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SERIES L: ENVIRONMENT AND ICTS, CLIMATE
CHANGE, E-WASTE, ENERGY EFFICIENCY;
CONSTRUCTION, INSTALLATION AND PROTECTION
OF CABLES AND OTHER ELEMENTS OF OUTSIDE
PLANT

Energy efficiency, smart energy and green data centres

**Q factor: A fundamental metric expressing
integrated circuit energy efficiency**

Recommendation ITU-T L.1318

ITU-T L-SERIES RECOMMENDATIONS

**ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION,
INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT**

OPTICAL FIBRE CABLES	
Cable structure and characteristics	L.100–L.124
Cable evaluation	L.125–L.149
Guidance and installation technique	L.150–L.199
OPTICAL INFRASTRUCTURES	
Infrastructure including node elements (except cables)	L.200–L.249
General aspects and network design	L.250–L.299
MAINTENANCE AND OPERATION	
Optical fibre cable maintenance	L.300–L.329
Infrastructure maintenance	L.330–L.349
Operation support and infrastructure management	L.350–L.379
Disaster management	L.380–L.399
PASSIVE OPTICAL DEVICES	L.400–L.429
MARINIZED TERRESTRIAL CABLES	L.430–L.449
E-WASTE AND CIRCULAR ECONOMY	L.1000–L.1199
POWER FEEDING AND ENERGY STORAGE	L.1200–L.1299
ENERGY EFFICIENCY, SMART ENERGY AND GREEN DATA CENTRES	L.1300–L.1399
ASSESSMENT METHODOLOGIES OF ICTS AND CO2 TRAJECTORIES	L.1400–L.1499
ADAPTATION TO CLIMATE CHANGE	L.1500–L.1599
CIRCULAR AND SUSTAINABLE CITIES AND COMMUNITIES	L.1600–L.1699
LOW COST SUSTAINABLE INFRASTRUCTURE	L.1700–L.1799

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T L.1318

Q factor: A fundamental metric expressing integrated circuit energy efficiency

Summary

Recommendation ITU-T L.1318 outlines a method and fundamental metric for expressing integrated circuit energy efficiency, the Q factor. The Q factor could be applied to measure and improve the integrated circuit technology behind information and communication technology itself.

The method consists of two separate parts:

- 1) Method and metric development;
- 2) Examples of Q factor scores for different integrated circuits and energy and carbon saving potentials in relation to Q factors.

History

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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Table of Contents

		Page
1	Scope	1
2	References.....	1
3	Definitions	1
	3.1 Terms defined elsewhere	1
	3.2 Terms defined in this Recommendation.....	1
4	Abbreviations and acronyms	1
5	Conventions	2
6	The framework or methodology — method and metric development	2
	6.1 The framework or methodology for Q factor	2
	6.2 The Q factor metric with examples of Q factor scores.....	3
	Appendix I – Challenges, feasible technologies and recent and ongoing work	4
	Appendix II – Carbon saving potential: energy and carbon saving potential relation to Q factor	5
	Appendix III – Example of governmental programme mandating energy efficient computers.....	7
	Appendix IV – Performance metrics for different semiconductor technologies and the corresponding electricity use	8
	Bibliography.....	10

Introduction

As [b-Lewis] describes, current computing technology is not sustainable, owing to the increased heat generation that accompanies the ever increasing capability of chips. The large number of such chips packed into a limited space makes cooling a major challenge, which will eventually become insurmountable. Therefore, it is likely that the trend of improved performance provided by increased power consumption is reaching its end, unless the relationship between performance and heat generation can be broken by new technological solutions. Energy-efficient computing, and reversible adiabatic¹ computing specifically, could be one of these solutions, as it would fulfil the need described by [b-Lewis] to reduce power consumption per unit of computation, potentially within the next ten years.

[b-Andrae] provides a comparison of the energy efficiency of reversible versus conventional computing: "If a traditional 180 W processor chip using 5 nm node ... would process the anticipated operations in 2030 with current transistor technology, an absurd amount of electricity will be used for computing. The same chip using reversible computing would use only 0.08 W." Appendix IV presents tables of performance metrics for different semiconductor technologies and the corresponding electricity use.

There are several ways in which the energy efficiency of integrated circuits (ICs) can be expressed. [b-Kenneth] proposed a Q factor based on radian frequency, electrical and magnetic energies stored in the IC, and the power dissipation from the IC. [b-Ionescu] proposed the E factor, an energy factor related to the state change in the field-effect transistors, dependent on physics, materials and voltages.

The focus of this Recommendation is the Q factor as a metric by which the energy efficiency of IC technologies can be measured. The Q factor described herein thus provides a way of establishing the energy efficiency of ICs, computing and information and communication technology (ICT).

¹ Adiabatic: Greek term for a "closed system", in contrast to the term diabatic for an "open system".