Sudan University of Science and Technology

College of Graduate Studies

A Proposed Design for an Optical Fiber Link for SUST

مقترح لتصميم ربط بالالياف الضوئية لجامعة السودان للعلوم والتكنولوجيا

A Dissertation Submitted in Partial Fulfillment for the Degree of MSc. In Electronics Engineering (Communication)

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الآيـةُ

الحمد لله ، رب خلق الكون وسخَّره للكائنات وخص الانسان بنعمة العقل كى يستخدمه فى التأمل والتفكير ، وجعل كل ذلك عمقا عقائديا لمعنى التسبيح:﴿ سُبْحَانَ الَّذِى سَخَّرَ لَنَا هَذَا وَمَاكُنَّا لَهُ مُقْرِنِينَ ﴾ {الزخرف 13}. ﴿ٱلَّذِينَ يَذْكُرونَ ٱللهَ قِيَاماً وَقُعُوداً وَعَلَى جُنُوبِهِمْ وَيَتَفَكَّرُونَ فِى خَلْقِ ٱلسَّمَاوَاتِ وَالأَرْضِ رَبَّنَا مَا خَلَقْتَ هَذَا بَاطِلاً سُبْحَانَكَ فَقِنَا عَذَابَ ٱلنَّارِ﴾ {آل عمران 191} وصلى الله وسلم وبارك على معلم البشريه ورافع راية التوحيد سيد الخلق وعلى آله وصحبه أجمعين.

DEDICATION

To the permanent residents of my heart and my mind.

To my mother, my father and my family.

To all our friends and all who made this project come true.

This thesis is totally dedicated to you.

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I wish to express my true thanks, first of all, to ALLAH (SWT) who helped, supported, and guided me by every mean during the stages of this work.

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ABSTRACT

In this thesis optical fiber links have been proposed between the Western campus, the Southern campus and the Northern campus of SUST.

The link distance between the Southern campus and Western campus is 6 kilometers and between Western campus and Northern campus is 9.5 kilometers.

The components have been selected to support the application of the link which is to transmit video, audio, and data at 622 M b/s and with a BER of 10^{-9} using NRZ code without repeaters.

The suitable components are found to be a Laser with 1300nm operating wavelength, a PIN photodiode with a sensitivity of -33dBm, and a 9.3/125μm single mode fiber with attenuation of 0.5dB/km.

The link was proposed applying both link power budget and rise time budget concepts. The route for both links is also proposed.

مستخلص

فى هذه الدراسة أقترح ربط بالألياف الضوئية بين الجناح الغربى وكل من الجناح الجنوبى والجناح الشمالى لجامعة السودان للعلوم والتكنولوجيا.

مسافة الربط بين الجناح الغربى والجناح الجنوبى هى 6 كلم و بين الجناح الغربى والجناح الشمالى هى 9.5 كلم .

تم اختيار العناصر التى تدعم تطبيقات الربط والتى هى ارسال الفيديو والصوت والبيانات بمعدل 622Mb/s وبمعدل خطأ 10^{-9} مستخدمين الترميز (NRZ) بدون معيدات.

وجد ان العناصر المناسبة هى ليزر يعمل بطول موجى 1300nm وكاشف ضوئى PIN بحساسية -33dBm و ليف وحيد النمط (9.3/125) وبفقد 0.5dB/km.

تم تطبيق كل من مفهوم ميزانية القدرة وميزانية زمن الصعود على الربط المقترح. أيضا تم اقتراح المسار لكلا الربطين.

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LIST OF ABBREVIATIONS AND SYMBOLS

Al	Aluminum.
APD	Avalanche Photo Diode.
As	Arsenide.
A/W	Amperes per Watt.
ATM	Asynchronous Transfer Mode.
BER	Bit Error Rate.
BR	Bit Rate (bit/s).
B.L	Bit rate–distance product.
BW.L	The bandwidth-length product for modal dispersion in MHz.Km.
dB	Decibel.
dBm	Decibel relative to 1 mili watt.
DIP	Dual Inline Package.
DFB	Distribute Feed Back.
ELED	Edge-Emitting Light Emitting Diode.
FDDI	Distributed Data Interface.
F/O	Fiber Optic.
FSK	Frequency Shift Keying.
FWHP	Full Wave at Half Power.
Ge	Germanium.

GRIN	Graded Index fiber.
GVD	Group-Velocity Dispersion.
In	Indium.
ISDN	Integrated Service Digital Network.
km/s	Kilometer per second.
LAN	Local Area Network.
LASER	Light Amplification by the Stimulated Emission of radiation.
LED	Light Emitting Diode.
LD	Laser Diode.
MAN	Metropolitan-Area Network.
Mb/s	Mega bit per second.
MMF	Multi-Mode Fiber.
NA	Numerical Aperture.
NRZ	Non Return to Zero.
nm	Nanometer.
OTDR	Optical Time Domain Reflectometer.
OD	Outer Diameter.
P	Phosphide.
POF	Plastic Optical Fiber.
PPM	Pulse Position Modulation.
PCS	Plastic clad silica.
PSK	Phase Shift Keying.
PIN	Positive-Intrinsic-Negative.
P-N	Positive-Negative.
RZ	Return to Zero code format.
Si	Silicon.
SI	Step Index fiber.

SLD	Super Luminescent Diode.
SLED	Surface- Emitting Light Emitting Diode.
SMF	Single Mode Fiber.
SNR	Signal to Noise Ratio.
SUST	Sudan University of Science and Technology.
SFF	Small Form Factor.
TIR	Total Internal Reflection.
VCSEL	Vertical – Cavity Surface-Emitting Laser.
WDM	Wave Division Multiplexing.
C_L	Is the total channel loss
M	The multiplication factor.
v	Velocity.
s	Second.
f	Frequency.
h	Planck's constant.
M_s	Is the system margin.
L	The installation length in Km.
D	The chromatic dispersion parameter in ns/nm.Km.
E_g	Is the energy bandgap.
I_d	The dark current.
T_{mod}	The rise time in ns caused by modal dispersion.
T_{GVD}	The chromatic rise time in ns.
T_{sys}	The system rise time.
T_{tr}	Transmitter's rise time.

T_{re}	Receiver's rise time.
T_{fiber}	Fiber rise time.
R	Responsivity.
α	index profile parameter.
α_{dB}	Attenuation of the fiber per unit length.
α_f	Is the net loss (in dB/km) of the fiber cable.
α_{splice}	The splices loss.
α_{con}	The connectors loss.
P_{in}	The mean input optical power launched into the fiber.
P_{out}	Is the mean incident optical power required at the receiver.
P_{RS}	Receiver sensitivity.
B_{max}	Maximum bit rate in Mbps.
σ_T	Is the total rms pulse broadening.
σ_c	Is the intramodal broadening.
η	Quantum efficiency.
Δf	The bandwidth in MHz.
λ	The operating wavelength.
$\Delta\lambda$	The spectral width.