DOE Office of Electricity TRAC

Peer Review

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

This presentation is covered by the following IP:
Title: Solid-State Power-Conversion System
Inventor: Sudip K Mazumder
Application No. 62/953,465 (Original Filing Date: December 24, 2019)
US Utility Patent Application and International PCT Application filed, Dec 2020
US Patent Application No. 17/134,178; PCT International Application PCT/US20/67047.

PROJECT SUMMARY

NEXT-GENERATION MODULAR FLEXIBLE LOW-COST SILICON CARBIDE (SIC)-BASED HIGH-FREQUENCY-LINK TRANSFORMER

Summary of the project goes here. The project research objectives are to provide an innovative design for a high-frequency-link (HFL) large power transformer (LPT) that is more flexible, lighter, and resilient than current 60-Hz LPT designs. Research efforts will focus on developing the lab scale HFL-LPT prototype that demonstrates proof-of-concept and performance evaluation. The project specific objectives include the following: a) Design, fabricate, and test a 100-kVA module for a three-phase 20 kHz HFL-LPT; and b) Demonstrate a cascaded multi-HFL-LPT for three-phase high-power operation.

PRINCIPAL INVESTIGATORS

Dr. Sudip K. Mazumder, President, NextWatt LLC

Dr. Juan Balda, Professor, University of Arkansas

WEBSITE

http://www.nextwattllc.com/

https://engineering.uark.edu/directory/index/uid/jbalda/name/Juan-Balda/

The Numbers

DOE PROGRAM OFFICE:
OE – Transformer Resilience and Advanced Components (TRAC)

FUNDING OPPORTUNITY:
DE-OE0000909

LOCATION:
Hoffman Estates, IL

PROJECT TERM:
09/23/2019 to 06/30/2022 (with NCE)

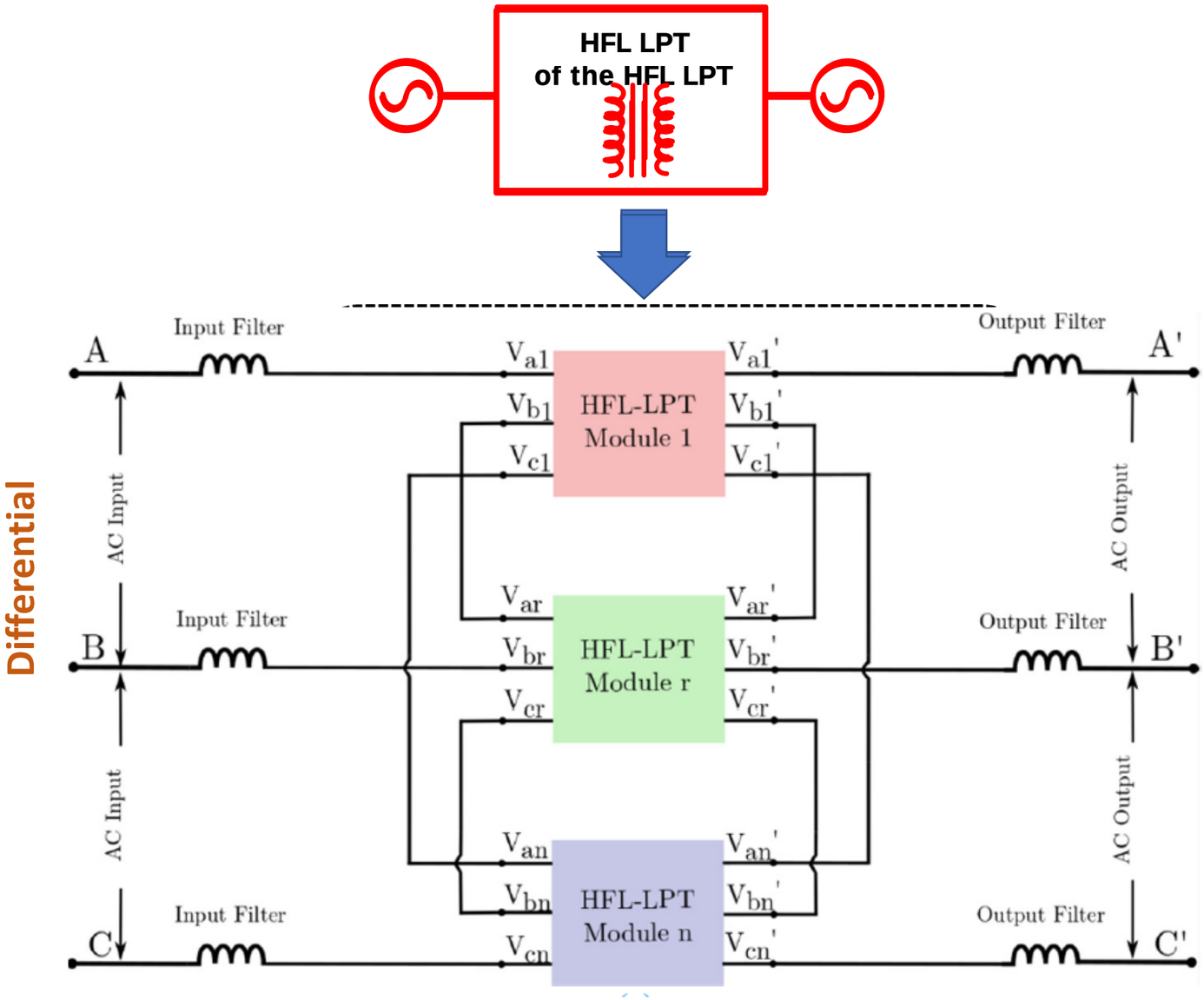
PROJECT STATUS:
Ongoing

AWARD AMOUNT (DOE CONTRIBUTION):
$1,499,545

AWARDEE CONTRIBUTION (COST SHARE):
$375,361

Primary Innovation

- True single-stage power conversion
- Reduced device count
- Integrated magnetics
- Soft switching (all ver. not shown)
- Up/down capability
- Input-output continuous
- EMI filtering reduced
- Multi-functional
- Modularly scalable (3x1ph; 3ph)



Impact/Commercialization

IMPACT:

- ❑ Operation of 20-kHz HFL-LPT module demonstrated with significantly lighter nanocrystalline- and integrated-magnetics based transformer compared to 60-Hz LPT approach and demonstrated with single stage compared to multi-stage HFL-LPT approach
- ❑ Peak efficiency of HFL-LPT module exceeding 97.5% demonstrated so far without customized SiC MOSFET modules
- ❑ Scaled-power HFL-LPT conducted, demonstrating modular operation. Rated-power three-phase HFL-LPT operation due in Feb'22

POTENTIAL PARTNERS:

Eaton, ABB, Silicon Power Corp., Open to licensing possibilities.

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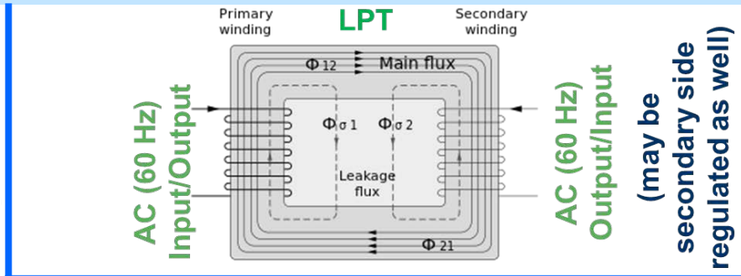
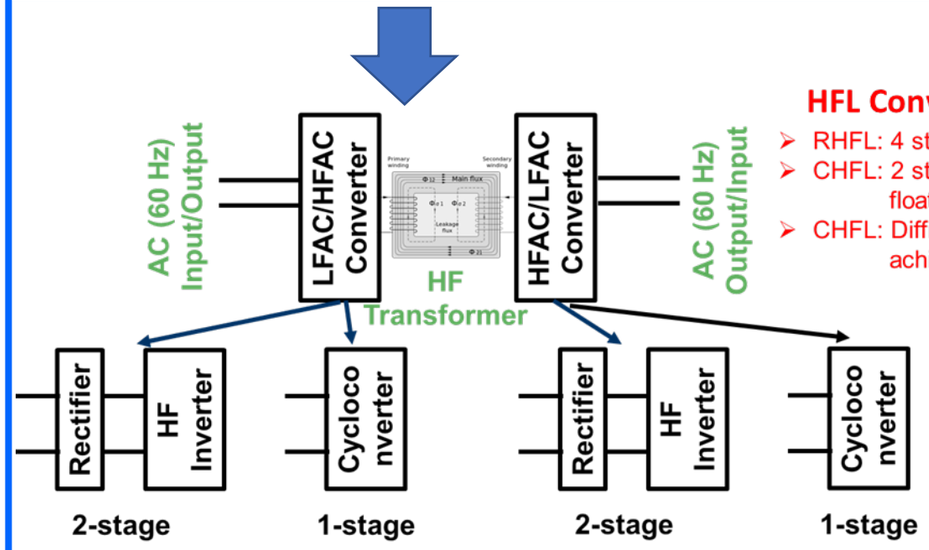


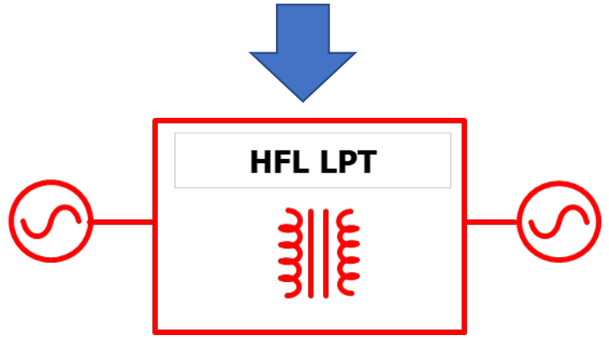
60-Hz Approach:

- Bulky transformer
- Material cost
- Logistics cost



HFL Conventional

- RHFL: 4 stages
- CHFL: 2 stages with 3 floating potentials
- CHFL: Difficult to achieve modularity



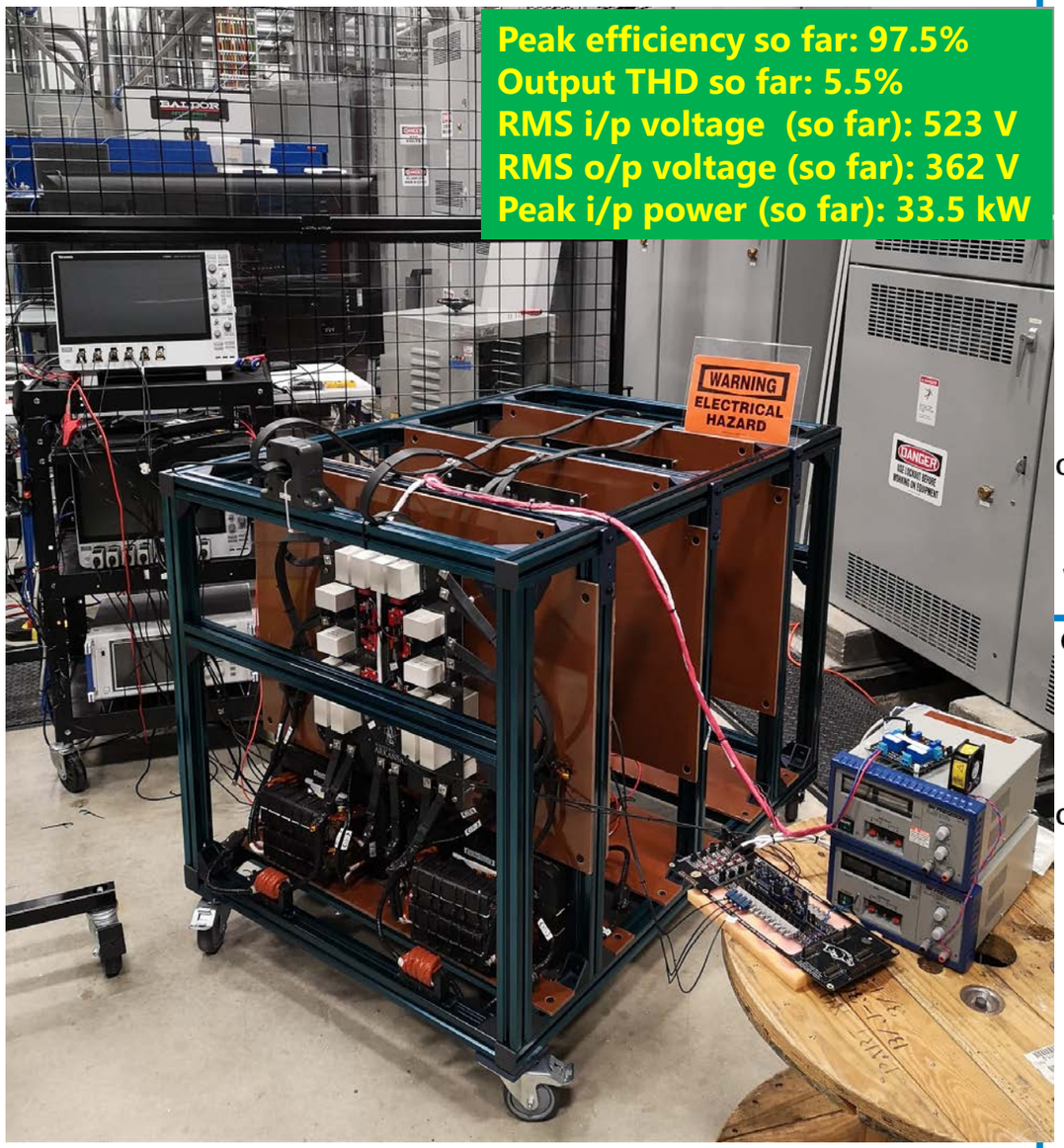
HFL Proposed

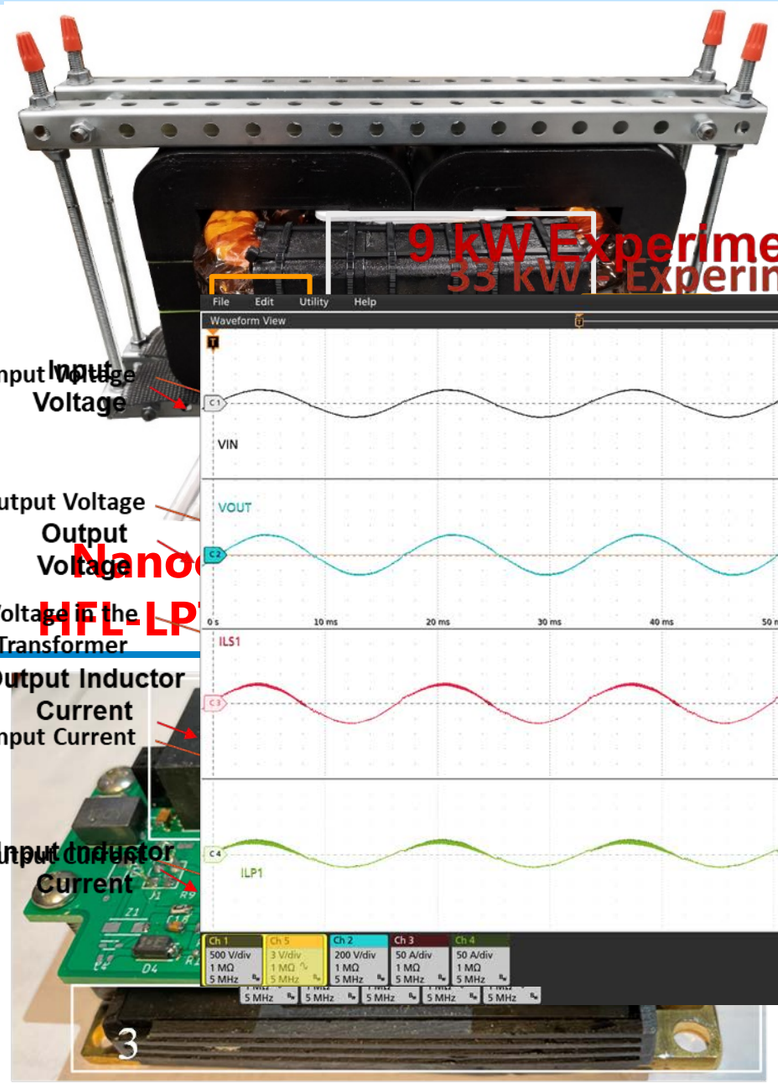
- Novelties outlined in slide 5
- Prototype in slide 8

Innovation Update

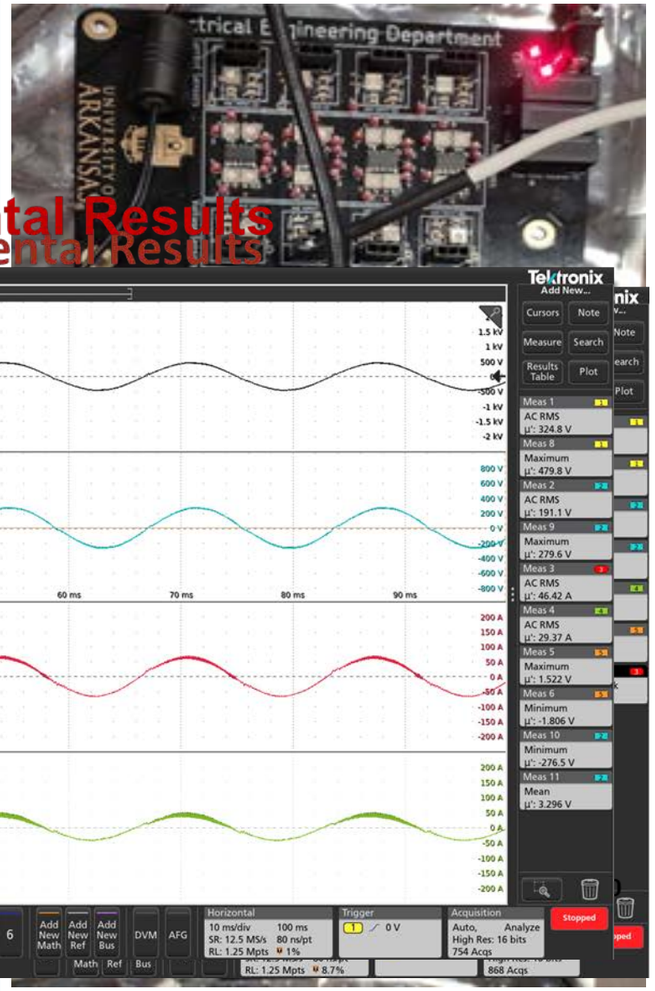
- US utility patent filed and international PCT application filed. Legal team feedback "…. the examiner has not found any publications so far that affect your novelty and obviousness in all 20 claims. This is wonderful news"
- Design, optimization, and fabrication of nanocrystalline-core based integrated magnetics (IM) completed (for the HFL-LPT), integrating the HF transformer and filter inductors
- Design and optimization of the HFL-LPT module SiC-FET-based power and DSP- and fiber-optics-based control stages completed
- Fabrication, testing, and characterization of an HFL-LPT module including power and control stages conducted and demonstrated
- Design, fabrication, testing, and characterization of additional HFL-LPT modules for a three-phase being carried out for demo in Feb'22
- Design, fabrication, testing, and characterization of a cascaded multilevel HFL-LPT using 2 HFL-LPT three phase modules to be demonstrated in June'22
- Delays incurred in the project are due to the following reasons: a) COVID-19; b) initial procurement delays and sustainable supply of 1.7 kV SiC FET modules but now a supply chain has been procured; c) HF nanocrystalline magnetic cores procurement

Video/Picture





SiC FET Gate Driver for HFL-LPT Module



Fiber-Optics and DSP-based HFL-LPT Module Controller

THANK YOU

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Table

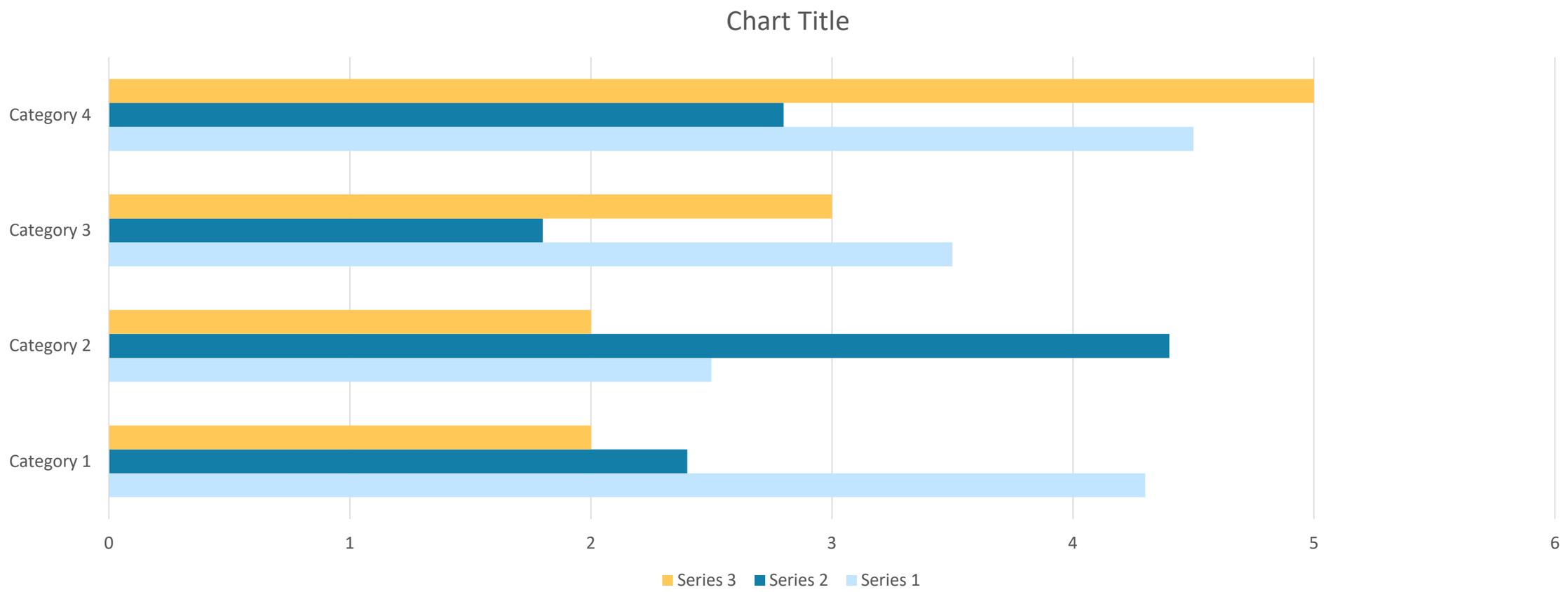

TABLE INFORMATION:
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Acronyms

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