IMPROVED TESTING CHARACTERIZATION ON RADIO FREQUENCY CONNECTOR IN CALIBRATION SYSTEM

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DOCTOR OF PHILOSOPHY IN MANUFACTURING ENGINEERING

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**A thesis submitted
in fulfillment of the requirements for the degree of
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2021

DECLARATION

I declare that this thesis entitled "Improved Testing Characterization On Radio Frequency Connector In Calibration System" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : TAN MING HUI

Date : 05 July 2021

APPROVAL

I hereby declare that I have checked this thesis and in my opinion this thesis is adequate in terms of scope and quality for the award the degree of Doctor of Philosophy in Manufacturing Engineering.

Signature : ....

Supervisor Name : PM DR AHMAD YUSAIRI BANI HASHIM
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Date : 05 July 2021
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DEDICATION

To my beloved family.

ABSTRACT

For extending the dynamic range of measuring equipment, radio frequency connectors are found in a wide variety of electronic types of equipment. An important part of characterizing RF microwave circuits and devices required precision in S-parameters measurement. Variety type of dimension and frequency range can be found with RF connector. The main issue is the RF connector neglects the insertion loss causing an unknown error contributed to an RF system in calibration. The unknown insertion loss could create a phenomenon that triggered a false failure in the RF system. The objective of this study is to develop and calculate the Error normalize ratio for characterizing RF connectors, identify the unique RF connector characterization process and techniques associate with measurement uncertainty calculation by using the vector network analyzer, and integrate the power sensor calibration system with RF connector mismatch into the component of the calculation. This is to determine the methodology into several effective techniques of RF connector insertion loss, port match, measurement uncertainty, decision rule to a newly developed product specification in an RF manufacturing process into a power sensor calibration system as the final product to the end customer. In addition, the method applied in this study refers to the international requirements example ANSI/NCSL Z540.3 released in the year 2006, ISO/IEC 17025:2017 released in the year 2017, and ISO GUM (JCGM 100:2008) released in the year 2008 to meet the quality results. The expected outcome of this study would provide a summary of RF connector mismatch is extremely important to an RF measurement system that required extensive research by applying appropriate equipment in precision measurement.

PENAMBAHBAIKAN UJIAN PADA PENCIRIAN PENYAMBUNG RADIO FREKUENSI DALAM SISTEM PENENTUUKURAN

ABSTRAK

Radio Frekuensi terdapat pelbagai penyambung dalam jenis peralatan elektronik untuk memperluaskan julat dinamik mengukur peralatan. Pengukuran keperincian tepat adalah satu bahagian penting dalam mencirikan Radio Frekuensi dalam bidang gelombang mikro litar dan peranti elektronik memerlukan kejituan dalam pengurukan S-Parameter. Penyambung Radio Frekuensi boleh didapati dalam mana-mana jenis dimensi dan kekerapan julat frequensinya. Masalah utamanya ialah penyambung Radio Frekuensi ia tidak dapat dibaca kehilangannya terhadap julat frekuensi adalah punca utama kepada kegagalan dalam satu system Radio Frequensi. Objektif projek ini adalah untuk mewujudkan satu proses yang baru untuk mencirikan penyambung Radio Frekuensi menggunakan penganalisis rangkaian yang unik iaitu nisbah Error Normalize bersama dengan ketidakpastian dalam pengukuran yang dibaca oleh perkakas Vector Network Analyzer, menyatukan system kalibrasi pembaca kuasa dengan nisbah kehilangan penyambung Radio Frequensi. Untuk menentukan metodologi dalam cara yang tertentu untuk mengira kehilangan penyambung Radio Frequensi, ketidakpastian dalam pengukuran, peraturan keputusan spesifikasi diambil kira semasa pembuatan dalam sector perkilangan dalam system kalibrasi pembaca kuasa sebagai satu product yang akan disampaikan kepada pelanggan. Di samping itu, penganalisa ini juga merujuk kepada piawai antarabangsa seperti ANSI/NCSL Z540.3 diperkenalkan pada tahun 2006, ISO/IEC 17025:2017 diperkenalkan pada tahun 2017, dan ISO GUM (JCGM 100:2008) yang diperkenalkan pada tahun 2008 untuk mencapai tahap kualiti yang ditentukan. Pada akhir tesis ini akan mengemukan satu ringkasan membimbing terhadap kehilangan penyambung Radio Frequensi adalah sangat penting dalam satu system Radio Frequenci iaitu memerlukan kajian yang sangat perinci untuk menentukan kejituan dalam system kalibrasi.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Γ	-	Reflection Coefficient
$\Delta\emptyset$	-	Measured Phase Shift
ℓ	-	Length in Meter
c	-	Speed of Light
λ	-	Wavelength
$\mathcal{E}r$	-	Permeability
δLm	-	Correction To Mismatch Loss
δLk	-	Correction For Leakage For Signal Between Input And Output
δLr	-	Resolution of The Network Analyzer
Γ_g	-	Network Analyzer Directivity
Γ_d	-	Reflection Coefficient of DUT
Γ_s	-	Reflection Coefficient of Standard
δUs	-	Standard Uncertainty Contributor
δUd	-	Distribution Type Of Divisor
δUf	-	Sensitivity Coefficient
$\delta U(s)$	-	Standard Uncertainty Contributor
Zo	-	Impedance at Load
Ω	-	Ohm
∞	-	Infinity
S-Parameter	-	Scattering Parameter
kHz	-	kilo Hertz
MHz	-	Mega Hertz
GHz	-	Giga Hertz
VNA	-	Vector Network Analyzer
SOLT	-	short/open/load/thru
S_{11}	-	Port 1 Reflection Voltage (S_{11})

LIST OF SYMBOLS AND ABBREVIATIONS

S_{12}	-	Reverse Transmission (S_{12})
S_{21}	-	Forwards Transmission
S_{22}	-	Port 2 reflection voltage
RF	-	Radio Frequency
VSWR	-	Voltage Standing Wave Ratio
S1p	-	Single 1 Port
F2p	-	Full 2 Ports
E Cal	-	Electronic Calibration Kits
M Cal	-	Mechanical Calibration Kits
dB	-	Decibel
DC	-	Direct Current
f	-	Frequency
SNA	-	Scalar Network Analyzer
DUT	-	Device Under Test
PNA	-	Programable Network Analyzer
Zin	-	Input Impedance
Z_0	-	Output Impedance
TRL	-	Transmission Reflection and Loads
PTS	-	Proficiency Testing Scheme
ILC	-	Inter laboratory Comparisons
PT	-	Proficiency Testing

LIST OF SYMBOLS AND ABBREVIATIONS

EN Ratio	-	Error Normalize Ratio
0_{s21}	-	Offset S_{21}
0_{s12}	-	Offset S_{12}
A_{s21}	-	RF connector S_{21} Loss
A_{s12}	-	RF connector S_{12} Loss
SI Units	-	International System of Units
OQI	-	Output Quality Investigation
IF	-	Intermediate Frequency
BW	-	Bandwidths
OEM	-	Original Equipment Manufacturer
UUC	-	Unit Under Calibration
TAR	-	Test Accuracy Ratio
TUR	-	Test Uncertainty Ratio