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～ Ultra-low Jitter of 1ps rms or less ～

RF Reference Signal Transmission System

For J-PARC Linac and SuperKEKB

Ultra-low Jitter RF Reference Signal
Optical link System

WSL-1 (Laser Source)　*WRM-2* (O/E Receiver)

Enable to NIM
Standard Compatible

Installation record: KEK and others

■Overview

In J - PARC proton linac, 972 MHz RF reference signal is distributed to Klystron driving stations by optical fiber transmission.
In the accelerated electric field (972 MHz), the phase deviation should be ± 1 ° or less and the amplitude fluctuation should be ± 1% or less. In 300 m of the linac, 60 Klystron driving stations are installed, so the RF reference signal requires super high stability.
The phase deviation from station to station should be ± 0.3 ° or less (about ± 0.9 ps) at 972 MHz).
The optical components (E/O Module and O/E Module) for the transmission devices, which Graviton has developed, provide excellent temperature characteristics and ultra-low jitter, in addition to clearing such a strict phase deviation requirement.

【Key Feature】

●A Butterfly DFB Laser Diode with built-in Peltier is mounted

WSL-1 Transmitter (1 output channel)

W430mm、D260、H44
(EIA-1U)

WSL-16 Transmitter (出力16ch)

●16 output channel version of WSL-1 (by branch coupler)

W430mm、D360、H88
(EIA-2U)

【Key Feature】

●WRM-2(3Gbps O/E Receiver Module)

WRM-2 Receiver

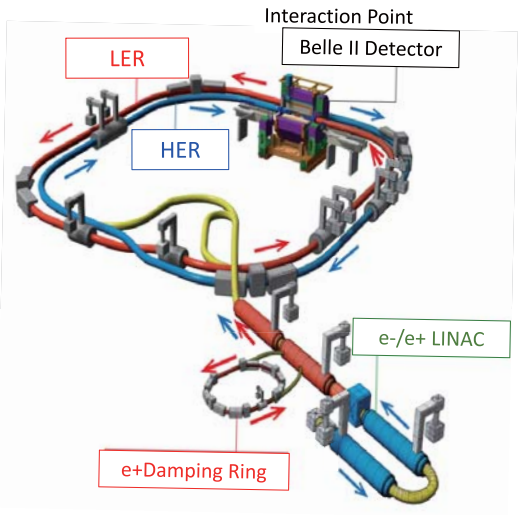
O/E conversion by digitalizing with a transimedance amplifier and a limiting amplifier

Peltier can be optionally mounted, contact Graviton for details.

J-PARC (Japan Proton Accelerator Research Complex)

J-PARC consists of multiple proton accelerators and experimental facilities for a wide range of research purpose including proton particle and nuclear physics, materials and life science, and nuclear technology.

© KEK (Kou Enerugii Kasokuki Kenkyū Kikō)
High Energy Accelerator Research Organization



This image is provided by KEK.

～ 26th anniversary ～
Graviton

KEK-JAPAN
High Energy Accelerator Research_Organization

WSL-1(Laser Source) / WRM-2(O/E Receiver)

■WSL-1 (Wavelength Stabilized Laser Source)

WSL-1 is a Laser source with wave-length stabilization and modulation function.

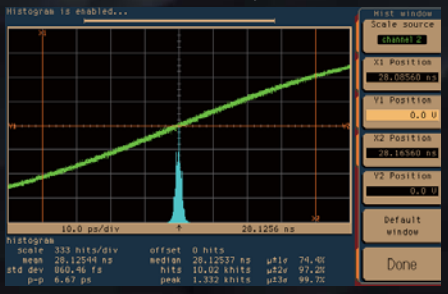
A DFB Laser diode with Peltier is mounted: Direct modulation by Laser drive current modulation is employed: The internal circuit of the device shapes waveform into square wave: Ultra-low jitter is provided.

■WRM-2 (O/E Receiver Module)

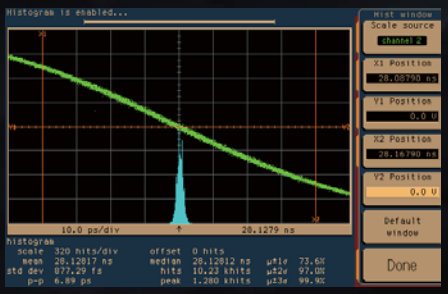
WRM-2 is the O/E Receiver module, which mounts a transimpedance amplifier and a limiting amplifier to digitalize.

■Using a combination of WRM-2 and WSL-1 provides ultra-low jitter of 1ps or less (See the example).

■Measurements of jitter when modulated with 960MHz



Rising of the jitter from the non-inverting output terminal when inputting 960MHz modulation light RMS jitter: 860fs (including the measuring system jitter of 746fs)



Falling of the jitter from the non-inverting output terminal when inputting 960MHz modulation light RMS jitter: 877fs (including the measuring system jitter of 741fs)

■ WSL-1 Specification

Item	Description	Remark
Model name	WSL-1	
Function	Wavelength stabilized Laser source with modulation function	
Light emitting element	Butterfly package DFB Laser module with Peltier	
Wavelength	1550nm	
Emission spectrum bandwidth	10MHz	
Wavelength stability	±0.1nm or less	
Number of emitting device	1	
Number of optical output channel	1 channel	
Optical output level	0dBm	
Compatible optical fiber	Single-mode quartz optical fiber	
Optical output connector	FC receptacle on the front panel	
Light intensity modulation	Direct modulation by Laser drive current modulation	Shaping waveform to square wave by the internal circuit of the device
Modulation rise time	200ps or less (10%-90%)	
Frequency modulation bandwidth	100kHz to 2GHz	
Modulation input level	800mVp-p(Recommended) (100mVp-p to 1Vp-p)	
Modulation input impedance	50Ω 0V(Terminator) , AC coupling	
Modulation input connector	SMA receptacle on the front panel	
Polarity of modulation signal	Light intensity increases at a falling of the voltage of the modulation input signal and it decreases at a rising of the voltage.	
Extinction ratio of optical modulation	7dB or greater (modulated by Pseudo Random Binary Sequence (PRBS) with 2.5Gbps)	
Laser output stabilization	Controlling the drive current of the LD by feeding back the current monitored from the	
Modulated signal monitoring	The output terminal to send the monitor signal to external device, after shaping the waveform of the input signal from the modulation input terminal.	If not used, use 50 Ω terminator to terminate.
Polarity of modulation signal	Opposite phase to modulation input signal	
Output impedance of modulation monitor signal	50Ω , AC coupling	
Output level of modulation monitor signal	400mVp-p or greater	
Output connector of modulation monitor signal	SMA receptacle on the front panel	
Temperature controlling of Laser	Double Peltier system by controlling the feed-back from thermistor and Peltier built in the LD module and the temperature of the entire LD module	
Setting temperature to Laser	30 ℃	
Controllable ambience temperature	20 ℃ to 40 ℃	
Supply voltage and current	AV100V, Max 500mA	
Dimensions	430mm(W)x260mm(D)x44mm(H) for EIA -1U	Excluding protruding parts, such as

■ WSL-2 Specification

Item	Description	Remark
Model name	WRM-2	
Function	3Gbps O/E Receiver module	
Light-receiving element	InGaAs PIN photodiode	
Rated wavelength of receiving light	1550nm	
Wavelength range of receiving light	1000nm to 1650nm	
Level of receiving light	+1dBm to -20dBm	-3dBm as standard
Number of light-receiving element	1	
Compatible optical fiber	Single-mode quartz optical fiber	
Optical input connector	Pigtail connector with FC plug, 1m length	
O/E conversion	Digitalizing by a transimpedance amplifier and a limiting amplifier	
Convertible frequency bandwidth	100kHz to 2GHz	Dduty cycle : 50%
Signal Output level	400mVp-p	5Ωtermination
Rise time of output signal	200ps or less (10% to 90%)	
Conversion input impedance	50Ω 0V(Terminator) , AC coupling	
Number of channel to output converted signal	2 channels	Two outputs are in opposite phase
Output connector of conversion signal	SMB type receptacle	
Supply voltage	+5V	
Supply current	150mA or less	
Dimensions of OE module	42mm(W)x35mm(D)x15mm(H)	Excluding protruding parts, such as screws and connectors, etc.

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～ Ultra-low Jitter of 1ps rms or less ～

RF Reference Transmission System

For J-PARC Linac and SuperKEKB

Ultra-low Jitter RF Reference Signal
Optical link System

WSM-NIM-1

(Wavelength Stabilized Laser Module)

WRU-NIM-1

(3Gbps O/E Receiver Unit with Pertie)

Enable to NIM Standard Compatible

Installation record: KEK and others

■ Overview

In J-PARC proton linac, 972MHz RF reference signal is distributed to Klystron driving stations by optical fiber transmission. In accelerated electric field (972MHz), the RF reference signal requires super high stability: the phase deviation should be ±1° or less and the amplitude fluctuation should be ±1% or less. In 300m of the linac, 60 Klystron driving stations are installed, the transmission devices require the strict specification: the phase deviation from station to station should be ±0.3° or less (about ±0.9ps at 972MHz).

J-PARC (Japan Proton Accelerator Research Complex) consists of multiple proton accelerators and experimental facilities for a wide range of research purpose including proton particle and nuclear physics, materials and life science, and nuclear technology.

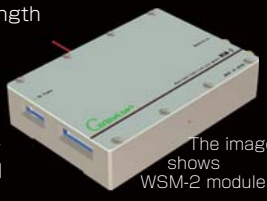
"KEK has decided to use the optical transmission devices (O/E and E/O) which has been developed for use in J-PARC linac to SuperKEKB.
The optical transmission devices provide the critical specifications required to transmit RF reference signal: keeping the temperature stability by built-in Peltier: controlling the changes of optical intensity and extinction ratio by shaping pulse waveform."
-Reference from "Proceedings of the 10th Annual Meeting of Particle Accelerator Society of Japan (August 3-5, 2013, Nagoya, Japan) SUP094 _ P.1161-1162."

NIM (Nuclear Instrument Modules) standard conforms to "Radiation Measurement Module Standard TID - 20893" established in the 1960's at the US Atomic Energy Commission (AEC).

WSM-NIM-1 (O/E) and WRU-NIM-1 (E/O) are the NIM compatible devices, featuring highly stable temperature characteristics and ultra-low jitter.

【Key Feature】: Wavelength Stabilized Laser Module

NIM standard compatible WSM-NIM-1 is the wavelength stabilized Laser module,
which equips Graviton's WSM-2 E/O module.
WSM-2 E/O module has been developed as the light emitting module of the device to distribute RF reference signal to the accelerated cavity in the linac.Ultra-low jitter can be obtained by using a combination of E/O module WSM-MIN-1 and O/E module WRU-NIM-1.

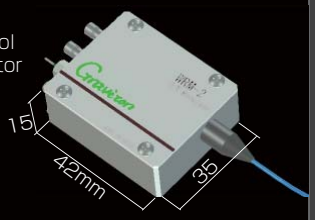


The image shows WSM-2 module.

Light emitting element: Butterfly DFB Laser Diode with built-in Peltier
Wavelength stabilization: Feeding back the monitored current from the built-in PD in the LD to the Laser driving current
Modulated signal monitoring: The output terminal to send the monitor signal to external device, after shaping the waveform of the input signal from the modulation input terminal

【Key Feature】: 3Gbps O/E Receiver Module with Pertie

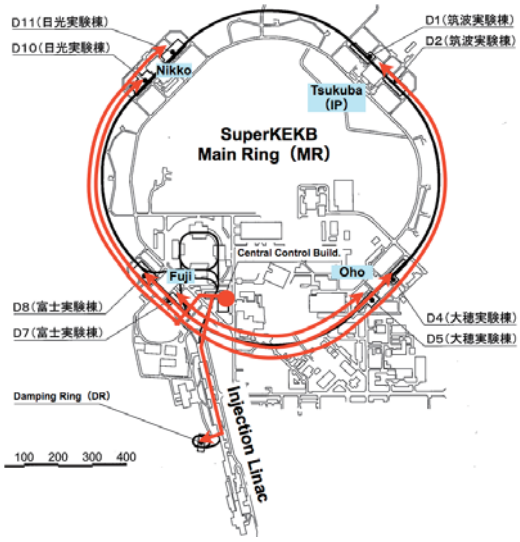
Light-receiving element: InGaAs PIN photodiode
Temperature controlling: Analog PID servo control using a Peltier element and a thermistor
Wavelength range of receiving light: 1000nm to 1650nm
Level of receiving light: +1dBm to -20dBm
O/E conversion: Digitalizing by a transimedance amplifier and a limiting amplifier



The image shows WRU-2 module.

SuperKEKB RF reference signal transmission route in SuperKEKB

The image is provided by KEK.



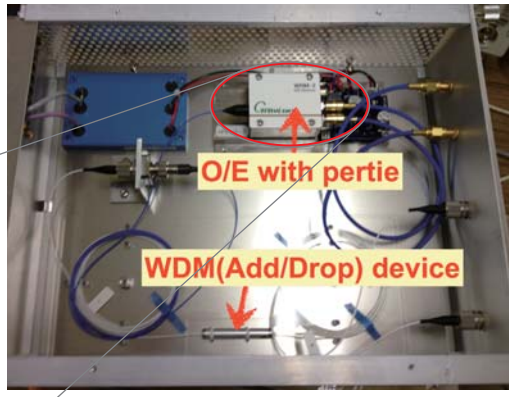


Photo of the low-noise E/O unit equipped with thermal stabilizer and the WDM device, which are assembled as a NIM module.

～ Anniversary 26th ～

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