Center for Embedded Systems
An NSF Industry/University Cooperative Research Center

All-optical embedded fiber-optic up/down-links for motor controller

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Project Overview and Description

- ## Project Description

Design of all-optical bi-directional linkage of the power switches (PS) and sensors which are embedded in a harsh environment (125^{o}c) to the control/gate drives (CD) electronics in a benign environment (70^{o}c).

Gate Drive Requirement	
Von	20v
Voff	-5v
Drive Power	1w
Peak Gate current	3A
Drive frequency	100 kHz
Min max duty cycle	5%-95%
Ambient temp	-55C 125C

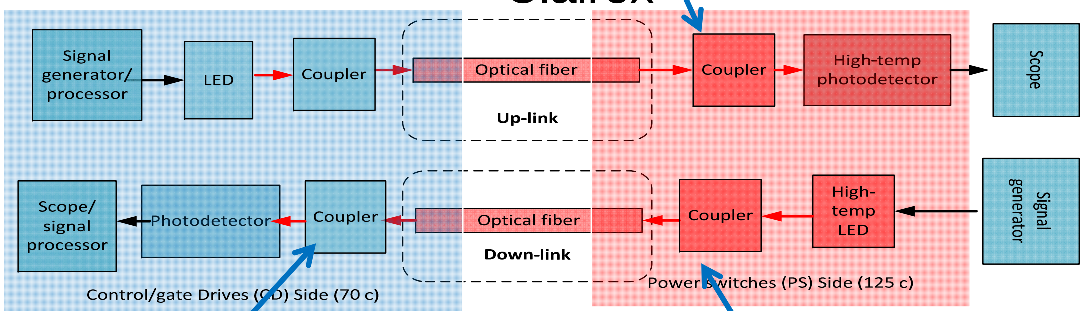
Current Sensor Requirement	
Max Amplitude	300 A
Frequency	200 kHz
dI/dt	100 A/us
Ambient Temperature	-55C 125C

Voltage Sensor Requirement	
Max Amplitude	1000 V
Frequency	10 kHz
dv/dt	1000 V/uS
Ambient Temperature	-55C 125C

Approach

- Implementation of optical links connecting the Control Drives (CD) plate to the Power Switches (PS) plate through the typical light sources (LEDs) located in CD side and the high-temperature photodetectors located in PS side .
- Implementation of the optical down-links from the harsh environment through the high-temperature LEDs to the benign environment (CD side) via photodetectors.

CLD156
Clairex



ClearCurve® Multimode Mid-Temperature
Corning

CLE330-335W
Clairex

Project Status

- **Phase I:**
- **Study the existing off-the-shelf optical components for the up-link. - done**

- **Study the existing off-the-shelf optical components for the down-link. - done**

- **Prepare a proposal for a follow-up project to address an architecture of the optical uplink and downlink. – done**

- **Phase II:**
- **Design, build, and test the up-link and down-link according to the industry specifications. If needed, apply the back-error propagation network for reduce the unwanted disturbances. – planned**

Project Tasks/ Deliverables

	Tasks Description	Date	Status
1	Design the up-link according to the industry specifications.	Aug. – Dec. 2013	planned
2	Build the up-link where the detector is in the harsh environment.	Aug. – Dec. 2013	planned
3	Test the up-link for noise and nonlinearity. If needed, apply the back-error propagation network for reduce the unwanted disturbances.	Jan. – March 2014	planned
4	Design the down-link according to the industry specifications.	April – May 2014	planned
5	Build the down-link where the LED is in the harsh environment.	June – July 2014	planned
6	Test the down-link for noise and nonlinearity. If needed, apply the back-error propagation network for reduce the unwanted disturbances.	August 2014	Planned
7	Report	August 2014	Planned

- **Deliverables: A report with the detail design, build, and test results of the fiber-optic links will be given.**

Executive Summary

- This project is to design, build, and test an all-optical bi-directional embedded linkage for the power switches (PS) and sensors which are placed in a harsh environment to the control/gate drives (CD) electronics in a benign environment.

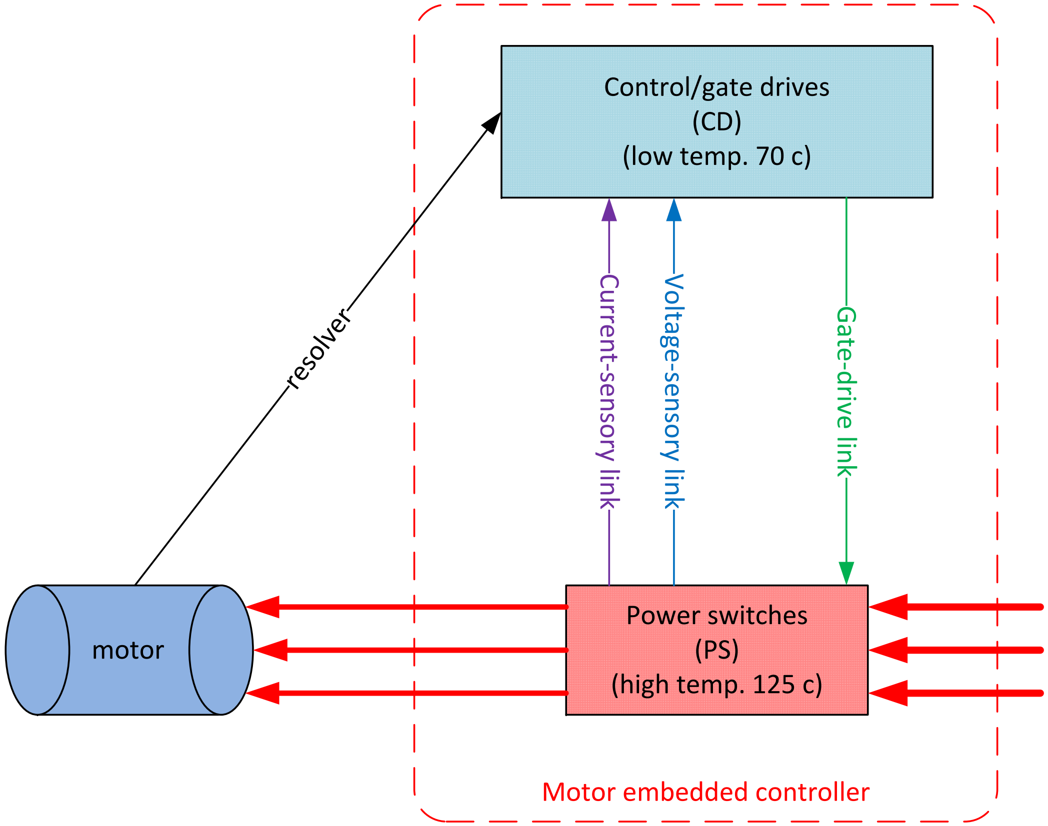
- The optical isolation of the high-temperature power switches from the control/gate drives will enhance the performance and cost-effectiveness of the state-of-the-art high power motors. The embedded optical links will provide a high-temperature tolerant, EM interference free, and light-weight linkage.

- High-temperature (< 225^{o}c) AlGaAs photodiodes are used to convert the optical signal to electrical one.

- To convert the sensory data to the optical form, a GaAlAs high-temperature (<125^{o}c) LED is directly modulated.

Technical Detail

Motor Controller



High Temperature Photodiode

Absolute Maximum Rating

(TA = 25°C unless otherwise stated)
storage temperature .... -65°C to +250°C
operating temperature .... -65°C to +225°C
lead soldering temperature(1) ....260°C
reverse voltage 10V
continuous power dissipation(2)... 250mW

Electrical Characteristics

electrical characteristics at T_A = 25°C (unless otherwise noted)

symbol	parameter	min	typ	max	units	test conditions
I_{SC}	Short-circuit current[3]	2.0	3.5	-	µA	V_{BIAS} = 0V, E_e = 1mW/cm^2
I_D	Dark current	-	0.1	1.0	nA	V_R = 5V, E_e = 0
R_S	Shunt resistance	-	3000	-	Meg.Ω	V_R = 10mV
V_{BR}	Reverse breakdown	20	-	-	V	I_R = 10µA
C_j	Junction capacitance	-	170	-	pF	V_{BIAS} = 0, f = 1MHz
Θ_{HP}	Total angle at half sensitivity points	-	70	-	deg.	
t_r, t_f	Output rise and fall time[3]	-	1.0	-	µs	R_L = 50Ω, V_R = 5V

note: 3. Radiation source is an aluminum gallium arsenide IRED with a peak emission wavelength of 850nm.

Technical Detail

High Temperature LED

Absolute Maximum Rating

SYMBOL	PARAMETER	MIN	MAX	UNITS
P_d	Power Dissipation		200	mW
I_f	Continuous Forward Current		100	mA
I_p	Peak Forward Current		2.5	A
V_r	Reverse Voltage		2	V
T_{STG}	Storage Temperature	-55	+125	°C
T_O	Operating Temperature	-55	+125	°C
T_S	Soldering Temperature*		+240	°C

Electro Optical Characteristics

SYMBOL	CHARACTERISTIC	TEST CONDITIONS	MIN	TYP	MAX	UNITS
P_o	Output Power	I_f = 100 mA	2.2	2.7		mW
V_f	Forward Voltage	I_f = 100 mA		1.7	2.2	V
V_r	Reverse Breakdown Voltage	I_f = 10 μA	2.0			V
λ_p	Peak Wavelength	I_f = 20 mA	830	850	870	nm
$\Delta\lambda$	Spectral Bandwidth @ 50% (FWHM)	I_f = 20 mA		35		nm
C_t	Terminal Capacitance	V_r = 0V, f = 1MHz		68		pF
t_r	Rise Time	I_f = 20 mA		15		nS
t_f	Fall Time	I_f = 20 mA		15		nS