

Digital Phase Shifters

Lorch Microwave's DP Series, Digital Phase Shifters, are available for frequencies from 1 to 1000 MHz. These phase shifters are composed of high performance GaAs switches that have little power consumption, fast switching time, and extremely low switching transients.

All units are TTL compatible, with one control line per bit. TTL high voltage state corresponds to zero phase shift on standard units, but reversed logic may be obtained if required. As a convention, all phase shifts are negative.

Description

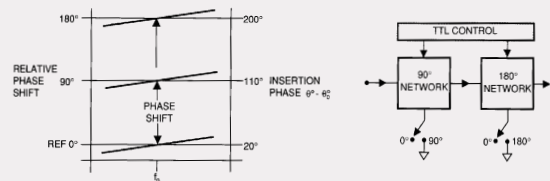
Figure 1 illustrates three distinct types of phase shifters, namely: Type 1 (Phase Shifter), Type 2 (Time Shifter), and Type 3 (Phase Inverter). They have quite different performance characteristics, proper selection is governed by consideration of the system in which the shifter is to be used.

Type 1 (Phase Shifter) uses special networks to obtain any desired phase shift, shown as 0 degrees, 90 degrees and 180 degrees in the example of Figure 1A. The 90 degree and 180 degree shifts have phase/frequency slopes parallel to that of the initial insertion phase characteristic, signifying constant time delay. The Type 1 Phase Shifter changes the phase of the incoming signal while maintaining constant time delay, or group delay. The delay is that of the initial insertion phase characteristic. At all settings, the absolute insertion phase is proportional to frequency, depending on the value of the insertion delay, but the phase shift is not. This type of device is inherently narrowband in nature. Wider bandwidths are obtainable, but at a higher cost because of the complex networks required. Type 1 shifters should be used only where special characteristics of constant delay and frequency independent phase shift are required.



- 1-1000 MHz frequency range
- Up to a full octave bandwidth
- 0-360 Degrees phase shift
- Integral TTL driver
- 1-8 bit control
- Accuracy to ½ least significant bit
- Time shifter or frequency independence

FIGURE 1A
TYPE 1 (PHASE SHIFTER)



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Type 2 (Time Shifter) is illustrated in Figure 1B, which shows two sections, each with a 'thru' path of length l_0 and a 'line' path of length l_1 and l_2 . The length l_2 is assumed to be longer than l_1 . It is seen that the insertion phase of the path l_0 is linear with frequency, having a slight slope, and curve l_2 is steeper yet. Type 2 is a true time shifter compared to the Type 1 Phase Shifter. The phase characteristic is proportional to frequency at any phase setting, with a slope proportional to frequency at any phase setting. Group delay is constant for each phase setting but proportional to phase shift as the setting is changed. The zero degree phase setting corresponds to the insertion phase, or delay; all other delays are longer in time. The Type 2 device has an inherently wide bandwidth, limited only by the switching circuits used. Type 2 shifters are less expensive than Type 1, have wider bandwidths with good transient response. They are recommended for most applications, particularly those in which time is in fact the variable desired, such as antenna beam formers.

Type 3 (Phase Inverter) of Figure 1C is a special case and consists of a simple phase-reversing transformer. It provides only two possible phase states, namely the insertion phase, 0 degrees and 180 degrees. The phase/frequency slope, or time delay, is approximately the same for each state. The device exhibits wide bandwidth and excellent transient response. It has limited applications, and is the simplest and least expensive.

FIGURE 1B
TYPE 2 (TIME SHIFTER)

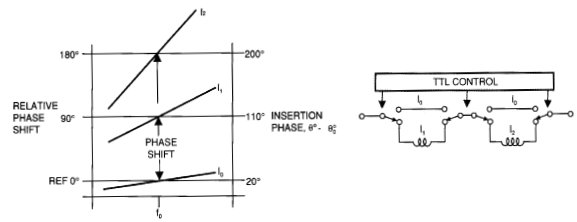


FIGURE 1C
TYPE 3 (PHASE INVERTER)

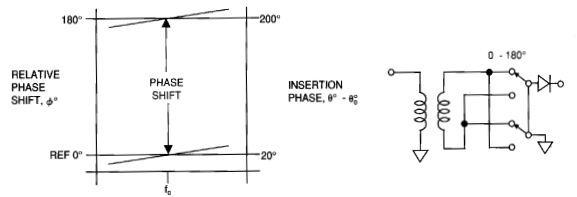
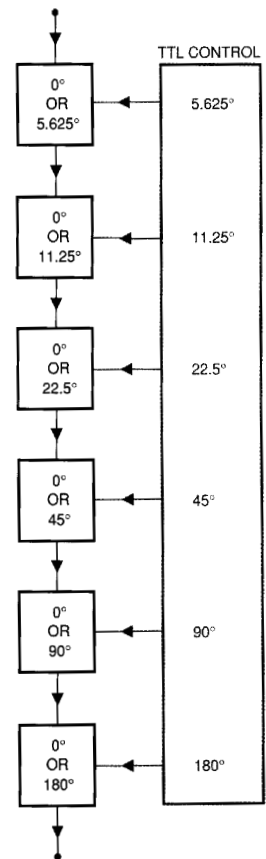


FIGURE 2



MIN PHASE = 0.0°
 MAX PHASE = $5.625^\circ + 11.25^\circ + 22.5^\circ + 45^\circ + 90^\circ + 180^\circ = 354.375^\circ (360^\circ - 5.625^\circ)$

Phase Shifters of Type 1 and Type 2 can be arranged to give identical phase shift at a single frequency, e.g. f_0 in Figure 1. It is when the frequency is varied that the difference between these two types becomes apparent. In the case of Type 2, (Time Shifter), performance should be specified in units of time delay. Common usage, however dictates the specifications of degrees of phase shift at a given frequency. Only at that frequency will the device meet the phase specifications. In many instances, the frequency will be at the center of the bandwidth specified. To resolve this difficulty, a 'datum' frequency is given in each case, that being the frequency at which the specified phase shifts occur.

This catalog covers TTL compatible digital phase shifters comprising of one or several shifters, usually in a binary sequence as shown in Figure 2. In that example, six sections are arranged in the sequence 5.625 degrees, 11.25 degrees, 22.5 degrees etc., with a total phase shift of 354.375 degrees, the next step returning to 0 degrees. Thus a complete 360 degree of phase variation is obtained, in nominal steps of 5.625 degrees. For convenience, the nominal phase angles are rounded to one decimal place, e.g. 5.6 degrees and 354.4 degrees, etc. Other sequences and step sizes are available.

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SUMMARY

Parameter	Type 1	Type 2	Type 3
Phase Shift	Independent of Frequency	Proportional to Frequency	Inverts Phase, 0°/180°
Group Delay	Constant with Frequency	Proportional to Phase Shift	Constant with Frequency
Bandwidth	Narrowband	Wideband	Wideband

COMMON BIT/PHASE SHIFT SEQUENCES

BIT	LSB ← → MSB							
2	90°	180°						
3	45°	90°	180°					
4	22.5°	45°	90°	180°				
5	11.2°	22.5°	45°	90°	180°			
6	5.6°	11.2°	22.5°	45°	90°	180°		
7	2.8°	5.6°	11.2°	22.5°	45°	90°	180°	
8	1.4°	2.8°	5.6°	11.2°	22.5°	45°	90°	180°

TYPICAL PERFORMANCE SPECIFICATIONS

Part Number	Type	# Bits	Center Frequency (MHz)	BW (MHz)	Bit Sequence see note 2 (Deg)	Phase ERR/Bit (Deg)	INS Loss see note 3 (dB)
DP-1-6-30-5-75	1	6	30	5	5.6, 11.2, 22.5, 45, 90, 180	± 2.0	6.0
DP-1-8-80-10-77	1	8	80	10	1.4, 2.8, 5.6, 11.2, 22.5, 45, 90, 180	± 1.0	8.0
DP-1-6-90-20-75	1	6	90	20	5.6, 11.2, 22.5, 45, 90, 180	± 2.0	6.0
DP-1-3-95-20-72	1	3	95	20	45, 90, 180	± 2.0	3.5
DP-3-1-150-120-70	3	1	150	120	180	± 1.0	1.5
DP-1-2-210-50-71	1	2	210	50	90, 180	± 2.0	3.0
DP-2-8-215-2-77	2	8	215	2	1.4, 2.8, 5.6, 11.2, 22.5, 45, 90, 180	± 1.3	8.0
DP-2-4-290-10-73	2	4	290	10	22.5, 45, 90, 180	± 1.5	4.0
DP-2-5-350-3-74	2	5	350	3	11.2, 22.5, 45, 90, 180	± 1.5	5.0
DP-2-7-575-12-76	2	7	575	12	2.8, 5.6, 11.2, 22.5, 45, 90, 180	± 1.5	7.0
DP-2-6-850-5-75	2	6	850	5	5.6, 11.2, 22.5, 45, 90, 180	± 2.8	6.5

Notes:

- All standard digital phase shifters have the following common specifications:
DC power supply requirements: +5V @ 20 mA, -5V @ 20 mA;
RF input power: +16 dBm max.;
Switching time: 100 nS max.
- Please specify bit sequence, if other than standards.
- Units with lower insertion loss are available for applications with RF input power of +5 dBm max.

Digital Phase Shifters

Part Number Description



- 1 DP** Series, Digital Phase Shifter
- 2 2** Type, See Description
- 3 8** Number of Bits
- 4 250** Center Frequency in MHz
- 5 20** Bandwidth in MHz
- 6 77** Package Style, See Outlines
- 7 75** Impedance, if other than 50 Ohms

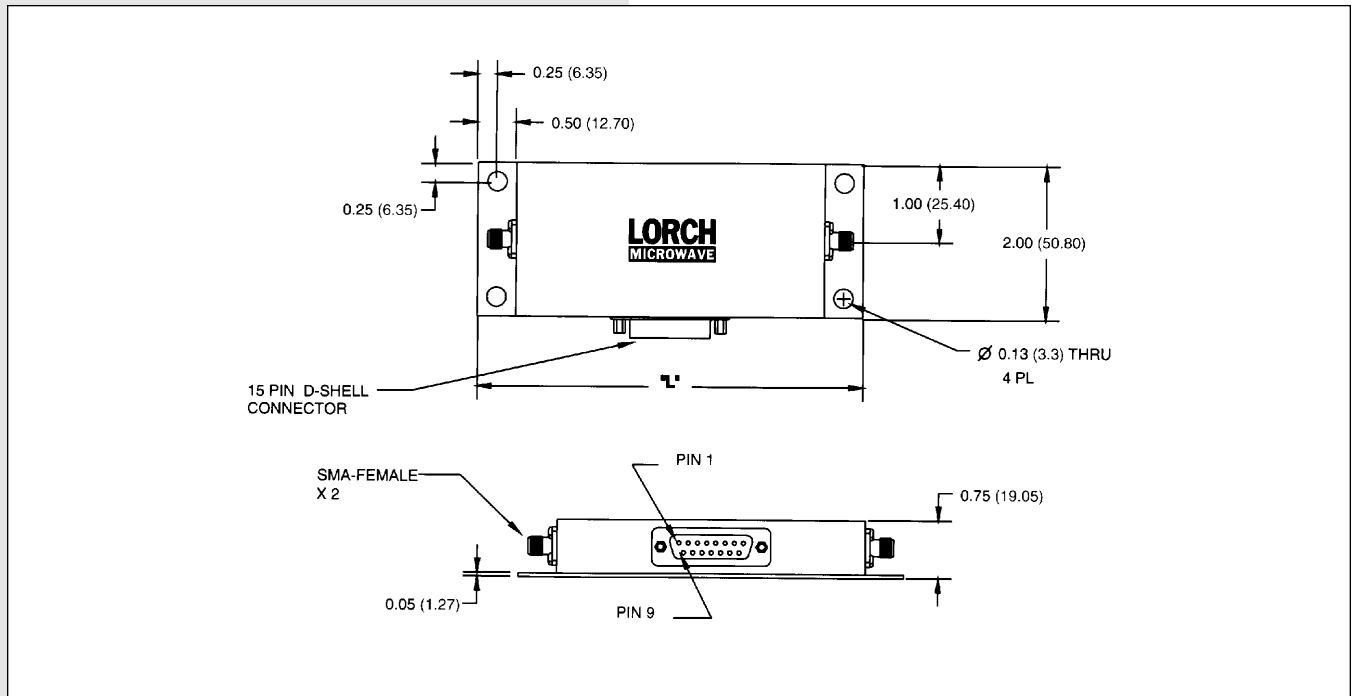
Creating a Part Number

Lorch Microwave's DP Series, Digital Phase Shifters, have descriptive part numbers indicating the important electrical characteristics that define the unit. A list of "standard" Digital Phase Shifters is given in the preceding sections. For specifications outside these operating parameters, please contact the factory.

Package Style	Length 'L' INS (mm)	# Bits
-70	3.0 (76)	1
-71	3.5 (89)	2
-72	4.0 (103)	3
-73	4.5 (114)	4
-74	5.0 (127)	5
-75	5.5 (140)	6
-76	6.0 (152)	7
-77	6.5 (165)	8

Power / Logic Pin Connections	
Pin	Function
1-8	Logic Inputs
9-12	GND
13	+5 VDC
14	-5 GDC
15	GND

OUTLINE, DIGITAL PHASE SHIFTER



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