OD-103 ODIN Delay Line Datasheet

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OD-103 Overview

The OD-103A is a delay line guaranteed to operate over the range 5 MHz to 6 GHz. The OD-103B is a delay line guaranteed to operate over the range 5 MHz to 18 GHz. In all other respects the OD-103A and OD-103B are equivalent. For convenience this manual refers to these delay-lines jointly as an OD-103.

The OD-103 is designed to be used in conjunction with the ODIN-320A analyser and a suitable ODIN receiver, such as the OR-101A or OR-102A. Accordingly, this OD-103 User's Manual is to be used in conjunction with the ODIN-320A User's Manual and the User's Manual of the receiver you will be using in conjunction with the delay line.

The OD-103 is a member of the family of ODIN-320A external devices, up to six of which can be "daisy-chained" together on the ODIN-320A external device bus. Each device is powered by its own IEC mains cable. The interface cable connects as shown in Figure 1.

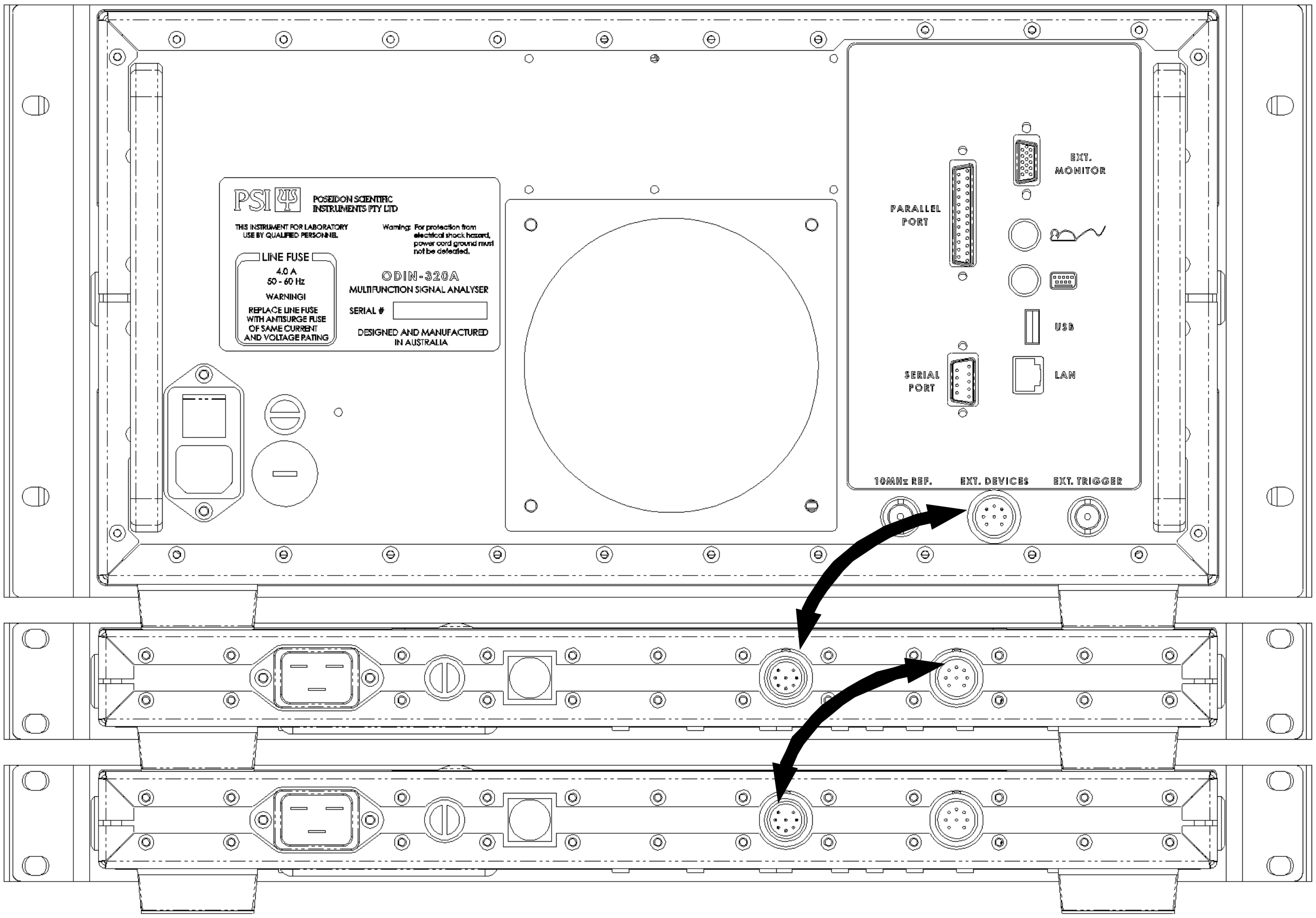

Figure 1. Connecting the OD-103 to the ODIN-320A External Device Bus.

The OD-103 is a 5 MHz to 6 GHz or 18 GHz Delay Line unit, useful for adjusting the phase of an RF/microwave signal, to configure phase and amplitude noise measurements. It is housed in a 1U 19" rack-mountable chassis. Figure 2 shows the front panel of the OD-103.

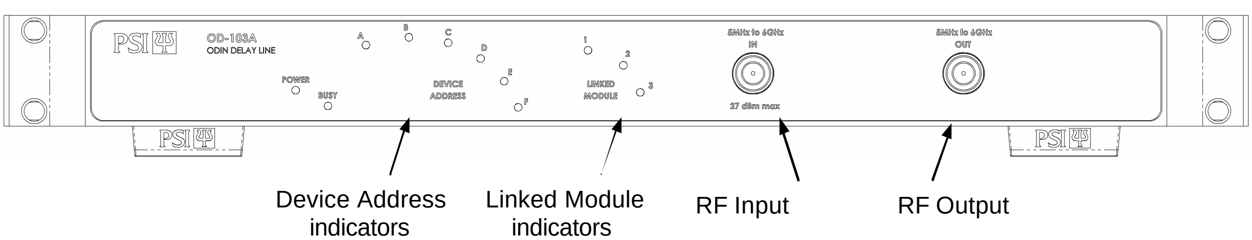

Figure 2. OD-103 Front Panel

The front panel of the OD-103 has status LEDs, and input and output RF connectors. The LEDs are described in Table 1. The RF input and output connectors are 50 ohm N-type.

The rear panel of the OD-103 has an IEC mains inlet, a voltage selector switch, a mains fuse holder, and input and output interface connections.

Maximum RF Input Level: +27 dBm (0.5 Watts)

Input signal levels above the specified range can cause permanent damage
to the unit. Take care to estimate power level before connecting RF power.

Figure 3 shows an overview of the inside of an OD-103 unit. The key elements are the microwave switch matrix, the delay line switch matrix (and associated stripline and cable delay sections), and the motorised phase shifter. A microprocessor controls the various elements and liases with the ODIN-320A mainframe, and a linear power supply provides regulated power to each element.

Power	Lights when the OD-103 is powered up. This requires line voltage to the rear panel and the unit to be connected to an ODIN-320A.
Busy	Lights when the OD-103 is switching delay elements, driving the in-built motorised phase shifter or communicating with the ODIN-320A.
Device Address	Shows the device address, one of ‘A’ through ‘F’.
Linked Module	Shows which plug-in module is linked to the OD-103 (this should match any RF cable connections made between the delay line and a module).

Table 1. OD-103 Front Panel LEDs

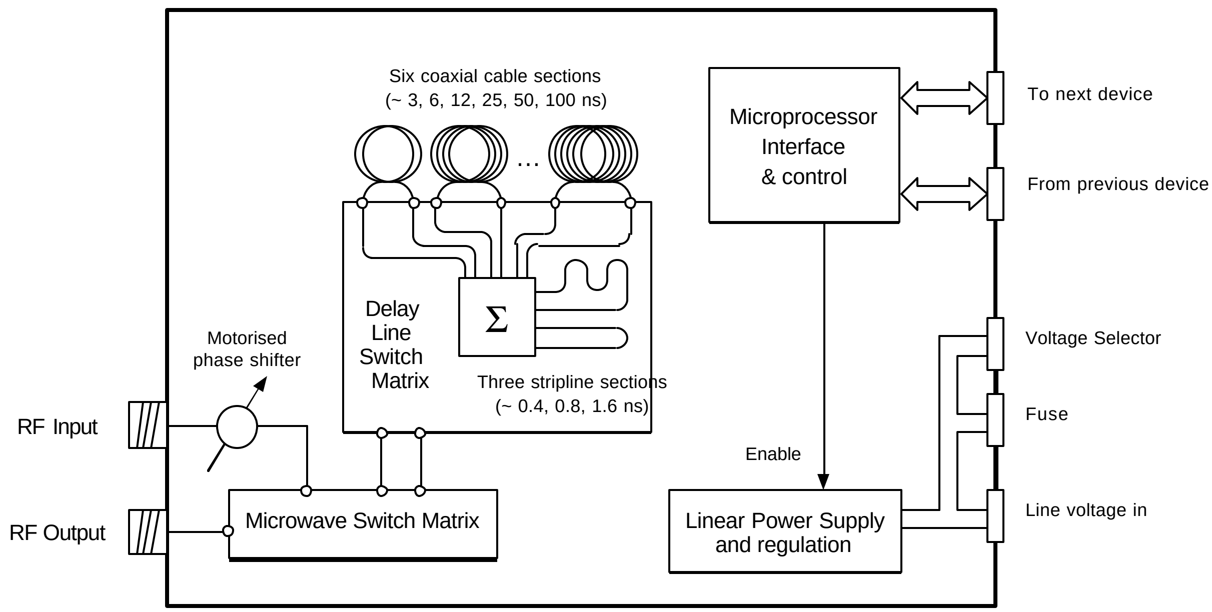

Figure 3. OD-103 Overview.

OD-103 Capabilities

The OD-103 is capable of performing many different measurements when linked to an OR-101A or OR-102A receiver in an ODIN-320A mainframe.

Key capabilities include:

- Automatic search for phase quadrature by adjusting delay line insertion length (phase) under ODIN control. This allows phase noise measurements to be performed on two-port devices such as amplifiers, and for dual-channel cross-spectrum measurements on signal generators;
- Manual control of all insertable delay line elements;
- Fine continuous phase control, using the in-built trombone phase shifter;
- Manual setting of phase to generate a peak amplitude for AM noise measurements.

Automatic Phase Quadrature Search

The OD-103 can be used to automatically find the voltage/phase "zero-crossing" for phase noise measurements, using the "Conversion Ratio from Delay Line" menu function of a suitable receiver that is linked to the delay line (see the receiver module User's Manual for more information).

To minimise the delay line insertion loss, the OD-103 determines which switches and cable lengths are required based on the carrier frequency. The carrier frequency is generally measured directly by an OR-101A or OR-102A during the "Conversion Ratio from Delay Line" sequence. The OD-103 uses an optimised search algorithm that increases the lifetime of the RF relays used for switching by evenly distributing the state changes amongst the relays.

If the carrier frequency cannot be measured by the receiver, for example if an external mixer is being used, then the carrier frequency must be entered manually. Refer to the receiver module User's Manual for how to do this.

Once the microwave switches and RF relays are set correctly, the motorised phase shifter sweeps until the desired zero-crossing is found.

The "Conversion Ratio from Delay Line" sequence returns the voltage/phase slope at the zero-crossing, determined by one of two methods:

1. for carrier frequencies greater than 200 MHz, a local "two-point" fit is used;
2. for carrier frequencies less than 200 MHz, a linear best-fit approximation to the phase shifter data is used, since the maximum phase deviation is around 12° (motorised phase shifter ~ 12° at 200 MHz) which gives rise to 20 log (cos 12°) = -0.2 dB maximum error. For frequencies under 100MHz, this error is less than 0.05 dB.

[Find Local Peak] Move the phase shifter to a local maximum or minimum, but does not measure or alter the conversion ratio. This function moves the trombone phase shifter only. If the signal frequency is such that a local maximum or minimum is not present within the full travel of the phase shifter, an error message will result.

[Find Local Zero] Move the phase shifter to a local zero crossing, but does not measure or alter the conversion ratio. This function moves the trombone phase shifter only. If the signal frequency is such that a local zero crossing is not present within the full travel of the phase shifter, an error message will result.

Getting the Most out of your OD-103

This section describes in detail the operation of the OD-103 delay line to allow users to correctly operate the delay line under manual control. Manual control of the switch matrix and cable sections is performed using the menus described in sections **Error! Reference source not found. Error! Reference source not found.** and **Error! Reference source not found. Error! Reference source not found.** of this manual.

Figure 4 shows an overview of the OD-103 unit again. The microwave switch matrix, the delay line switch matrix (and associated stripline and cable delay sections), and the motorised phase shifter sections are described in more detail below.

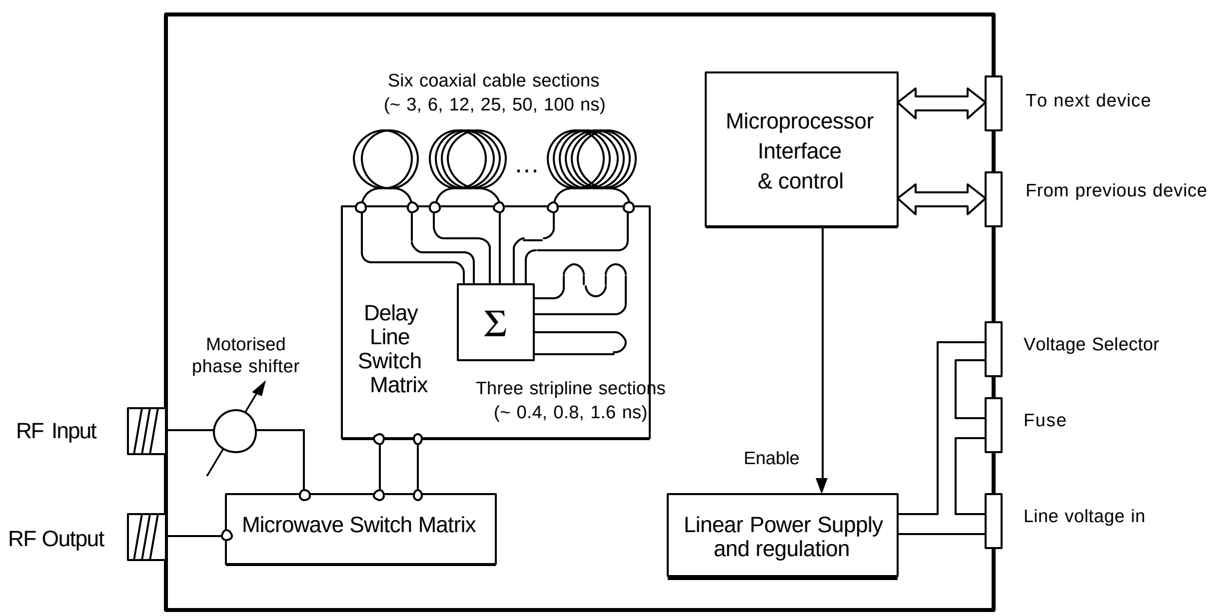

Figure 4. OD-103 Overview.

Microwave Switch Matrix

Broadband microwave switches route the RF signal through or past the delay line switch matrix, as required under ODIN control. Figure 5 shows an overview of the microwave switch matrix.

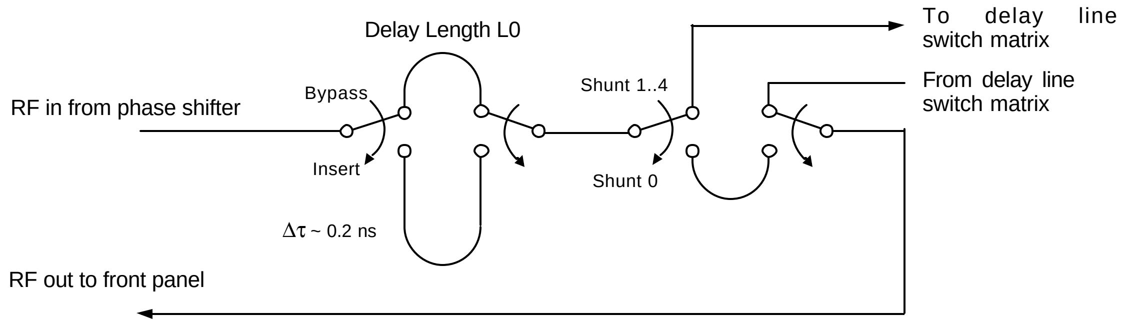

Figure 5. Overview of the Microwave switch matrix.

A switchable delay length is configured in semi-rigid coax cable, for microwave operation. This length, identified as ‘L0’ is typically 0.2 ns. It can be **inserted** (0.2 ns is added to overall delay line length) or **bypassed** (no length added).

A second switch arrangement enables the signal to be routed to (or bypass) the delay line switch matrix. Bypassing the delay line switch matrix is identified as ‘Shunt 0’, while various paths on the delay line switch matrix are otherwise identified as ‘Shunt 1’ to ‘Shunt 4’.

Delay Line Switch Matrix

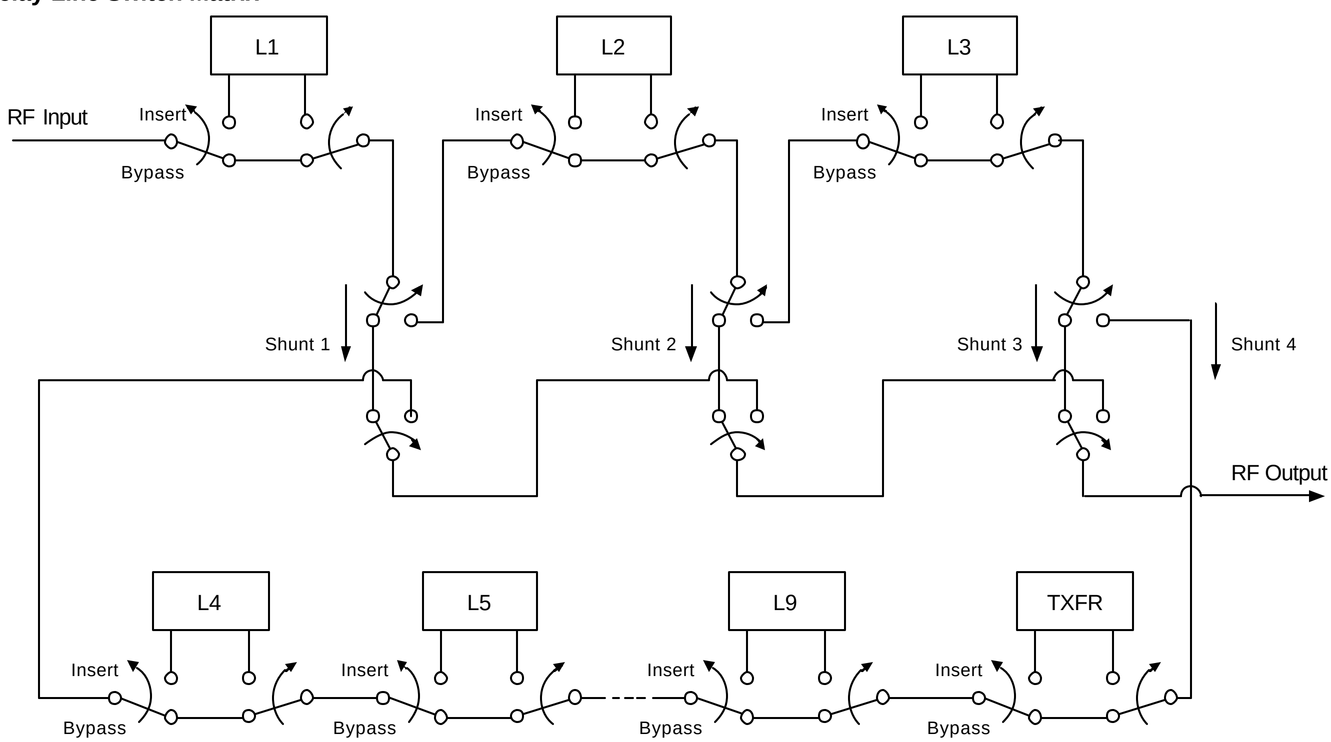

Figure 6. Overview of the Delay Line Switch Matrix.

The delay line switch matrix has nine delay sections that can each be inserted or bypassed; three of these, identified as ‘L1’ to ‘L3’ are constructed in stripline, while the longer sections, ‘L4’ to ‘L9’ are built in RG316/M17 coaxial cable. Table 2 shows the approximate lengths of the delay elements.

Delay Length ID	L9	L8	L7	L6	L5	L4	L3	L2	L1	L0
Delay length (ns)	100	50	25	12	6	3	1.6	0.8	0.4	0.2

Table 2. Delay Length Identifiers and approximate delays.

There are four shunt paths on the delay line switch matrix. For any given RF frequency, there is a maximum delay length that needs to be added to ensure at least 360° of phase shift. Table 3 shows the shunt section chosen under automatic control.

Shunt ID	Frequency Range
Shunt 0	> 3.0 GHz
Shunt 1	1.5 GHz .. 3.0 GHz
Shunt 2	750 MHz .. 1.5 GHz
Shunt 3	375 MHz .. 750 MHz
Shunt 4	< 375 MHz

Table 3. Shunt Identifiers and nominal frequency ranges.

Shunt Path		Shun t 0	Shun t 1	Shun t 2	Shun t 3	Shun t 4
Leng th	MPS	✓	✓	✓	✓	✓
	L0	✓	✓	✓	✓	✓
	L1	×	✓	✓	✓	✓
	L2	×	×	✓	✓	✓
	L3	×	×	×	✓	✓
	L4	×	×	×	×	✓
	L5	×	×	×	×	✓
	L6	×	×	×	×	✓
	L7	×	×	×	×	✓
	L8	×	×	×	×	✓
	L9	×	×	×	×	✓
	TXFR	×	×	×	×	✓

Table 4. Summary of Shunts and the associated effective Lengths.

The different shunts are available to minimise the insertion loss at various frequencies. For example, a 4 GHz signal can be phase shifted more than 360° by the motorised phase shifter and a single delay length L0, so there is no need to route the microwave signal onto the delay line switch matrix (which would unnecessarily increase insertion loss).

A transformer inverter can be inserted under manual control. This provides a switchable 180° of phase shift for frequencies below around 200 MHz, without significant change in insertion loss. Note that it is only active with Shunt 4.

Table 4 provides a summary of the length sections that are available for each shunt path. Available length sections are marked ‘ü’ and unavailable length sections are marked ‘û’. Manual insertion of an unavailable length (marked ‘û’) will have no impact on delay line length. ‘MPS’ refers to Motorised Phase Shifter and ‘TXFR’ refers to the transformer section.

Motorised Phase Shifter

The in-built motorised “trombone” phase shifter can sweep the phase by at least 60° per GHz. The change in insertion loss is negligible over its range, making it very useful for calibrating phase shift changes. It has an optical encoder on its drive shaft, and the control software accounts for mechanical hysteresis and start and stop delays. The encoder resolution is typically 0.025° at 1 GHz. The phase shifter can be driven manually or under automatic control.