ارامكو السعودية
Saudi Aramco

Temperature Effect on Twisted Pair Communication Channel

(Part of a Project)

Presented By: Khalid G. Darwish

Comm. Eng. & Tech. Supp. Dept.

khalid.darwish@aramco.com

Authors:

Khalid Darwish*, Khaled Al-Shehri*, Adel Al-Ghamdi*,
Dr. Ali Muqaibel** & Dr. Maan Kousa**

* Saudi Aramco

** King Fahd University of Petroleum and Minerals

CETEM 2008

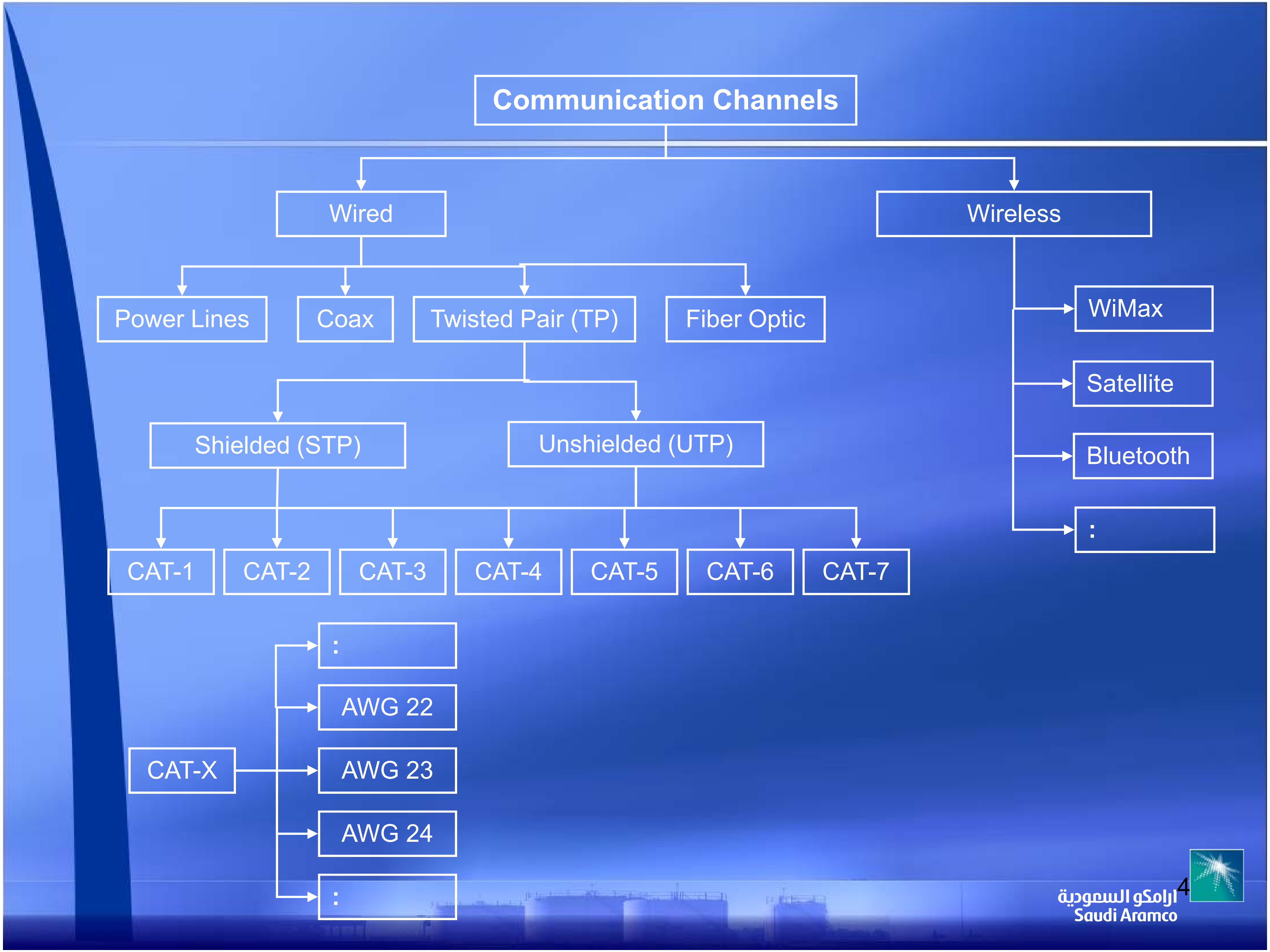
Outline

- Introduction
- Twisted Pair Modeling
- Experiments
- Temperature Effect
- Conclusion

ارامكو السعودية
Saudi Aramco

Outline

- **Introduction**
- Twisted Pair Modeling
- Experiments
- Temperature Effect
- Conclusion


Communication Channels
Wired
Wireless
Power Lines
Coax
Twisted Pair (TP)
Fiber Optic
WiMax
Satellite
Bluetooth
:
Shielded (STP)
Unshielded (UTP)
CAT-1
CAT-2
CAT-3
CAT-4
CAT-5
CAT-6
CAT-7
CAT-X
:
AWG 22
AWG 23
AWG 24
:
أرامكو السعودية
Saudi Aramco

Introduction (cont)

Category	Max Data Rate	Usual Application	Comments
CAT 1	1 Mbps	analog voice (POTS), ISDN, doorbell wiring	Obsolete
CAT 2	4 Mbps	mainly for IBM cabling system for token ring networks	Obsolete
CAT 3	**16 Mbps**	**voice & data on 10BASE-T Ethernet**	**Used**
CAT 4	20 Mbps	used in 16 Mbps token ring	Obsolete
CAT 5	100 Mbps 1000 Mbps (4 pair)	100 Mbps TPDDI, 10BASE-T, 100BASE-T, 155 Mbps ATM, Gigabit Ethernet	Replaced by CAT 5e
CAT 5e	**1000 Mbps**	**100 Mbps TPDDI, 10BASE-T, 100BASE-T, 155 Mbps ATM, Gigabit Ethernet**	**Used**
CAT 6	**250 MHz**	**super-fast broadband applications**	**Used**
CAT 6e	N/A	support for 10 Gigabit Ethernet	Under test
CAT 7	N/A	In the future	In the future

Introduction (cont)

- Twisted Pair (TP) Cable:
  - separately insulted copper wires twisted together to increase the immunity against interference and crosstalk.

- Higher bandwidth, security, and transmission rates than wireless.

Introduction (cont)

- Attenuation (in dB) increases linearly with distance.

- Applications:
  - Telephone lines
  - Ethernet
  - DSL

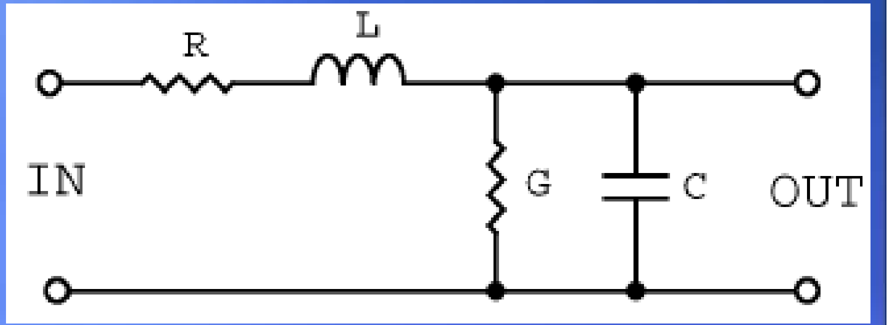
Outline

- Introduction
- **Twisted Pair Modeling**
- Experiments
- Temperature Effect
- Conclusion

Twisted Pair Modeling

- Characteristic impedance:

$$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = |Z_o| \angle \phi_o$$



- Propagation constant:

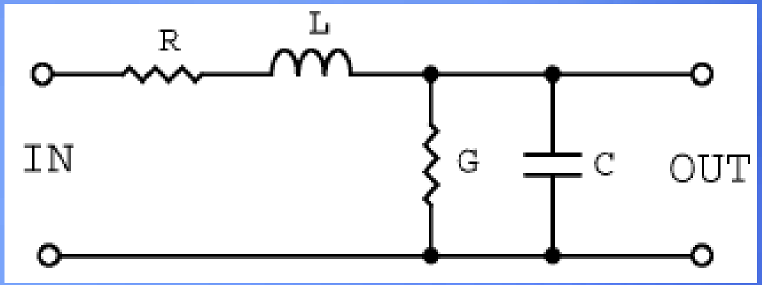
$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} = \alpha + j\beta$$

- *Attenuation (α)*: Real part of (γ), it describes the behavior of the amplitude.
- *Phase constant (β):* Imaginary part of (γ), it describes the behavior of the phase.

Outline

- Introduction
- Twisted Pair Modeling
- **Experiments**
- Temperature Effect
- Conclusion

Experiment



- Objective: to see the effect of temperature on the impedance and the attenuation.

- To do that: measure RLCG with temperature change.

Experiment (cont)

- Device used:
  - PM 6303A Automatic RCL Meter PHILIPS.
  - Operates on 1 kHz.

Experiment (cont)

- Varying temperature:
  - Oven
  - Start @ 80^{o}C
  - Let it cool to 26^{o}C
  - Thermometer

Experiment (cont)

- The samples used:
  - CAT-3 AWG-22 (10 meter)
  - CAT-3 AWG-24 (10 meter)
  - CAT-5 (10 meter)
  - CAT-6 (7.5 meter)
- The samples were rolled and put in the oven.
- The parameters are plotted per meter.

Experiment (cont)

- Sample of the data:

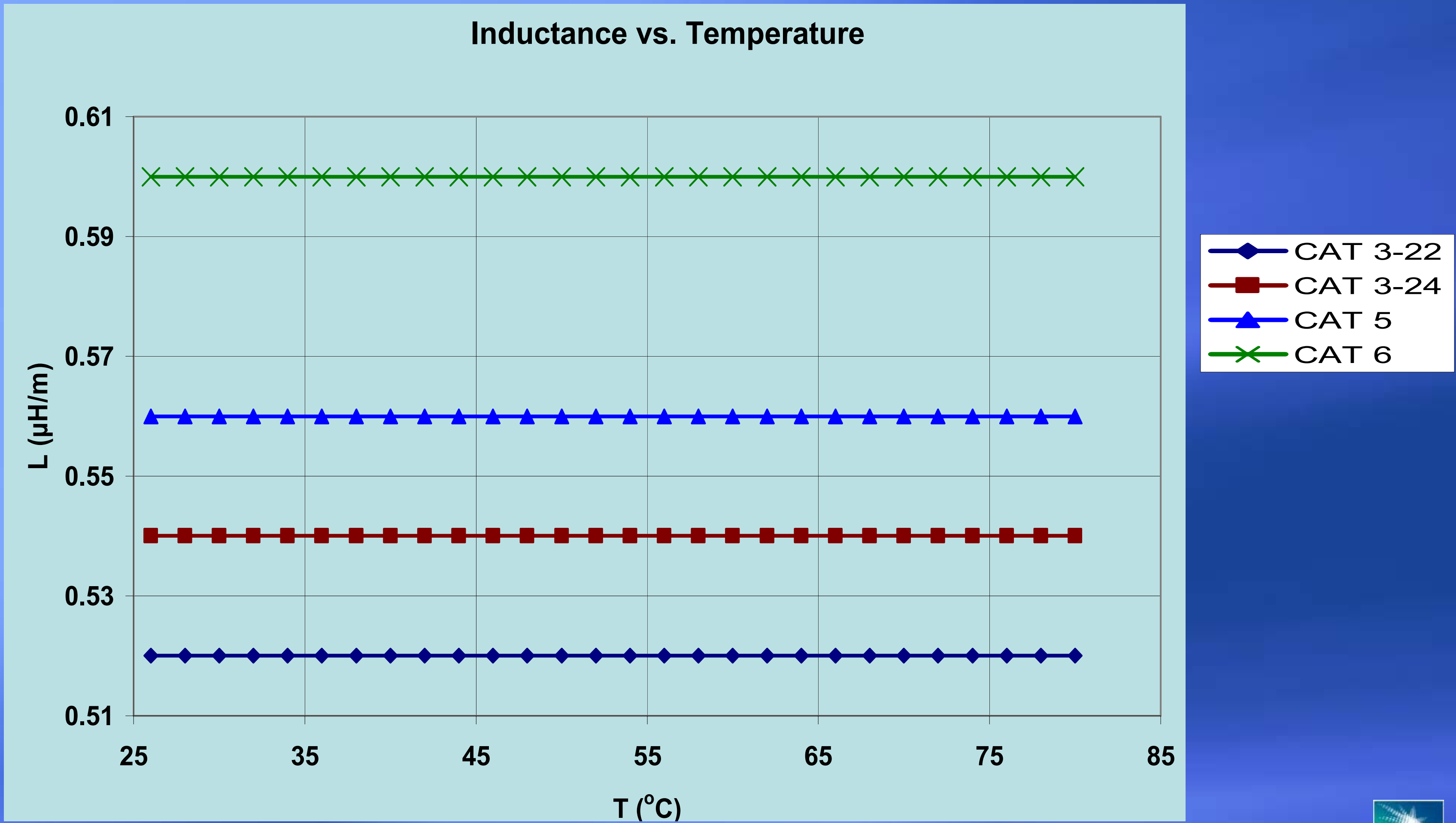
Temp (ºC)	CAT 6			
	C (pF/m)	G (nS/m)	L (µH/m)	R (Ω/m)
80	48.44	0.880	0.6	0.1725
62	48.39	1.079	0.6	0.1637
44	48.07	1.498	0.6	0.1525
26	47.60	1.642	0.6	0.1452

Outline

- Introduction
- Twisted Pair Modeling
- Experiments
- **Temperature Effect**
- Conclusion

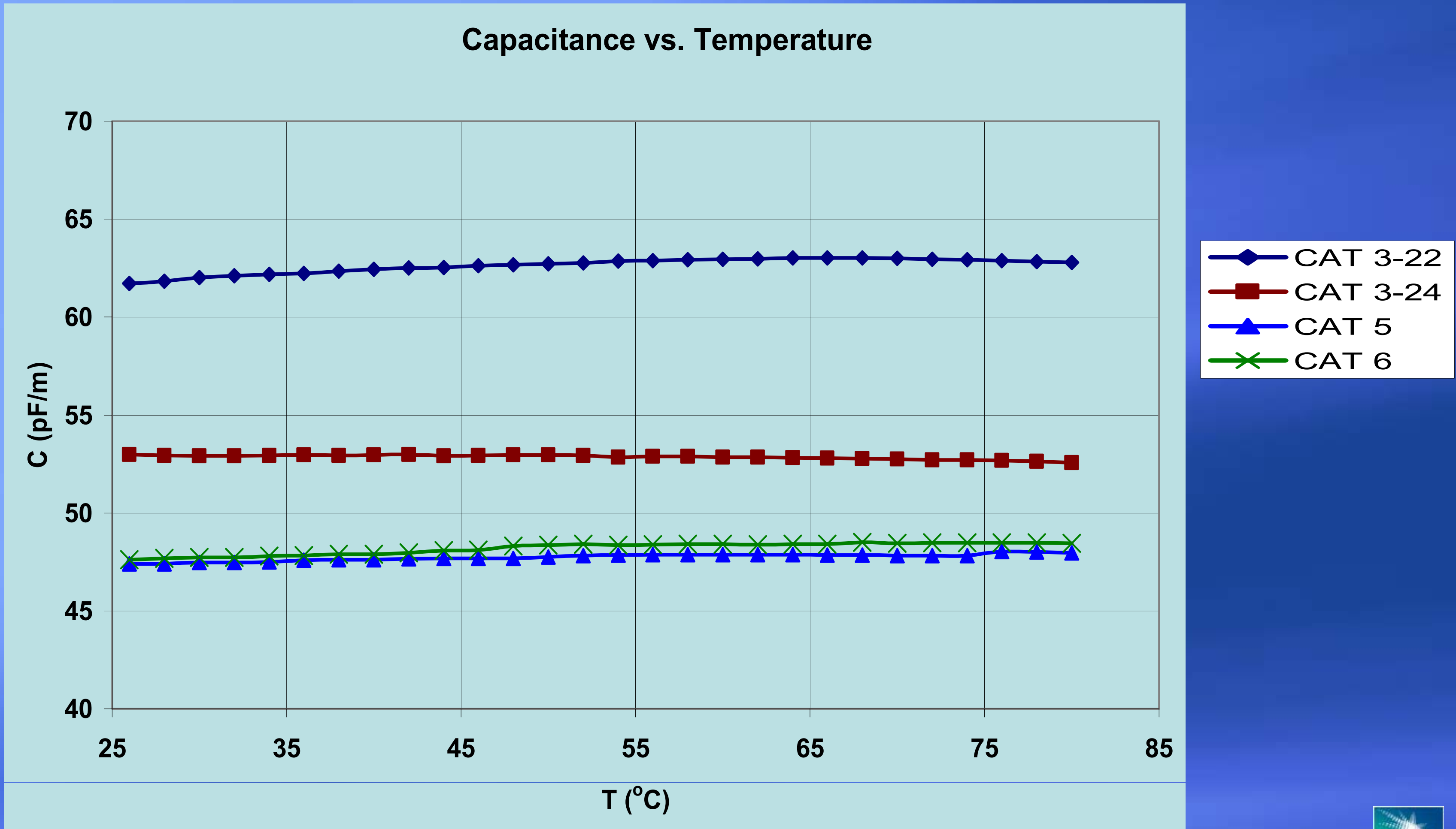
Temperature Effect (1)

- Inductance (µH/m)



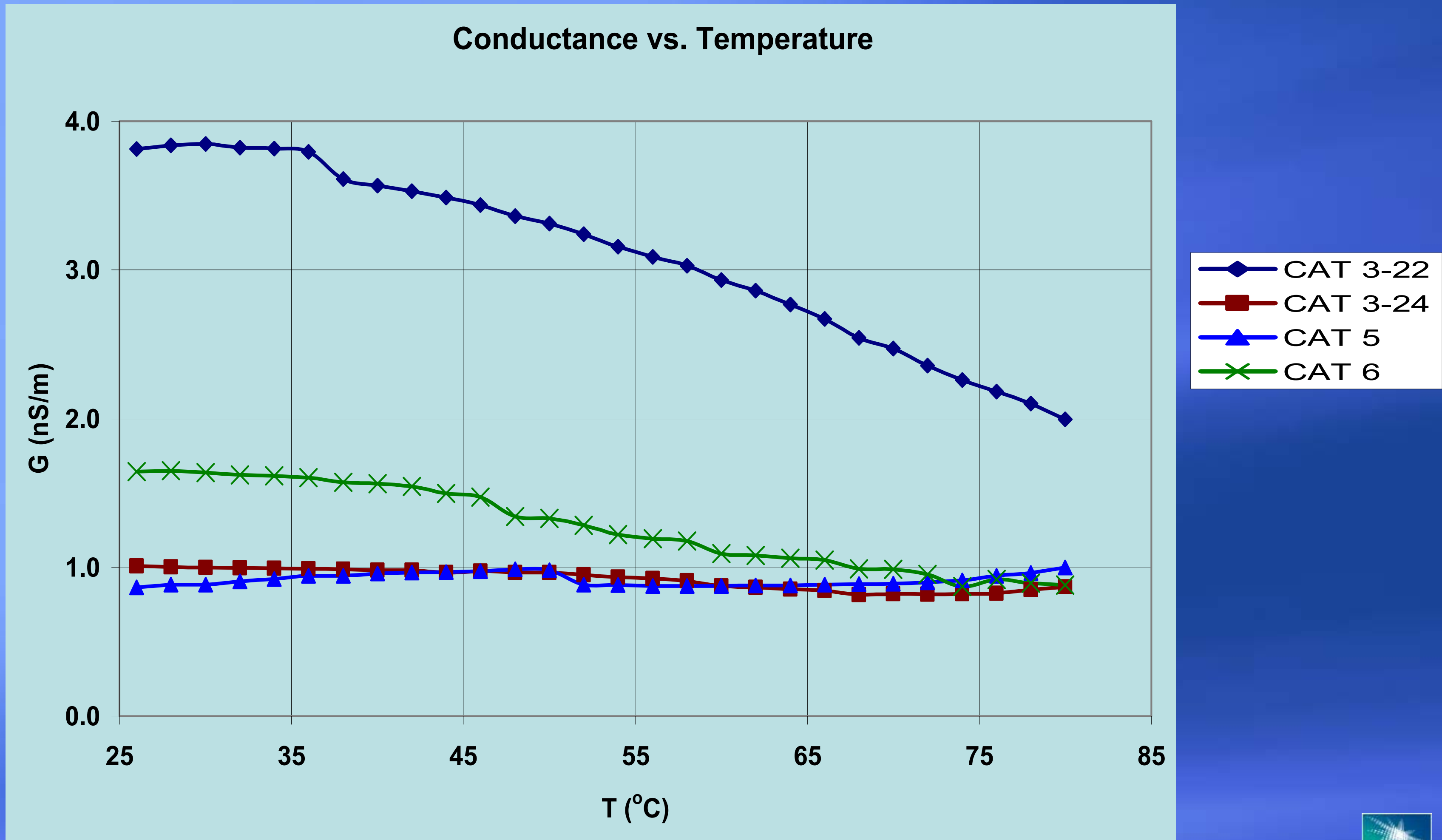
Temperature Effect (2)

- Capacitance (pF/m)



Temperature Effect (3)

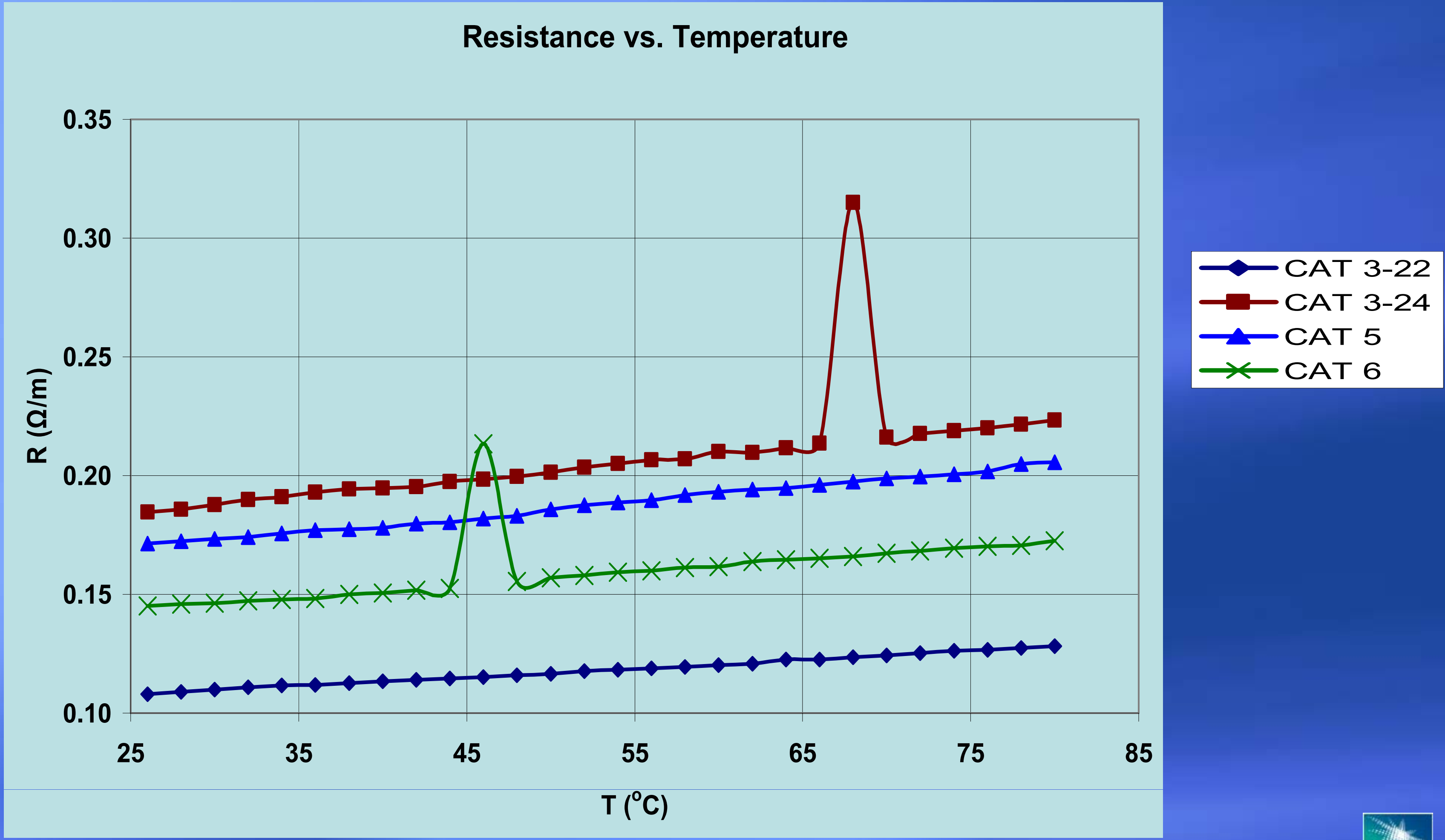
- Conductance (nS/m)



Saudi Aramco

Temperature Effect (4)

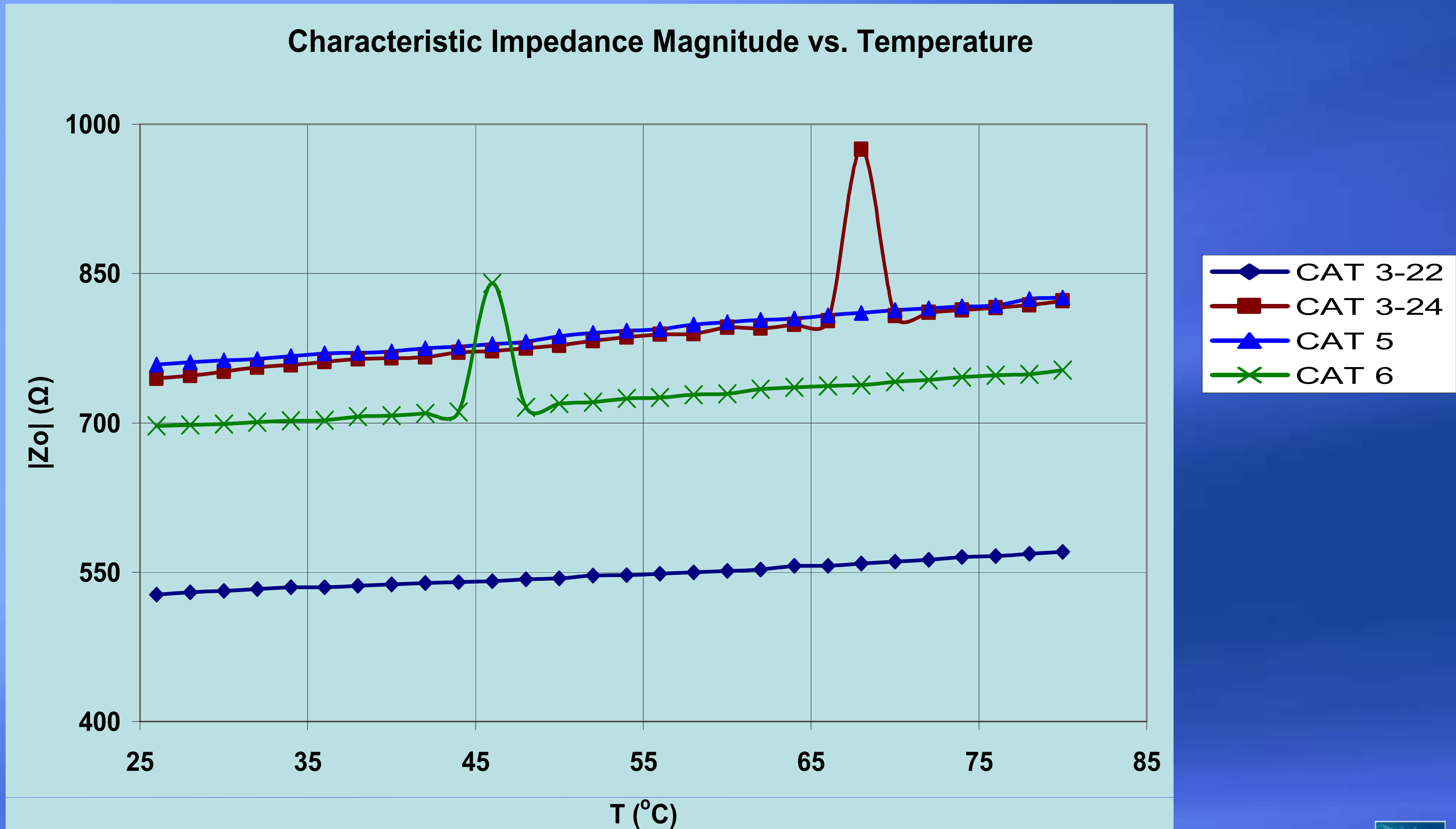
- Resistance (Ω/m)



Saudi Aramco

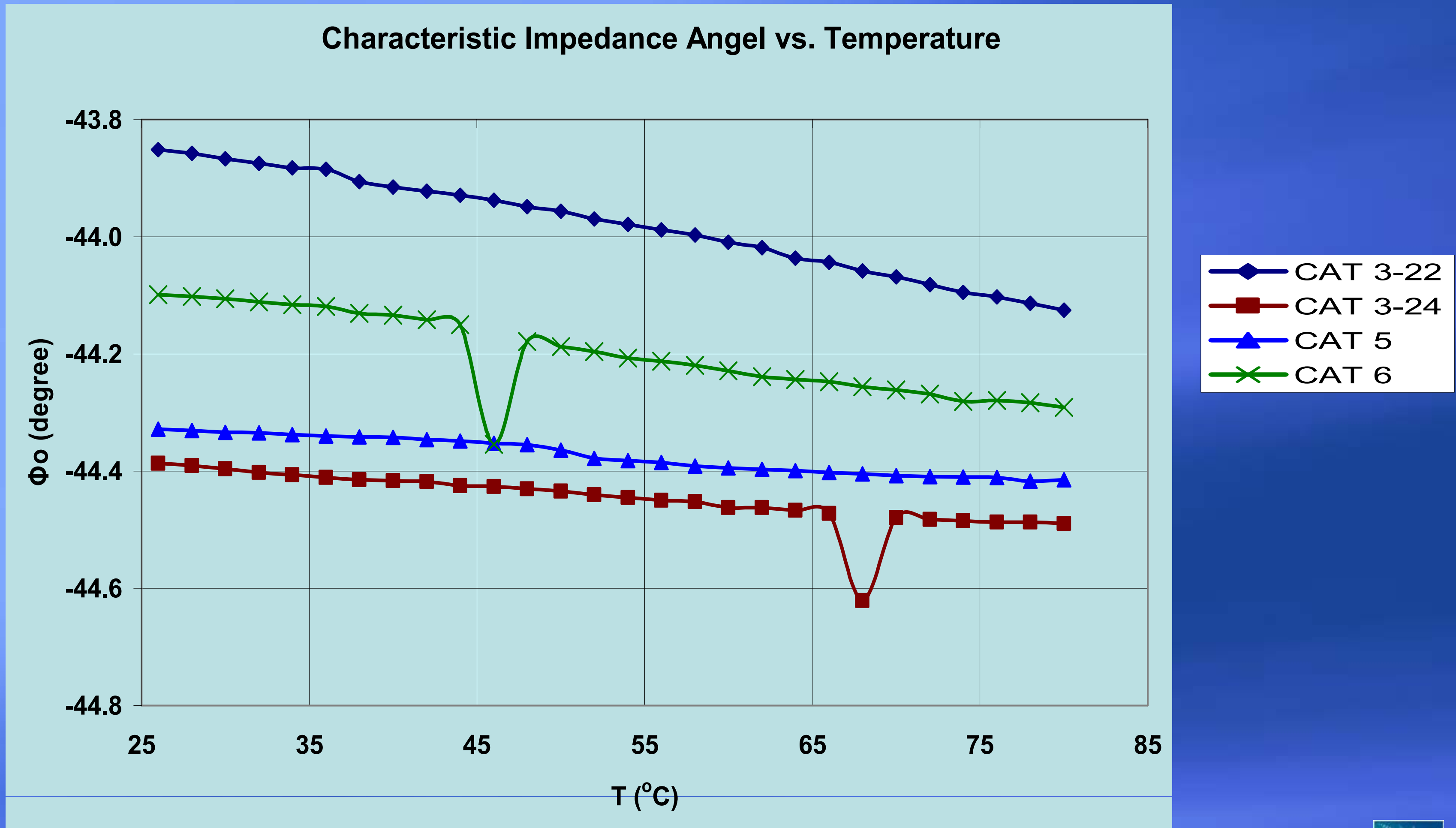
Temperature Effect (5)

- Characteristic Impedance Magnitude (Ω)



Temperature Effect (6)

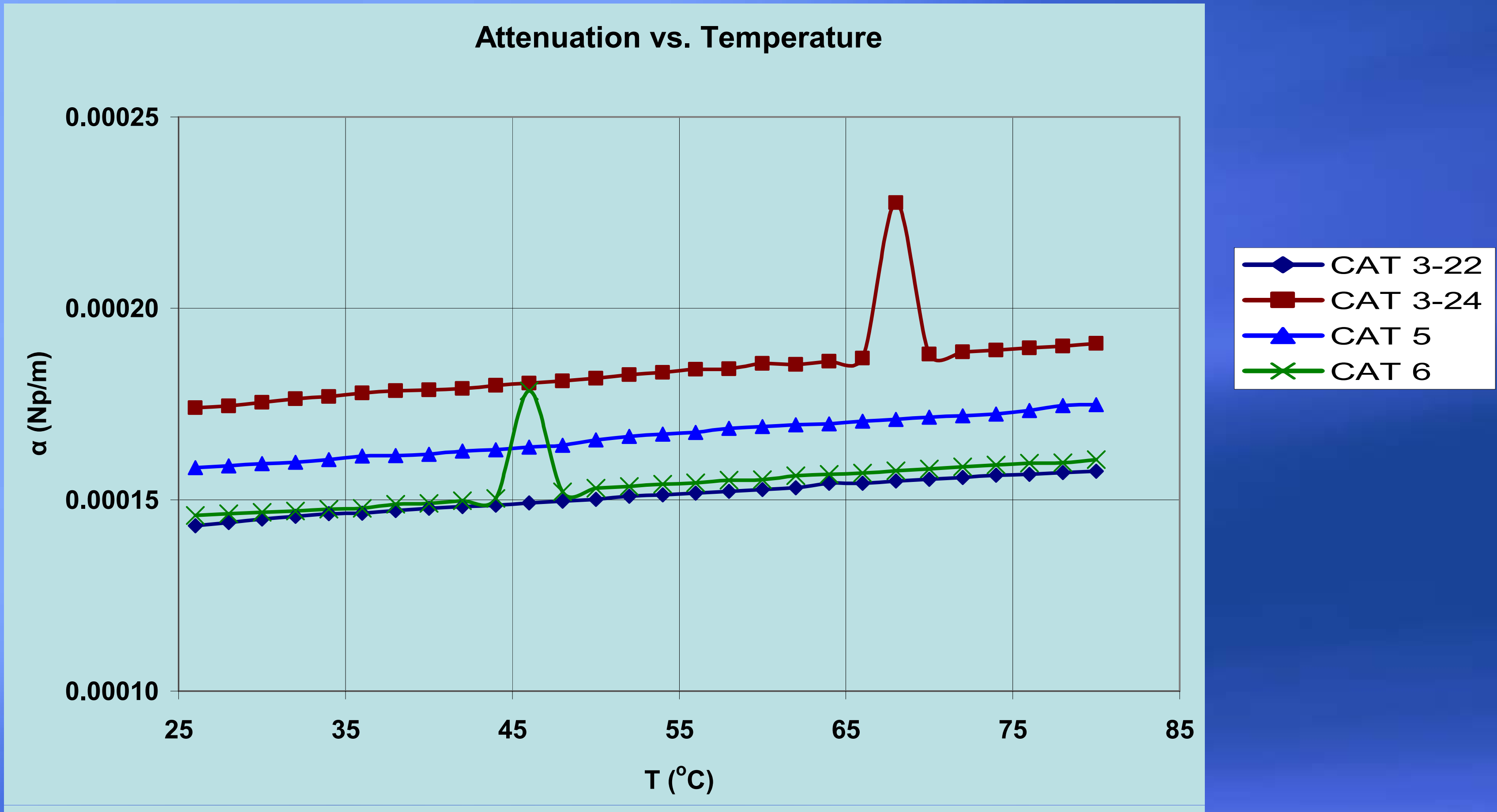
- Characteristic Impedance Angel (degree)



أرامكو السعودية
Saudi Aramco

Temperature Effect (7)

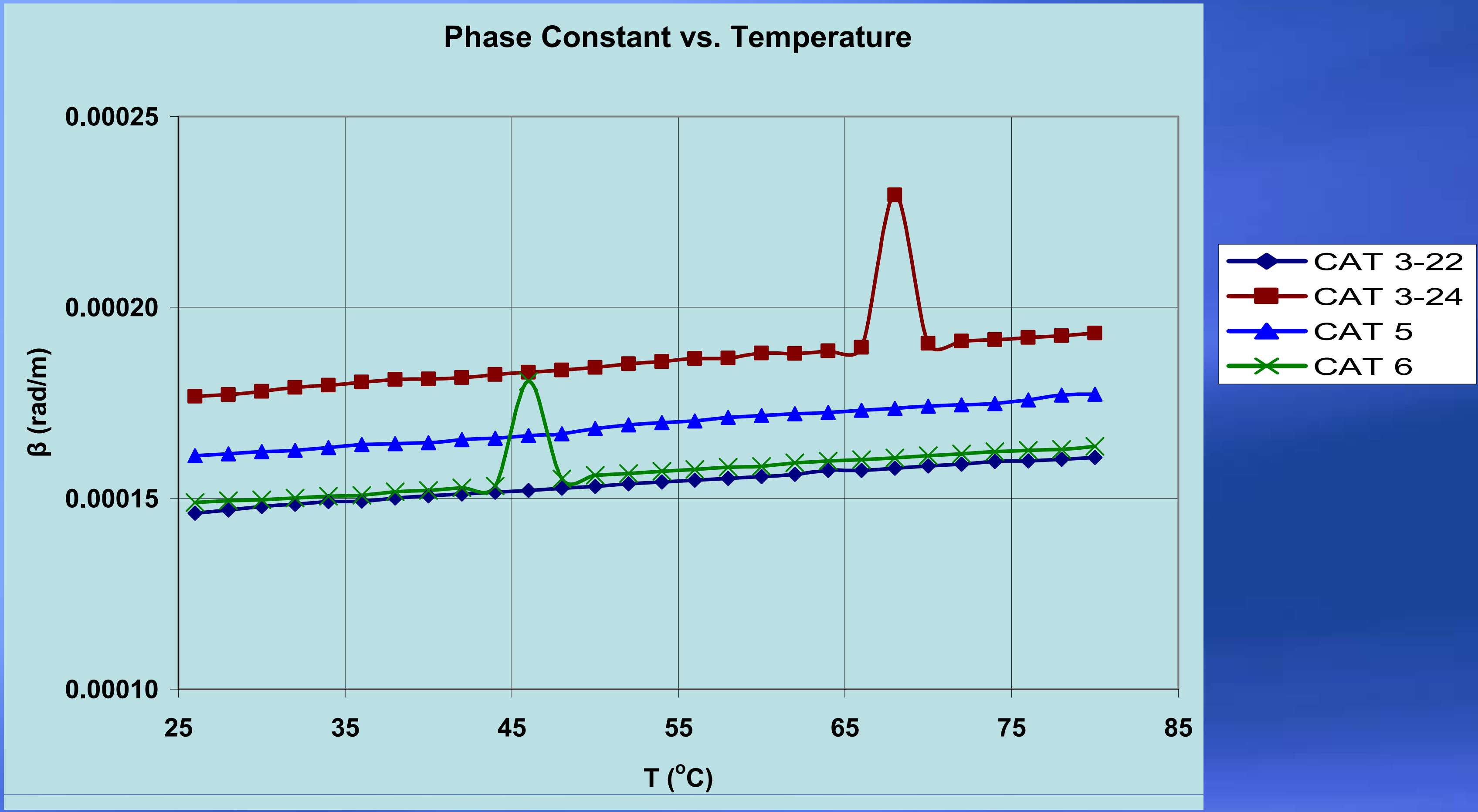
- Attenuation (Np/m)



أرامكو السعودية
Saudi Aramco

Temperature Effect (8)

➢ Phase Constant (rad/m)



أرامكو السعودية
Saudi Aramco

Temperature Effect (9)

➢ Summary of Temperature Effect

CAT		C (pF/m)	L (μH/m)	G (nS/m)	R (Ω/m)	$\lvert Z_0 \rvert$ (Ω)	Φ_o (deg)	α (Np/m)	β (rad/m)
3-22	max	63.02	0.52	3.846	0.1283	570.40	-43.85	0.0001575	0.0001607
	min	61.72	0.52	1.997	0.1079	527.59	-44.13	0.0001432	0.0001462
3-24*	max	52.98	0.54	1.010	0.3150	822.34	-44.39	0.0001908	0.0001932
	min	52.56	0.54	0.816	0.1846	744.74	-44.49	0.0001740	0.0001766
5	max	48.03	0.56	1.000	0.2056	825.98	-44.33	0.0001748	0.0001772
	min	47.40	0.56	0.865	0.1714	758.70	-44.42	0.0001584	0.0001612
6*	max	48.49	0.60	1.650	0.2133	753.00	-44.10	0.0001605	0.0001636
	min	47.60	0.60	0.873	0.1452	696.88	-44.29	0.0001459	0.0001489
General Trend		Constant	Constant	Decrease	Linearly Increase	Linearly Increase	Linearly Decrease	Linearly Increase	Linearly Increase

* Ignoring resonance values.

Outline

- Introduction
- Twisted Pair Modeling
- Experiments
- Temperature Effect
- **Conclusion**

Conclusion

1) Characteristic impedance increases linearly with temperature increase.

2a) The attenuation (in Np) increases linearly with temperature increase.

2b) The attenuation (in dB) increases logarithmically with temperature increase.

3) Temperature change → Resonance frequency change.

أرامكو السعودية
Saudi Aramco

Thanks

شكراً