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**Calibration Verification When Upgrading
From M9-Series to Di-Series Instruments**

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Overview

Calibration verification (CalVer), when run in addition to instrument self-test, determines whether individual Di-Series module measurement circuits are operating within specification. This verification process tests the functionality of several internal components of the Di-Series module using external instrumentation. CalVer should be executed annually if instruments are not returned for regular factory calibration.

When replacing M9-Series instruments within a system with Di-Series instruments, most programs will run with no modifications once an M9-Interface configuration file has been created. CalVer is the exception, and a new CalVer program must be created. This can typically be done using the same external test equipment that was used for the M9-Series CalVer, but a new test program using Di-Series API's or the provided UI is required.

The main differences between M9-Series and Di-Series CalVer are:
- Verification of channel modules for the Di-Series, but not for M9-Series
- Additional required front panel pin access for the Di-Series
- Additional voltage ranges required for verification of the Di-Series

This paper discusses obstacles that have been encountered and overcome when creating a Di-Series CalVer program for systems, replacing M9-Series instruments because of the differences between the instruments' capabilities. It does not detail steps on how to perform CalVer. The obstacles and countermeasures discussed include: determining the level of verification required for appropriate coverage, access to the required front panel pins, and the use of advanced settings to better emulate the behavior of the M9-Series calibration verification routine.

Levels of Calibration Verification

There are three levels of calibration verification that can be individually selected for each Di-Series module. These are the standard CalVer, reduced CalVer in Dedicated Master mode, and reduced CalVer in Non-Master mode. Whichever method is selected, the CalVer routine must be followed by the execution of Extended Diagnostics self-test on the full system configuration. (Refer to Di-Series Help documentation for instructions on how to run the calibration verification routine.)

The standard Di-Series CalVer is the most exhaustive of the three levels. Users should default to the standard CalVer, if full functionality of instruments is to be taken advantage of. Standard CalVer verifies the internal meter and internal channel paths, master clock, and Time Domain Reflectometer (TDR) of each module. This ensures every module has the capability to be the master module in any user-defined virtual instrument configuration. This differs from the M9-Series calibration verification because only the Central Resource Board (CRB) could be used as a master module in an M9-Series hardware configuration.

The reduced CalVer levels for the Di-Series instrument should be used when instruments are only to be used in M9-emulation mode. These reduced procedures should not be used if new development is to take place, which could take advantage of the virtual instrument capabilities of the Di-Series hardware. These reduced options are only available through an API with Di-Series driver version 4.0 or greater, whereas the standard CalVer routine is available via an API or the provided graphical DiCalVerify utility.

Reduced CalVer in Master mode can be executed on any module that will be used as a master module in test configurations emulating M9-Series hardware. This is typically the Di-Series Utility module (Di-050-3x) that is used to replace the M9-Series CRB. This routine verifies the internal meter, but no channel paths, within the instrument, similar to the M9-Series CalVer routine. It also verifies the master clock and TDR.

Reduced CalVer in Non-Master mode should be executed on any module that will not be used as a master in a test configuration emulating M9-Series hardware. This is typically a Di-Series channel module using a Utility module as the dedicated master. This routine only verifies the internal meter of the selected module. It does not verify channel paths, master clock, or TDR. This verification process is less time-consuming, but limits the virtual instrument capabilities of the system configuration.

The table below summarizes the differences between the levels of Di-Series CalVer available and when it is appropriate to use each.

Level of Cal/Ver	Utility Module tests	Channel Module tests	When to use
Standard (Full)	Meter Clock TDR	Meter with channel paths Clock TDR	- Whenever time and resources permit. This should be the default selection. - Should be performed if doing new Di-Series development.
Reduced - Master	Meter Clock TDR	Meter Clock TDR	- Perform on any module that will be used as a master - Should only be used if emulating M9-Series hardware (no new development)
Reduced - Non-Master	Not a valid combination	Meter	- Perform on any module that will never be used as a master - Should only be used if emulating M9-Series hardware (no new development)

Front Panel Pin Connections

The M9-Series Calibration Verification Routine is required to be performed on only the CRB, since this board controls timing and synchronization between the channel cards. The CRB provides the system clock, pattern clock, pattern controller, data acquisition controller, dynamic pattern set timer, system meter, and frequency counter for the entire digital instrument configuration. To perform CalVer on the M9-Series, only access to the CRB was required. See the table below for external instrument connections required for M9-Series CalVer.

Test	Instrument	Connector
System Meter	CRB front panel	J2B, pin 7 (meter monitor) J2B, pin 1 (system ground or GND)
	Spring Probe receiver	J1-26 (meter monitor) J1-25 (GND)
Clock	CRB front panel	J2A, pin 18 (system clock output or T0 cycle) J2A, pin 17 (GND)
	Spring Probe receiver	J1-32 (T0 cycle) J1-31 (GND)
TDR	CRB front panel	J1A
	Spring Probe receiver	J1A

Standard Di-Series CalVer requires verification of the meter and internal channel paths, clock, and TDR of all Di-Series channel and utility modules because any module can be used as a master in a virtual instrument. This means access to the METER_IN, all channel pins, CLKOUT, and T0CAL_OUT must be accessible to perform the full CalVer routine. Connections for CalVer can be made directly via the front panel, or through funnels attached to the front of the instrument. The table below lists the front panel pins required for standard CalVer connections.

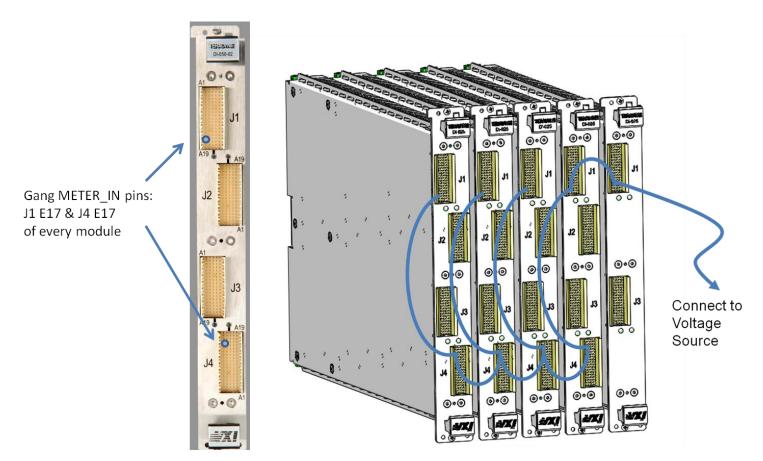| Module in Left Socket		Module in Right Socket	
All Modules			
METER_IN	J1/E17	METER_IN	J4/E17
CLKOUT	J1/C19	CLKOUT	J4/C19
T0CAL_OUT	J1/C18	T0CAL_OUT	J4/C18
32-Channel Modules			
CH0-CH15	J1/A1-A16	CH0-CH15	J4/A1-A16
CH16-CH31	J3/A1-A16	CH16-CH31	J2/A1-A16
24-Channel Modules			
CH0-CH15	J1/A1-A16	CH0-CH15	J4/A1-A16
CH16-CH24	J3/A1-A8	CH16-CH24	J2/A1-A8
16-Channel Modules			
CH0-CH15	J1/A1-A16	CH0-CH15	J4/A1-A16

To reduce the time it takes to execute the standard CalVer process and lessen the likelihood of user error, it is strongly recommended to short all channels and METER_IN together when performing standard meter verification. Products to simplify these connections are available from Teradyne for both front panel connections and use with standard funnels. Since M9-Series CalVer did not verify channel paths, there is no equivalent product, or requirement for the M9-Series.

Reduced Master CalVer requires access to the METER_IN, CLKOUT, and T0CAL_OUT pins, but does not require access to every channel pin for channel modules. This solution can be run on both channel and Utility modules, though it is most likely applicable to Utility modules that act as a master in the system configuration. The Di-Series also provides compatibility with the M9-Series option to perform master clock and TDR

verification through the probe circuitry; this will be discussed further in the next section. Since the M9-Series CRB CalVer required access to the same output signals, this is unlikely to require rework of any funnels or Interface Test Adapters (ITA) for the CRB.

Reduced Non-Master CalVer requires access only to the METER_IN pin. This level of CalVer can be run only on channel modules that will not be used as a master, and introduces a difference from the M9-Series CalVer routine due to the Di-Series additional capabilities. When designing custom funnels, ITAs, or CalVer fixtures for the Di-Series instrument, it is necessary to provide access to the METER_IN pin of every module.

The METER_IN pins of each Di-Series module in the system can be ganged together to avoid making multiple connections during the Reduced CalVer procedures. While access to the METER_IN pin for every module is a requirement unique to the Di-Series instrument, this allows one METER_IN connection to be brought out to an ITA or fixture, typically via the CRB. Since the M9-Series CRB required this connection, the front end of the ITA or fixture could remain the same, with additional wiring behind it to gang the pins together. A figure representing this configuration can be seen below. This wiring could also be accomplished when using funnels, connecting METER_IN from the bottom of the funnel.

Gang METER_IN pins:
J1 E17 & J4 E17
of every module

Connect to Voltage Source

Advanced Settings

Most differences between the M9-Series and Di-series CalVer routines, outside of front panel pin connections, can be accounted for using the Di-Series software in an API program.

Probe Buffer Board Verification Paths

To remain compatible with the M9-Series ability to perform portions of CalVer through the probe circuitry, the Di-Series driver API provides methods to select master clock and TDR verification paths when performing Reduced Master CalVer on the Utility module. The master clock and TDR of the Utility module can be verified either from the front panel CLKOUT and T0CAL_OUT pins, or from the Comp/Cal port of the probe buffer board.

The APIs to select the verification paths are:
- terDi_CalVer_SetDedicatedMasterFrequencyPath
- terDi_CalVer_SetDedicatedMasterTdrPath

These APIs are supported with Di-Series instrument driver version 4.2 or later. If not specified, the default path for the master clock is the Utility module front panel CLKOUT pin, and the default path for the TDR is the probe buffer board Comp/Cal port.

These features may prevent the need to rework funnels, ITAs, or fixtures to perform CalVer on the Utility module after an M9-Series to Di-Series upgrade, if the front panel pins are not accessible.

Meter Verification - Voltage Ranges

The M9-Series CalVer routine verified the CRB meter, using voltages from an external supply of -5V up to +5V in 1V increments. The Di-Series Utility module is verified with voltage from -3V up to 6V. These voltage levels are unlikely to require the purchase of new voltage supplies for calibration verification.

The Di-Series channel modules, however, also require meter verification as they do not solely rely on the meter of the utility module for accuracy as the M9-Series relied on the CRB. The default voltages, requested to verify the internal meter for Di-Series channel modules, range from -30V up to 30V. The specific voltages to apply can be found in the table below.

Module Type	Voltages
Channel	0.0; 3.3; 5.0; 6.0; 10.0; 15.0; 30.0; -2.2; -3.0; -5.0; -10.0; -15.0; -30.0
Utility	0.0; 6.0; -3.0

The -30V to 30V range is the default for Di-Series channel modules despite what voltage ranges the instrument actually supports in test programs. This is to ensure full accuracy of the internal meter since most Di-Series hardware is capable of being upgraded to a 30V model.

The option to verify only the supported voltage ranges of the Di-Series instrument is available when performing CalVer through the API. The APIs to set and verify this option are:
- terDi_CalVer_SetSupportedVoltagesOnly
- terDi_CalVer_GetSupportedVoltagesOnly

These APIs are supported with Di-Series instrument driver version 4.3 Update 2 or later.

The use of this option may reduce the need to purchase a new voltage supply for the Di-Series CalVer routine. If for instance, a Di-025-24 is being put into a system, the option exists to only test the supported -3V to 6V range. This is more likely to already be supported by the voltage supply used for M9-Series CalVer.

Writing Result Files

The Di-Series CalVer routine provides more result files compared to the M9-Series routine. These files provide traceability as well as debug information. The debug information may prove useful in debugging new fixtures and/or CalVer code when migrating from M9-Series to Di-Series instruments.

These files can be created when using either the graphical utility or the API to automate the process. The button used to write result files from the utility is circled in the figure below.

The API to write result files is:

- terDi_CalVer_WriteFiles

Five files are created on instruction after a complete CalVer:

- CalVer certificate
- Meter results CSV file
- Meter failures CSV file
- Meter results XML file
- Meter failures XML file

The CalVer certificate can be saved to archive when CalVer was performed, what external instrumentation was used, who performed the verification, and an overall pass/fail result.

The meter results CSV and XML store all measurements made by the internal meter, and the channels for standard CalVer of channel modules. The information stored in these files can be used to look for trends. For instance, if measurements on the meter and every channel to every voltage range were measured with the same offset, the voltage supply or fixture may need to be investigated.

The meter failures CSV and XML store only the failing measurements made by the internal meter, and through channel paths for standard CalVer of channel modules. The information stored in these files can be used to look for trends or identify user and/or hardware errors. For instance, if a module fails CalVer in the 30V range, and the file identifies that the meter and every channel measured 0V, there is likely a disconnect between the voltage supply and the instrument front panel, or the user made a wrong connection.

Summary

When migrating from M9-Series to Di-Series instrumentation, existing M9-Series CalVer routines cannot be run on the Di-Series hardware. A new routine must be created. This routine will require the use of software APIs or CalVer utility, and fixtures to access the required front panel pins required for CalVer.

The main differences between M9-Series and Di-Series CalVer are:

- Verification of channel modules for the Di-Series, but not for M9-Series
- Additional required front panel pin access for the Di-Series
- Additional voltage ranges required for verification of the Di-Series

When designing new funnels, ITAs, or fixtures that will be used during the Di-Series CalVer routine, it is necessary to provide access to the METER_IN pins of every module, at a minimum. Planning for access to pins required for the CalVer routine early in the design process will reduce design changes down the road. It is strongly recommended to also plan for a way to tie all channel pins and METER_IN together for channel modules during the CalVer routine if standard (full) CalVer is planned. Ganging together the METER_IN pins of every module in the system can simplify the reduced CalVer routine by requiring only one front end connection to a voltage supply, similar to the M9-Series routine.

To provide the highest level of M9-Series CalVer compatibility, the API should be used to automate the CalVer routine. The API has an option for a reduced CalVer routine, which shortens the verification times and reduces

the number of required pins for channel modules. The API also provides the option of verifying only the supported voltage ranges of the particular Di-Series module in verification rather than the full 30V range.

Due to its additional capabilities, the Di-Series instrument requires a more exhaustive CalVer routine than the M9-Series instrument required. With well thought out funnel/fixture design and the use of compatibility features, the creation of a new Di-Series CalVer routine can be customized to meet specific system requirements. This will result in the shortest possible set-up and execution times.

References

Dube, Matt & Lopes, Teresa. "Di-Series Calibration Verification," Application Note. Teradyne, Inc.

"M9-Series Digital Test Instrument" Online Help, v6.2.

"Di-Series Digital Test Instrument" Online Help, v4.5.