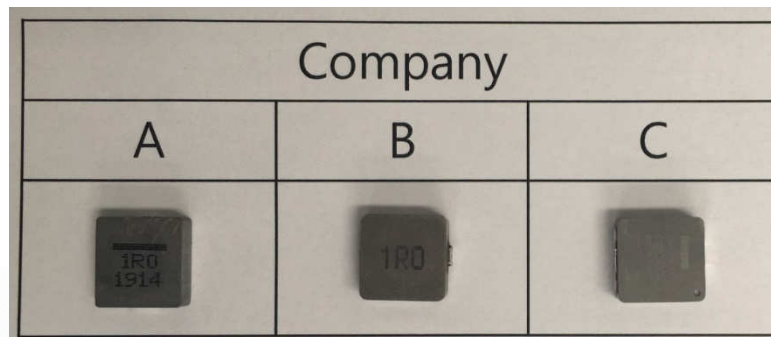


Crack formation on the packages



KETI試験結果のまとめ考察

1. 試験サンプル製品仕様詳細



Sample	Inductance		$R_{dc (max)}$ (mΩ)	Test Frequency(Hz)	Operation temp. (°C)
	L (uH)	Tol. (%)			
A	1.0	±20	3.2	1 M	-40 ~ +125
B	1.0	±20	3.1	100 K	-55 ~ +125
C	1.0	±20	2.86	100 K	unknown ~ +155

サンプル	メーカー	部品型番	仕様	外形寸法
A	Coilmaster	CMI-MMPP10040LL-1 R0M	1 uH ± 20%、 $I_s=14.2A$ ($\Delta T=40deg$)、 $DCR=3.2m\Omega$ 、 $T_{op}=-40\sim 125^\circ C$	10.85x10mm
B	Chilisin	BMRF001010401 R0MD1	1 uH ± 20%、 $I_s=26A$ ($\Delta T=40deg$)、 $DCR=3.1m\Omega$ 、 $T_{op}=-55\sim 125^\circ C$	11.6x10.1mm
C	Panasonic	ETQ-P4M1 R0KVC	1 uH ± 20%、 $I_s=23.9A$ ($\Delta T=40deg$)、 $DCR=2.86m\Omega$ 、 $T_{op}=-55\sim 125^\circ C$	10.7x10mm

KETI試験結果のまとめ考察

2. 試験結果比較

試験項目	A:Coilmaster	B:Chilisin	C:パナソニック
X線解析	異常なし	異常なし	異常なし
SEM観察	異常なし	異常なし	異常なし
高温保存試験	問題無し(規格内)	問題無し(規格内)	問題無し(規格内)
低温保存試験	問題無し(規格内)	問題無し(規格内)	問題無し(規格内)
高温高湿保存試験	問題有り(QF値異常発生)	問題無し(規格内)	問題有り(QF値異常発生)
サーマルショック試験	問題無し(規格内)	問題無し(規格内)	問題無し(規格内)
振動試験	問題無し(規格内)	問題無し(規格内)	問題有り(インダクタンス規格値オーバー)

※補足

- A/C社製品は高温高湿保存試験で**QF値が異常**となるサンプルが数個発生している。明確なスペック値の記載は無いが、インダクタ製品としては性能/機能問題である。
- C社製品は振動試験にて**クラックが発生**しており、インダクタンス**規格オーバー**/QF特性に異常が発生している。**構造的な欠陥**が有ると言える。

KETI試験結果のまとめ考察

3. 試験結果考察

① 高温高湿保存試験について

2社 (Coilmaster/パナソニック) にて**QF値の異常**が数点発生している。**メタルコンポジットコア部材**が高温高湿の影響でダメージを受けた結果と推測出来る。磁性体に水分が混入して**透磁率**が変化したためである。インダクタ製品として致命的な問題である。

② 重畳電流値測定

この試験が実施されていない。よって、真の電気性能実力は判断出来ない。

③ 振動試験結果について

3社で唯一**パナソニック製品**で異常が発生した。**クラック発生**が原因である。同社は各種の特許 (巻線接続方法他) を権利化しているが、実際の信頼性性能の点では問題が有ると言える。

