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Errata Notice

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Getting Started with the Centellax TR1C1-A Clock Recovery Unit (CRU)

Unpacking and Installation

The TR1C1-A CRU is shipped with the following:

- TR1C1-A Clock Recovery Unit
- AC power converter module
- AC power cord
- TR1C1-A Users Guide

Important Notes

- Use ESD protection at all times when using the instrument.
- Observe min/max specifications when applying input signals.
- Use only 2.92mm or equivalent connectors to avoid damaging the female center pins.

Performance Recommendations

- When using differential-mode connections, ensure the cables are phase balanced.
- Use a 8in-lbs torque wrench when attaching connectors.

Support and Warranty

Contact support@centellax.com for product support or warranty information, or see the TR1C1-A product library at the Centellax website:
http://www.centellax.com/products/testmeas/TR1C1-A.shtml

1. Connect the hardware

- Connect power cord to adaptor to TR1C1-A; plug in the power cord.
- Connect inputs and outputs following standard ESD precautions.

2. Turn on the hardware

- Verify that front panel push button is not depressed – this will cause the unit to perform a calibration (during calibration, all input signals must be removed).
- Turn on the power switch from the back panel.
- Calibration is not typically required for most applications.

3. Verify signal and clock

- The Signal LED will indicate the presence of a signal and initiate the auto lock sequence.
- The Lock LED will indicate when the CRU is locked and the clock signal is valid.

TR1C1-A: Clock Recovery Unit (CRU) Users Guide

The Centellax TR1C1-A is designed for signal integrity lab applications requiring multi-rate clock recovery. It can be used for SFP, fiber, and other photonic applications where polarization mode dispersion affects the data period. The unit can also be used for recovering a clock from a degraded data stream, for data recovery and resampling applications.

The CRU is ideally suited to be used with the other signal integrity test products offered by Centellax, specifically the low-cost 10G BERT and PRBS generators.

General

The TR1C1-A Clock Recovery Unit operates from 622Mbps – 13.5Gbps. The unit generates a clock signal from DC balanced, NRZ (non-return to zero) serial data patterns.

Key Features

- Operating range: 622Mbps to 13.5Gbps.
- Good input sensitivity (25mVpp)
- Low residual jitter (300fs)
- Differential input connectors
- GPIB programmable for automated use
- Modular power supply
- Small compact size (1.5" x 4.5" x 7")

Operating Modes

- Auto-lock <default>
- Manual ranging (gpib-only)

Display

- Signal indicator (on when signal present)
- Lock indicator (on when locked to clock)

Data Entry / Interface

- Push-button control (calibration & re-lock)
- Remote GPIB (IEEE 488.2-199)

TR1C1-A Operation Overview

The Centellax TR1C1-A is a cost-effective clock recovery unit designed to extract a synchronous clock from serial data. The TR1C1-A clock output can be used to trigger wide-bandwidth sampling oscilloscopes and BERTs when no synchronous clock is available. The TR1C1-A complements and extends the capabilities of existing equipment. Low jitter dividers, such as the Centellax UXD20PE, can be added to the clock output to drive lower bandwidth triggers.

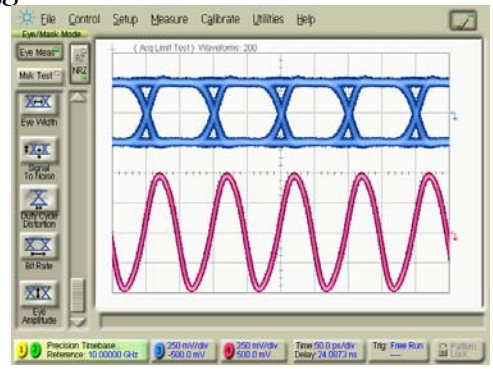

Figure 1 - 10GHz clock extracted from 10Gbps NRZ data stream

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1 TR1C1-A System Overview

The TR1C1-A is a PLL based clock recovery unit whose major functional blocks are:

- High Speed Phase/Frequency Detector
- Loop Filter
- Voltage Controlled Oscillator (VCO)

When a signal is detected, the TR1C1-A begins sweeping the VCO frequency from 622MHz to 13.5GHz until a locked condition is detected. If the TR1C1-A was unable to lock, it will repeat the process until lock is acquired. Using the GPIB interface, additional options become available. The TR1C1-A can be queried for the presence of a signal, lock status, or output frequency. The TR1C1-A can also be controlled to search over smaller frequency ranges when the input bit rate is known. This will reduce the time required to achieve lock. Adjustment of the PLL loop bandwidth is also available.

The only front panel control is a push button which sends the TR1C1-A into a new auto-lock search. The push button can also be held in when the unit is powered up to issue a calibration sequence for the signal detectors.

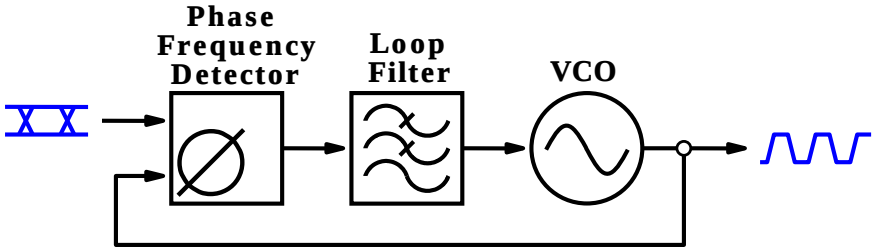

Figure 2 - TR1C1-A Simplified Block Diagram

1.1 Front Panel Quick Reference

Figure 3 - TR1C1-A front panel

Connectors

- Data In +/- (2.92mm F) – inputs to clock recovery unit (differential or single-ended)
- Clk Out (2.92mm F) – clock output

Display

- Signal (light) – indicates signal is present
- Lock (light) – indicates output clock is locked to input data

Controls

- Reset (button) – restarts auto lock sequence, used for calibration during power up

1.2 Rear Panel Quick Reference

Figure 4 - TR1C1-A rear panel

Connectors

- GPIB – GPIB connector, conforms to IEEE 488.1 mechanical specifications
- 8-pin DIN – Aux Connector
- 5-pin DIN – Input Power Connector

Controls

Power (switch) – TR1C1-A is powered when switch is toggled up
GPIB (switch panel) – TR1C1-A GPIB address (down is '0' , up is '1'), address value = $SW*2^0 + SW*2^1 + SW*2^2 + SW*2^3 + SW*2^4$ where SW = [0|1] depending on switch value. Default GPIB address as shipped from the factory is 25 – [up, dn, dn, up, up].

2 System Details and Performance Specifications

Specifications describe the instrument's warranted performance. Non-warranted values are stated as typical. All specifications are valid in a range from 10C to 40C ambient temperature after a 30 minute warm-up period. If not otherwise stated, all unused RF inputs and outputs must be terminated with the included 50Ω-terminated connectors.

2.1 General

Table 1 - General and mechanical parameters of TR1C1-A

Operating Temperature	+10°C to +40°C
Storage Temperature	-40°C to +70°C
Power Requirements	45W External AC Adaptor (included) • 85-265 VAC, 47-63 Hz
Physical Dimensions	Width: 105mm, Height: 39mm, Depth: 190mm
Weight	2lbs

2.2 Input Requirements

The TR1C1-A is designed to extract clocks from DC balanced, NRZ data streams. Inputs are differential and will also work with single-ended signals. Terminating the unused input is not required. Both inputs are DC coupled and terminated to GND with 50 ohms. Figure 4 & 5 show the typical input return loss and input sensitivity (single-ended drive) respectively.

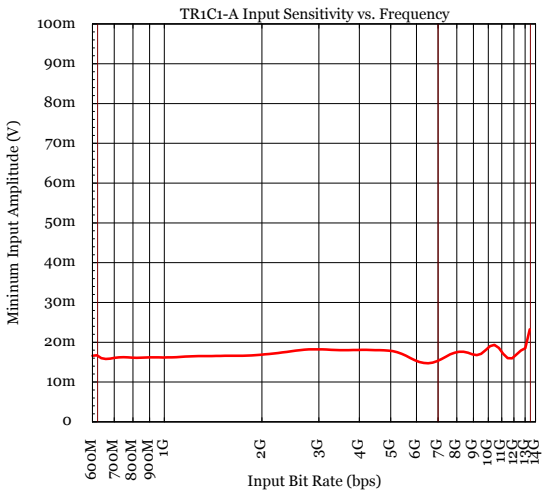

Figure 5 - Typical Input Sensitivity

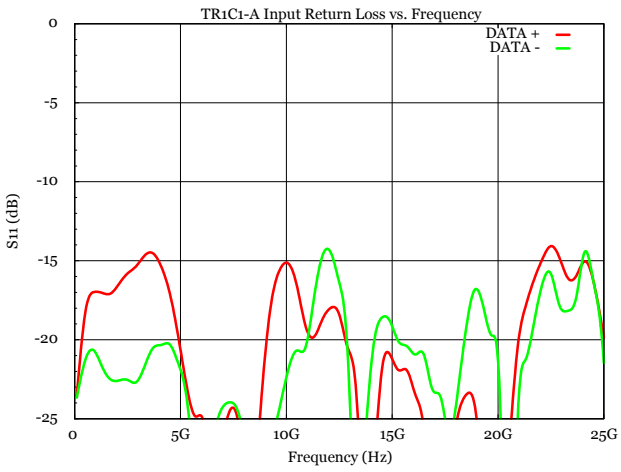

Figure 6 - Typical Input Return Loss

Table 2 - Input Specifications

	Units	Min	Typ	Max
TR1C1-A				
Operating Range	GHz	0.622	-	13.5
Input Sensitivity	mVpp	50	25	-
Input Match	dB	-	-15	-

2.3 Output Requirements

The TR1C1-A output clock frequency will match the input bit rate when locked. Figure 6 shows the typical clock output power vs. output frequency. With no signal applied, the clock output will default to its minimum output frequency.

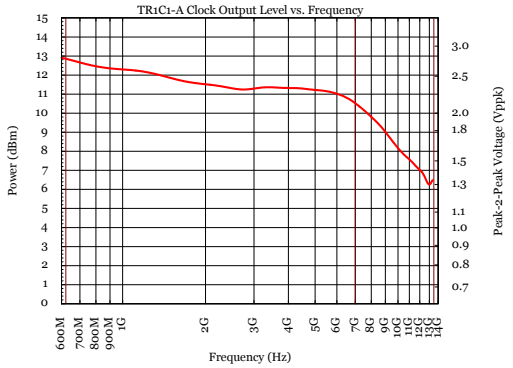

Figure 7 - Typical clock output power

Table 3 - Output Specifications

	Units	Min	Typ	Max
TR1C1-A				
Operating Range	GHz	0.622	-	13.5
Output Amplitude	Vpp	1	-	-
Residual Jitter	fs	-	300	-

3 Operation

When used to extract a synchronous trigger for wide band oscilloscopes or BERTs, the data signal needs to be split. A compact, microwave, resistive splitter (operating down to DC) mounted directly to the TR1C1-A input(s) is one method to achieve this. The choice of splitter is determined by the application and signal fidelity requirements. Applications with differential signals should use identical adaptors, splitters and cables to avoid skew between the two signals. Keep in mind that splitters will attenuate the incoming signal, hence if a splitter has a loss of 6dB, the input levels to the CRU will be reduced by a factor of 2.

3.1 Single-Ended/Differential Measurements

The TR1C1-A can be driven with either differential or single-ended input signals. Applications with differential signals should use identical adaptors, splitters and cables to avoid skew between the two signals. Either input can be driven single-endedly while the unused side can be left unterminated.

3.2 Calibration

Calibration of the TR1C1-A input signal detectors may be required if the unit indicates a signal is present with no inputs attached. Calibration of the signal detector is initiated by holding down the “Reset” button with the unit off followed by turning on the unit. No input signal should be present during the calibration which takes approximately 20 seconds.

3.3 System Verification

Operation of the TR1C1-A can be verified with either a signal generator or NRZ serial data source (a PRBS for example).

- Setup the signal generator to a valid frequency.
- Setup the signal generator output power to 0dBm.
- Verify that the Signal light on the CRU turns on.
- Verify that the Lock light turns on after an initial delay for the auto-lock.
- Verify output clock frequency using either a frequency counter, spectrum analyzer, wideband oscilloscope or other suitable measurement apparatus.

4 Remote GPIB Interface

The TR1C1-A can be controlled and queried with the rear-panel GPIB interface. The GPIB interface complies with IEEE standard 488.2-1992. To learn more about the GPIB interface, consult the following books from the IEEE:

- The International Institute of Electrical and Electronic Engineers. *IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation.* New York, NY, 1987.
- The International Institute of Electrical and Electronic Engineers. *IEEE Standard 488.2-1987, IEEE Stand Codes, Formats, Protocols and Communication Commands for Use with ANSI/IEEE Std 488.1-1987.* New York, NY, 1987.

A GPIB interface requires that all devices on a common bus have different addresses; the 5-bit address control switch is located on the rear panel next to the GPIB connector, shown in Figure 3 in Section 1.2. The factory default address is 25. The address is set with the 5 bit control switch located on the back of the instrument.

A Labview driver is available from Centellax for fast GPIB programming of the TR1C1-A.

4.1 GPIB Capabilities

The GPIB interface capabilities are described in Table 4.

Table 4 - TR1C1-A GPIB capabilities

Mnemonic	Function
SH1	Complete source handshake capability
AH1	Complete acceptor handshake capability
T6	Basic talker; serial poll; unaddressed to talk if addressed to listen; no talk only
L4	Basic listener; unaddressed to listen if addressed to talk; no listen only
SR1	Complete service request capability
RL2	Remote/local capability with local lockout (LLO)
PP0	No parallel port capability
DC1	Device clear capability
DT1	Device trigger capability (accepted but ignored)
C0	No controller capability
E2	Tristate outputs (except the handshake line)

4.2 GPIB Command Syntax

The TR1C1-A can be controlled through the GPIB interface using commands and queries. The commands and queries are documented in the Backus-Naur Form notation, detailed in Table 5.

Table 5 - TR1C1-A GPIB command and query syntax

Symbol	Meaning
<>	Defined element (eg: <arg>)
::=	Is defined as (eg: <arg> ::= argument)
|	Exclusive OR
{ }	One of this group is required
[ ]	Optional item
...	Previous elements may be repeated

4.2.1 Command Structure

The GPIB interface allows commands, which tell the instrument to take a specific action, and queries, which ask the instrument to return information.

Commands are composed of syntactic elements:

- Header – the command name; if it ends with a question mark, the command is a query.
- Delimiter – a space, colon (:), comma (,), or semi-colon (;) which breaks the message into segments for the instrument to process.
- Link – a command sub-function. Not all commands have links.
- Argument – a quantity, quality, restriction, or limit associated with the header or link.

Commands are case insensitive, although they are documented in an uppercase and lowercase manner that indicates which minimum characters are required to make the command. The commands can be shortened to the minimum length illustrated by the uppercase letters in the documentation.

- The command
  - **:SYSTem:ERRor?**
- Can be written in lowercase
  - **:system:error?**
- And it can be shortened to
  - **:SYST:ERR?**

4.3 IEEE Common Commands

The IEEE 488.2 standard has a list of reserved commands that must be implemented by all instruments using the standard.

Table 6 - TR1C1-A IEEE common commands

Command	Function
*CLS	Clear status command
*RST	Reset command
*WAI	Wait to continue
*TRG	Trigger
*IDN?	Identification Query
*STB?	Status Byte Query
*TST?	Self Test Query
*ESR?	Event Status Register Query
*ESE	Event Status Enable Register Set
*ESE?	Event Status Enable Register Query
*OPC	Operation Complete clear flag
*OPC?	Operation Complete Query
*SRE	Service Request Enable Set
*SRE?	Service Request Enable Query

4.4 SCPI Mandated Commands

The TR1C1-A also conforms to the Standard Commands for Programmable Instrumentation (SCPI 1999.0) command set. Two SCPI mandated commands are implemented, listed in Table 7.

Table 7 - TR1C1-A SCPI mandated commands

Command	Function
:SYSTEM:ERROR?	Returns event/error number and message from error queue
:SYSTEM:VERSION?	Returns SCPI protocol version number (1999.0)

4.5 TR1C1-A Device Commands

The following descriptions and examples assume the user is programming with Agilent BASIC, a simple interpretative language that is convenient for instrument programming.

For the examples below, the device being programmed is located at GPIB device address 725. The actual address varies according to how you have configured the GPIB bus for your own application. For information on changing the bus address, refer to Section 1.2.

SCPI Protocol Description

The TR1C1-A supports a simple SCPI syntax. The SCPI commands are meant to be compatible with the Agilent 83491A CRU module. SCPI has an associated hierarchy with it. The top level is referred as the Root mode. SCPI remembers the current hierarchy so you don't need to repeat it for subsequent commands.

SCPI Example

For example a command

:SYSTem:REMote

:SYSTem is the root level
:REMote is the second level

The command :SYSTem would set the new default level to be the system commands. Now if the user issued a command :REMote, it would put the system into remote mode. The capital letter in :SYSTem denote the required subset of pneumonic for correct state control. The lower case letters are optional but if they are used they must be spelled correctly.

COMMAND SUMMARY

:CRECovery subsystem

For backward compatibility with the Agilent 83491A CRU module all Agilent compatible commands may be preceded with the CRECovery subsystem except the command :CALibrate. This subsystem is not really needed for the TR1C1-A since it has a dedicated GPIB address and is not shared with other modules.

Example:

:CRECovery:LOCKed?	Will return if the CRU is locked.
:CRECovery:BAND?	Will return the approximate frequency band which the CRU has locked to.

:CRATe numeric

Set the current requested clock rate in MHz. This is used instead of the :AUTOlock command. This will force the CRU to look for a signal near the requested frequency only which can be useful in reducing acquisition time.

Example
:CRAT 10000; causes the CRU to attempt to lock to a 10G signal.

:CRATe?

Query the current requested clock rate. If no value has been specified it will return AUTOLOCK which indicates that the CRU has automatically found and locked to the signal.

:SYSTem:ERRor?

Return the interrupt status or error status remotely.

*IDN?

Return the version number of the instrument and software version as a string

"CENTELLAX, TR1C1-A, SN1001, 01.00"

:RATE <discrete>

Set the data rate to discrete values. (These values are similar to those used by the Agilent 83491).

<discrete> = R622 | R1061 | R1250 | R2125 | R2488 | R2500 | R2666 | R9953 | R10312 | R10664 | R10709 | RANGE10G

:LOCKed?

Report if the CRU is locked.
1 = signal present, 0 = no signal present

:SPResent?

Report if a signal is present at the input.
1 = signal present, 0 = no signal present

:AUTOlock

Cause the TR1C1-A to scan and lock to the input data. Searches all of the bands to lock to the input data stream. This parameter is not readable.

:RELock

Cause the TR1C1-A to relock to the data. If the last locked signal was found with Autolock then it will use Autolock. This parameter is not readable.

:LBANdwidth <discrete>

<discrete>= AUTO | 1-8

Set the loop bandwidth of the CRU. The automatic setting usually employs the maximum loop bandwidth for best capture and hold characteristics. The user can specify a value of 1 to 8 where 1 will have the lowest loop bandwidth and 8 will have the maximum loop bandwidth.

:LBANdwidth?

Query the loop bandwidth of the CRU. It will return an integer from 1-8 or AUTO. (1 being the lowest loop bandwidth and 8 being the highest loop bandwidth).

:BAND?

This is a query only parameter which returns the approximate frequency band which the CRU has locked to.

It is specified as a range of values of the form (LowEnd, Highend) MHz

:CALibrate

Calibrate the signal detector. This causes an internal calibration to be done on the internal data signal detector in the TR1C1-A. The calibration MUST BE DONE WITH NO INPUT SIGNAL! After calibration the **SPResent** command will have the best accuracy.

4.6 Examples

The following programming example assumes the user is programming with Agilent BASIC, a simple interpretative language that is convenient for instrument programming.

For the example programs below, the device being programmed is located at GPIB device address 725. The actual address varies according to how you have configured the GPIB bus for your own application. For information on changing the bus address, refer to Section 1.2.

This first block of code shows how to initialize the instrument and check the GPIB subsystem for errors.

```
10 OUTPUT 725; "*IDN?"                  ! request the instrument ID string
20 ENTER 725; RESULT$                   ! read the return string
30 PRINT RESULT$                        ! print the results
30 OUTPUT 725; ":SYSTEM:ERROR?"         ! check for errors
40 ENTER 725; SYSERROR$                 ! read the return string
50 PRINT SYSERROR$                      ! print the results
60 OUTPUT 725; "*RST"                   ! reset the CRU
```

The next block of code shows how to get the SCPI version number.

```
110 OUTPUT 725; ":SYSTEM:VERSION?"      ! query the control version
120 ENTER 725; VERSION$                 ! read the result
130 PRINT VERSION$                      ! print the version
```

The next block of code shows how to specify a specific frequency to reduce acquisition time.

```
110 OUTPUT 725; ":CRAT 1000;"           ! desired clk @ 10GHz
120 OUTPUT 725; ":CRAT?;"               ! query the state
130 ENTER 725; rate$                    ! read the result
140 PRINT rate$                         ! print the version
```

The next block of code shows an alternative method of specifying the rate.

```
110 OUTPUT 725; ":RATE R9953;"          ! specify oc-192 rate
```

The next block of code shows how to place the TR1C1-A into auto-lock mode

```
110 OUTPUT 725; ":AUTOLOCK;"            ! specify autolock
```

The next block of code shows how to force a re-lock of the TR1C1A

```
110 OUTPUT 725; ":RELOCK;"              ! start a new search
```

The next block of code shows how to cause the TR1C1-A to perform a signal detector calibration.

```
110 OUTPUT 725; ":CAL;"                 ! no signal on input
```

5 Warranty

Centellax, Inc. Standard Warranty
Test Instrument and Accessory Products

Centellax, Inc. ("Centellax") warrants that the Test Instrument(s) and Accessory(s) ("Product(s)") it manufactures is/are free from defective material and workmanship for a period of one (1) year subject to the following terms and conditions. Centellax will remedy any such warranted defect subject to the followings:

This warranty requires the Product to be delivered to Centellax intact for examination with an RMA number and with all transportation charges prepaid to the factory, within one (1) year from the date of sale to the original customer. Centellax will determine in its sole discretion when such defect exists. Centellax will return the repaired or replaced Product to the customer at its cost unless the shipment needs to be expedited or the shipment is international, in which cases customer will pay for return shipment.

During the warranty period, Centellax will, at its sole option, either repair or replace Products, which prove to be defective.

This warranty is only for the benefice of the original buyer registered with Centellax and is not assignable. This warranty does not extend to any of Centellax' Products which have been subject to misuse, neglect, accident, improper installation or used in violation of operating instructions. This warranty does not extend to Products, which have been repaired, calibrated, or altered in any way by a facility that is not approved, in writing, by Centellax to perform such work. This warranty does not apply to any Product where the seals or serial number thereof has been removed, defaced or changed, nor to Products not of our own manufacture.

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Additional information with regard to the applications and maintenance of this equipment may be available from time to time.

Centellax reserves the right to modify or change the warranty without notice.