Family of Curves Demonstrating Output Skews for Advanced BiCMOS Devices

Texas Instruments

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Introduction

The data in this paper demonstrates the skew between the outputs of a sample of Texas Instruments Advanced BiCMOS (ABT) devices. This explains which output skew is being examined, where the data for these curves comes from, and how the data is analyzed. Also, some of the errors that may be present in the data are discussed.

Skews

Skew is a term that is used to define the difference, in time, between two different signal edges. There are several different types of skew currently being used, they are defined in JEDEC 99 clause 2.3.5:

> **Output Skew** [$t_{sk(o)}$] – The difference between two concurrent propagation delay times that originate at either a single input or two inputs switching simultaneously and terminating at different outputs.
>
> **Input Skew** [$t_{sk(i)}$] – The difference between two propagation delay times that originate at different inputs and terminate at a single output.
>
> **Pulse Skew** [$t_{sk(p)}$] – The difference between the propagation delay times t_{PLH} and t_{PHL} when a single switching input causes one or more outputs to switch.
>
> **Process Skew** [$t_{sk(pr)}$] – The difference between identically specified propagation delay times on any two samples of an IC at identical operating conditions.
>
> **Limit Skew** [$t_{sk(l)}$] – The difference between: 1) The greater of the maximum specified values of t_{PLH} and t_{PHL} and 2) The lesser of the minimum specified values of t_{PLH} and t_{PHL}.

The skew discussed here is the skew of propagation delays across the outputs of a device. More specifically, it is the difference between the largest value obtained for a propagation delay and the smallest value across all of the outputs. For example, if output 3 has the largest propagation delay t_{PLH} and output 14 has the smallest, the output skew for this device would be the difference between the propagation delays for output 3 and output 14 (see Figure 1).

The majority of the curves presented in this paper consist of data taken on devices that have one output switching at a time. This produces a skew that should not be confused with the defined data sheet skew $t_{sk(o)}$. The data sheet value for $t_{sk(o)}$ is found by switching all of the outputs simultaneously. Two of the devices examined in this paper (′ABT16240 and ′ABT16500A) include curves which present $t_{sk(o)}$ data.

Source of Data

The data used to produce the curves presented in this paper was extracted from the characterization data bases used to set the data sheets for the devices presented. The sample size of the data base is approximately thirty devices for each characterization lot (wafer) used.

The data was sorted so that the maximum skew for each device at a particular V_{CC} and temperature combination could be determined. Next, the maximum skew values were averaged to produce a data point for each transition. Further statistical analysis of this data was performed to calculate a standard deviation of the maximum skew across the devices. This value was then used to produce a three standard deviations data point for each V_{CC} and temperature combination. The data is presented as a family of curves across V_{CC} with each member of the family being an output skew versus temperature curve. The curves for each device are broken out by output transition (i.e. t_{PLH}, t_{PHL}). Each transition is further separated into a set of curves depicting the average skew across the devices and a set representing the average skew plus three standard deviations.

For those devices (′ABT16952 and ′ABT16500A) that have registers, the data path chosen for each device was the path that put the device in a transparent mode. Also, for the bidirectional devices (′ABT16245, ′ABT16952, and ′ABT16500A), the A-to-B direction was used.

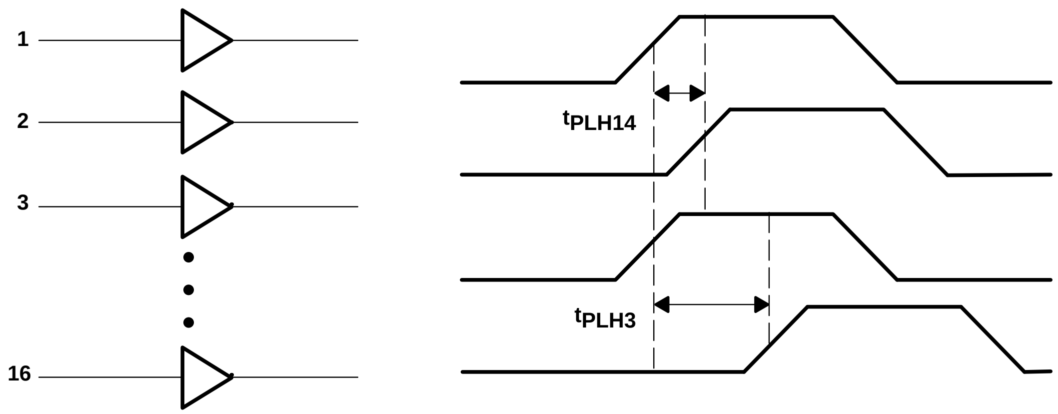


Figure 1. Skew = $|t_{PLH14} - t_{PLH3}|$

Sources of Error in Data

The data in this paper was taken on an IMPACT tester, which is a piece of automatic test equipment used to characterize integrated circuits. The tester is offset using a golden unit that has had data taken on a lab bench setup. It is this process of offsetting that is the main source of error in the data.

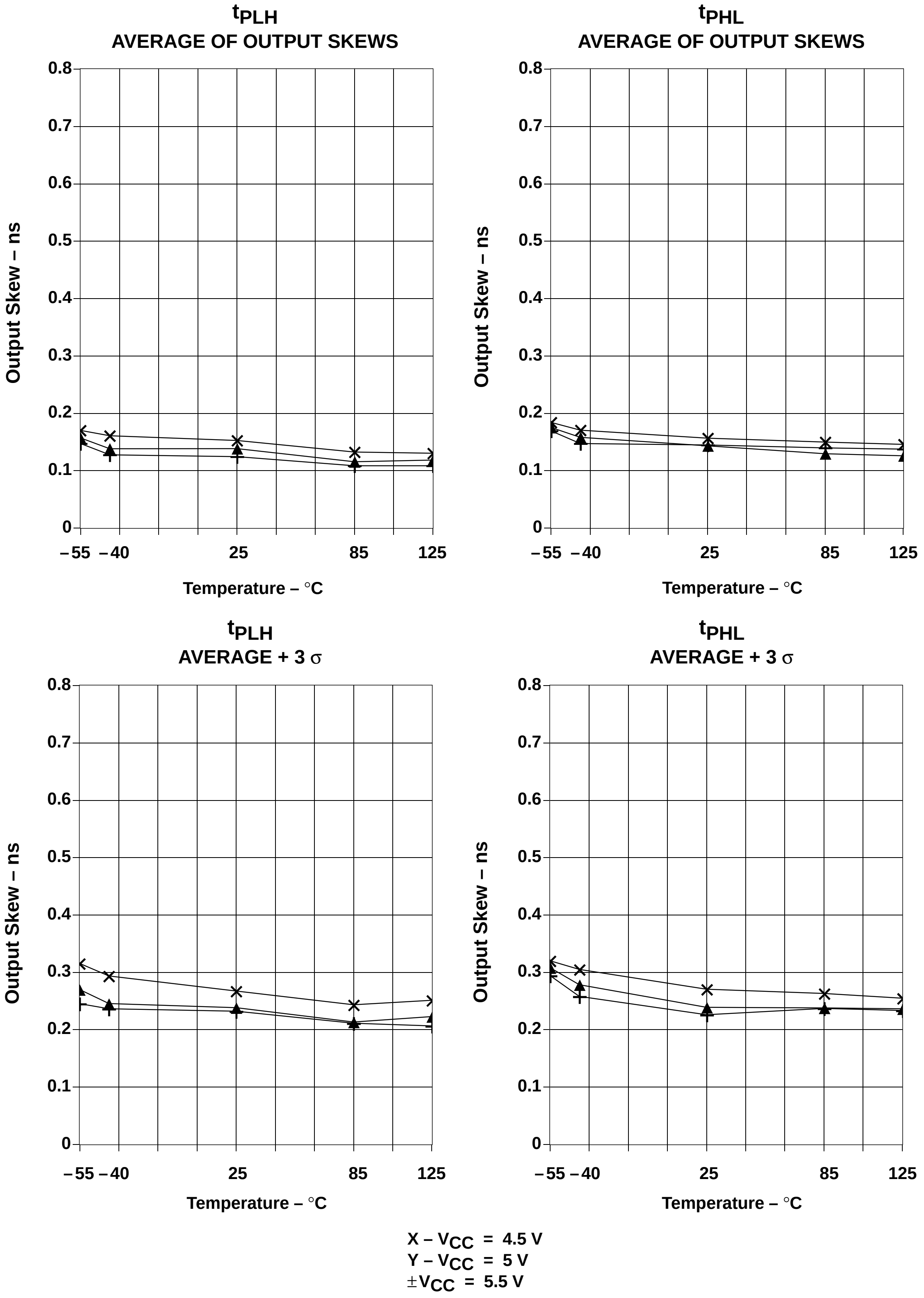
Briefly, the tester is offset in the following manner: The golden unit has its propagation delay measurements taken at 25°C and 85°C using a pulse generator as the source and an oscilloscope as the measurement unit. The golden unit is then placed on the IMPACT and the data is again taken. The difference between the two values is the offset. The 25°C offsets are used for the data taken at –55°C, –40°C and 25°C, while the 85°C offsets are used at 85°C and 125°C.

Great care is taken during this process to ensure that the induced error is kept to a minimum. For example, the boards are checked before use to ensure the output loads are correct, the oscilloscope is calibrated each day and the input signals are closely monitored to ensure that the intended signal is delivered to the golden unit.

This reduction in error is quite important in this application due to the fact that the average skews for the devices are about 200 ps. A 20-ps error in offsets translates into an approximate error of 10% in the output skew data. However, it can be seen in the curves presented here that the error has been kept to a minimum and that the curves are fairly well behaved.

Summary

The family of curves presented in Figures 2 through 9 demonstrates that the Texas Instruments Advanced BiCMOS family of devices can be expected to produce an average skew between outputs that remain below 400 ps for devices with single switching outputs. Also, when a device has its outputs switching simultaneously, the average skew across the outputs can be expected to remain below 700 ps.


t_{PLH} AVERAGE OF OUTPUT SKEWS

t_{PHL} AVERAGE OF OUTPUT SKEWS

t_{PLH} AVERAGE + 3 σ

t_{PHL} AVERAGE + 3 σ

Figure 2. ′ABT16240 – Single Switching

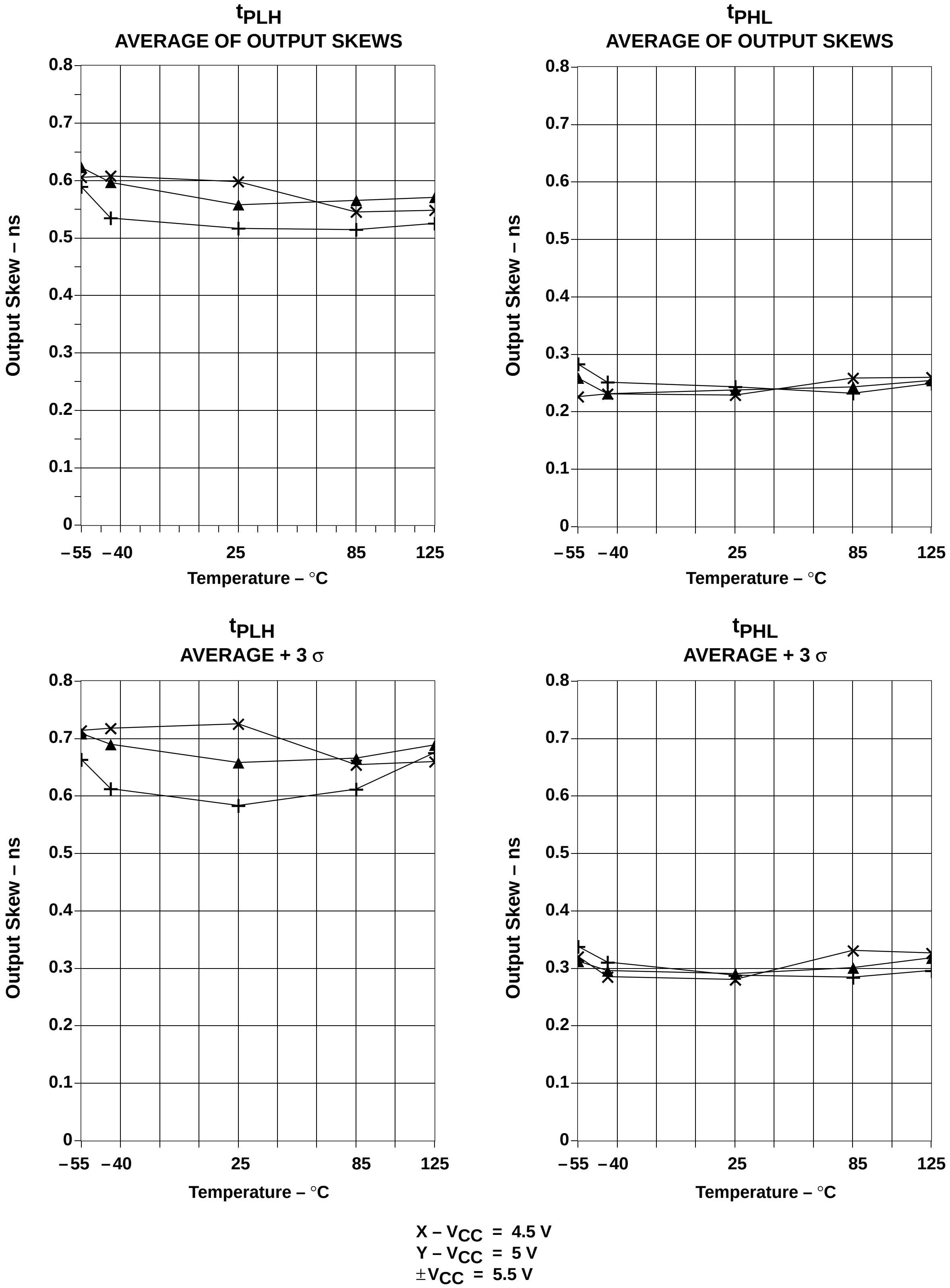


Figure 3. ′ABT16240 – Simultaneous Switching

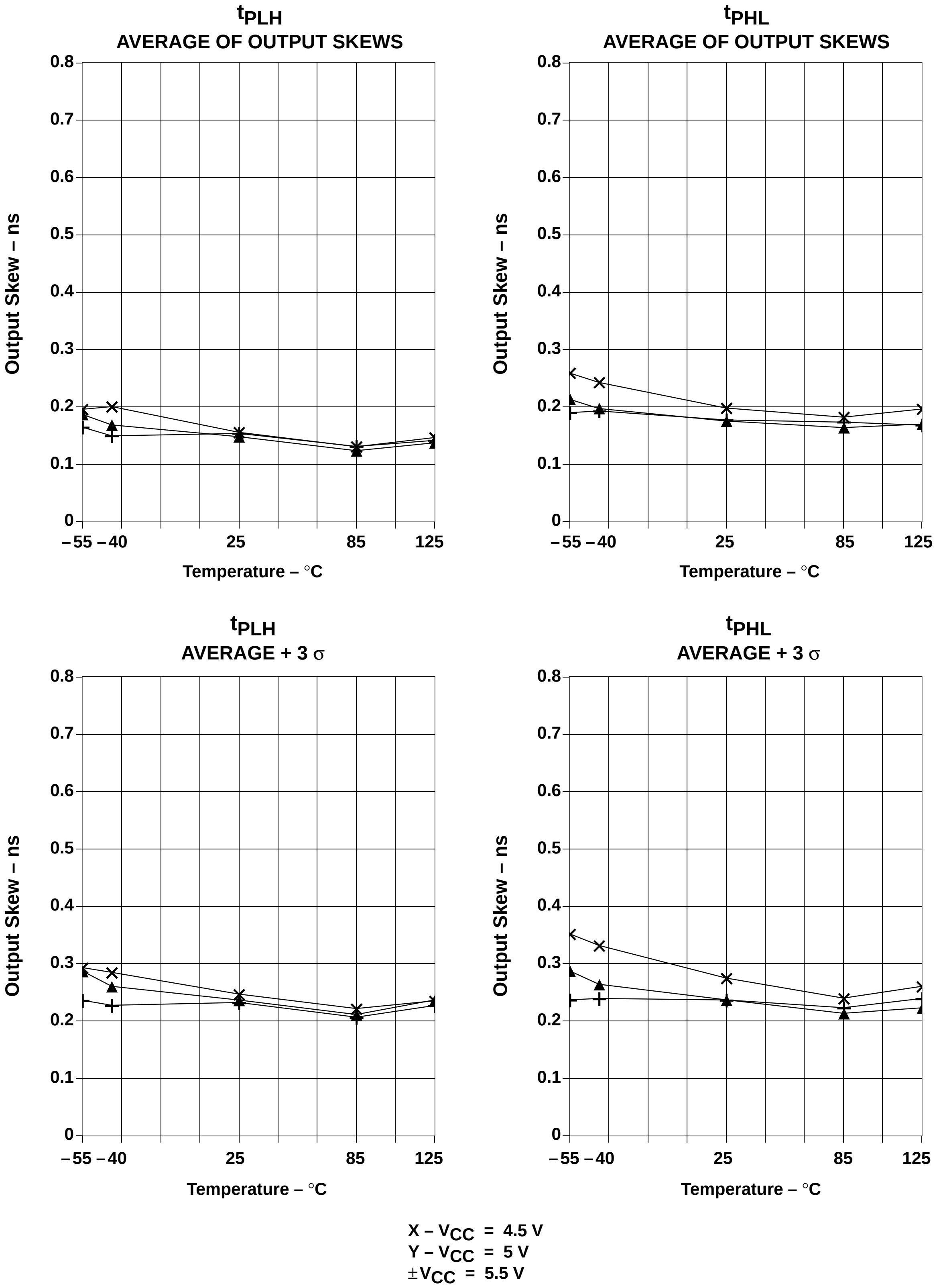


Figure 4. ′ABT16245 – Single Switching

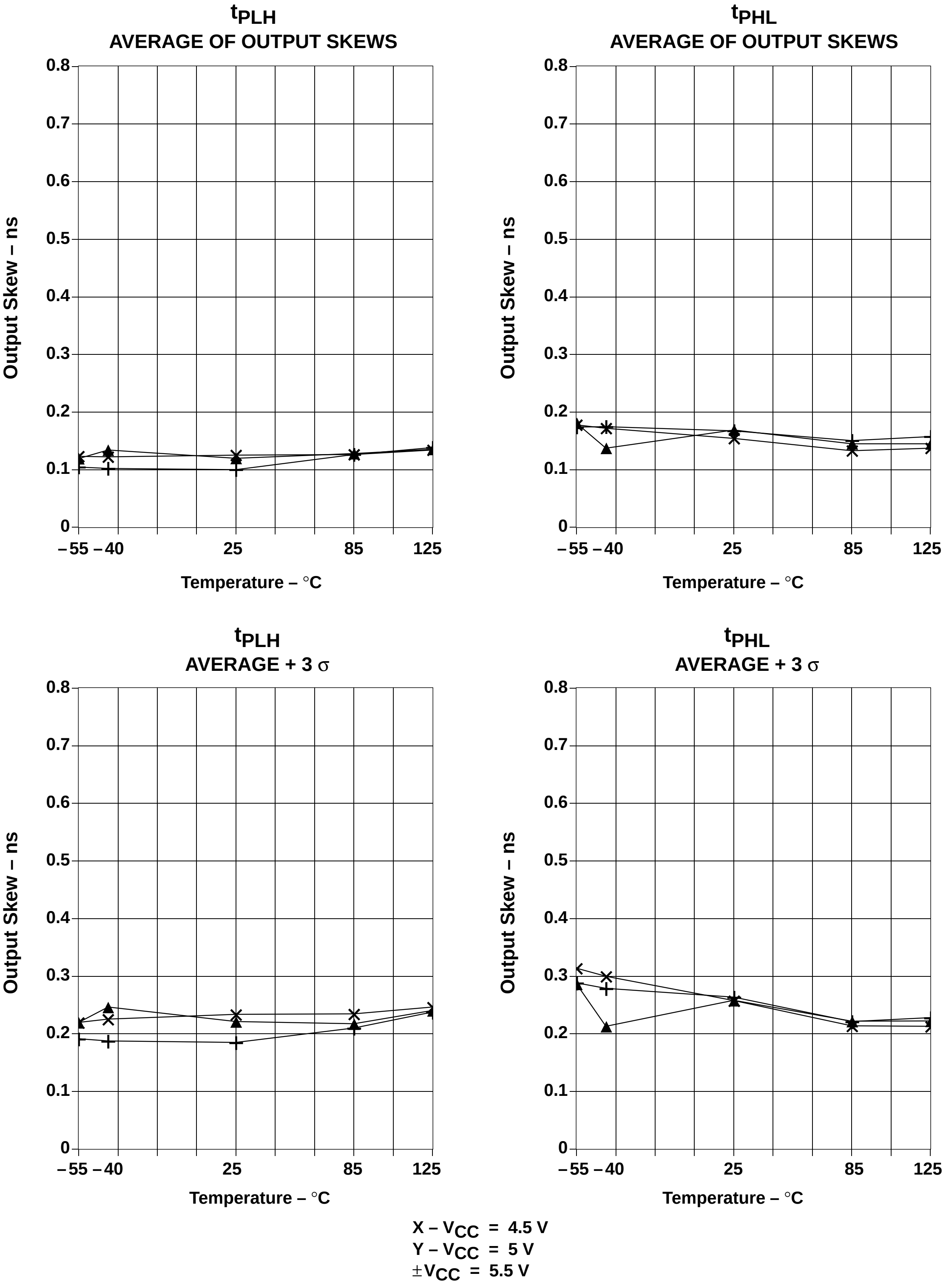


Figure 5. ′ABT16952 – Single Switching

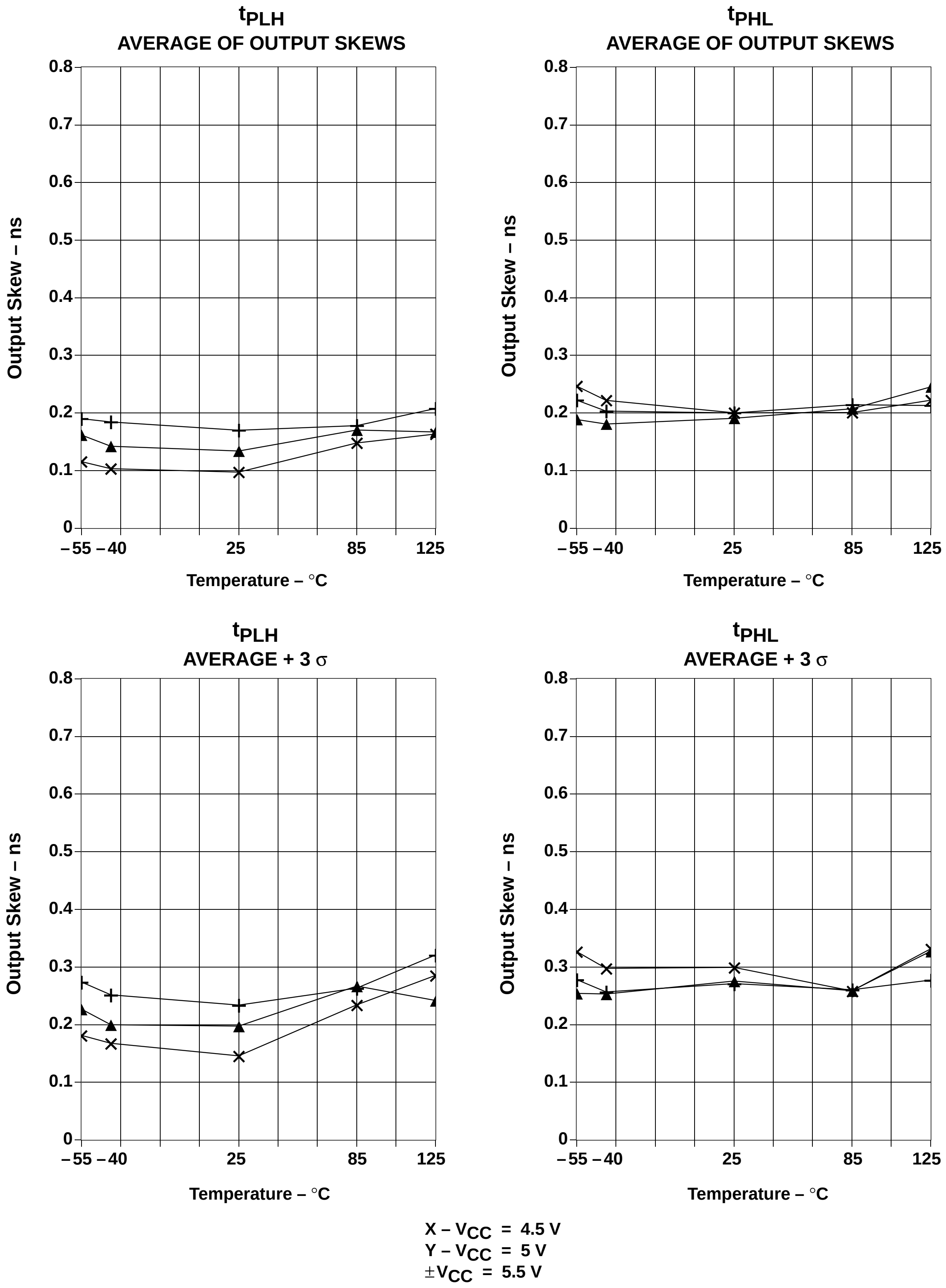
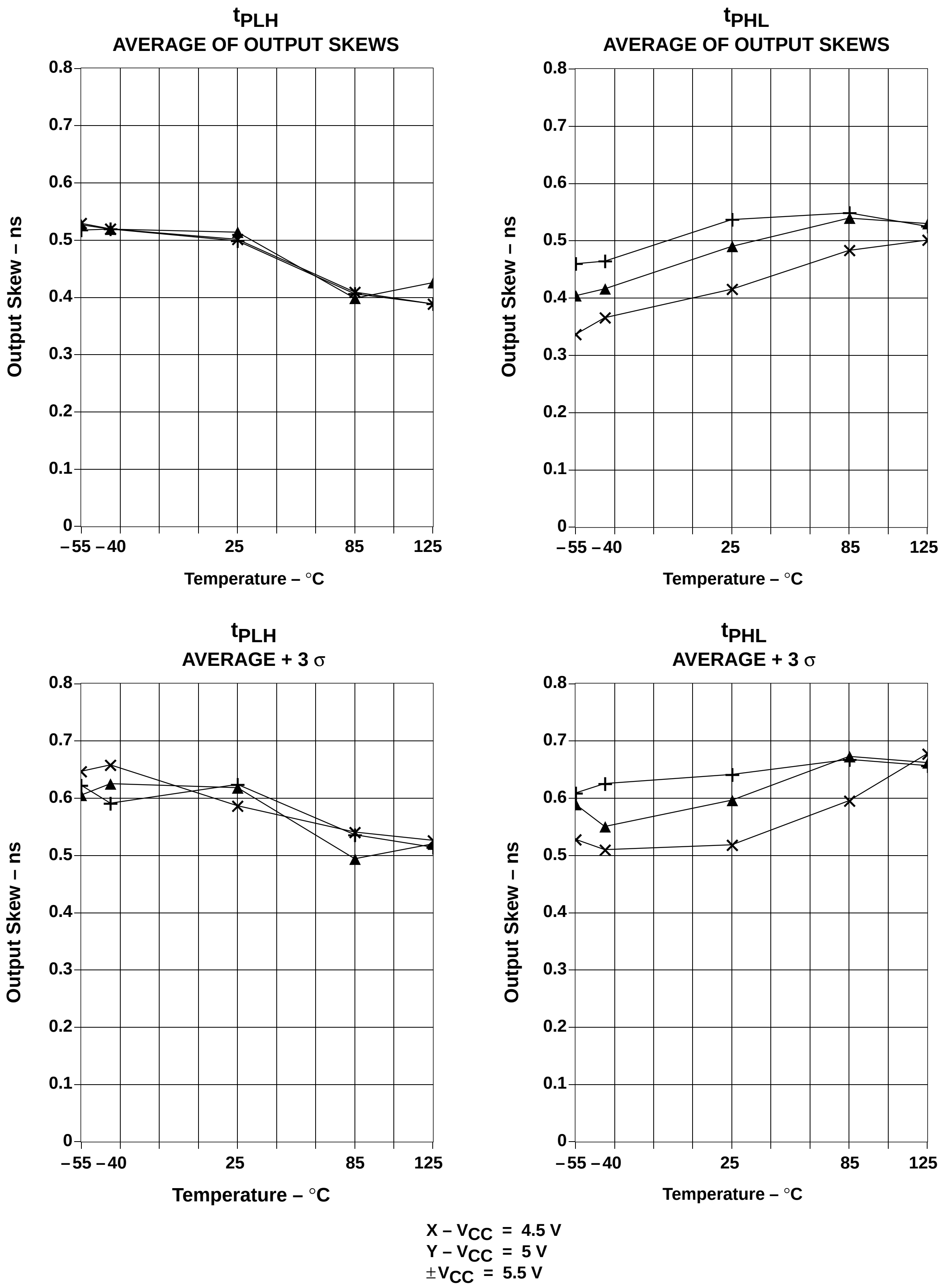


Figure 6. ′ABT16500A – Single Switching



t_{PLH} AVERAGE OF OUTPUT SKEWS

t_{PHL} AVERAGE OF OUTPUT SKEWS

t_{PLH} AVERAGE + 3 σ

t_{PHL} AVERAGE + 3 σ

Figure 7. ′ABT16500A – Simultaneous Switching

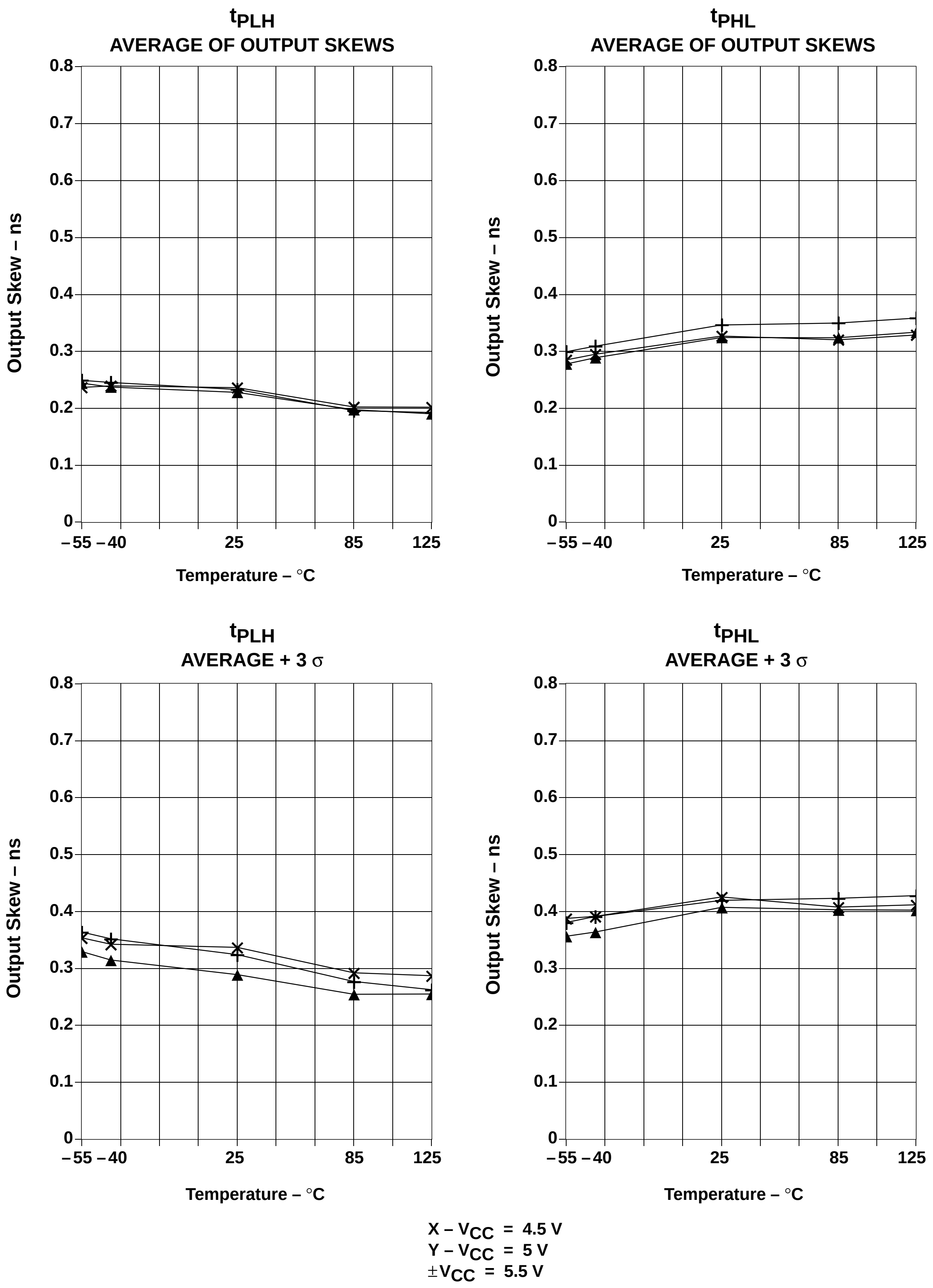


Figure 8. ′ABT244 – Single Switching

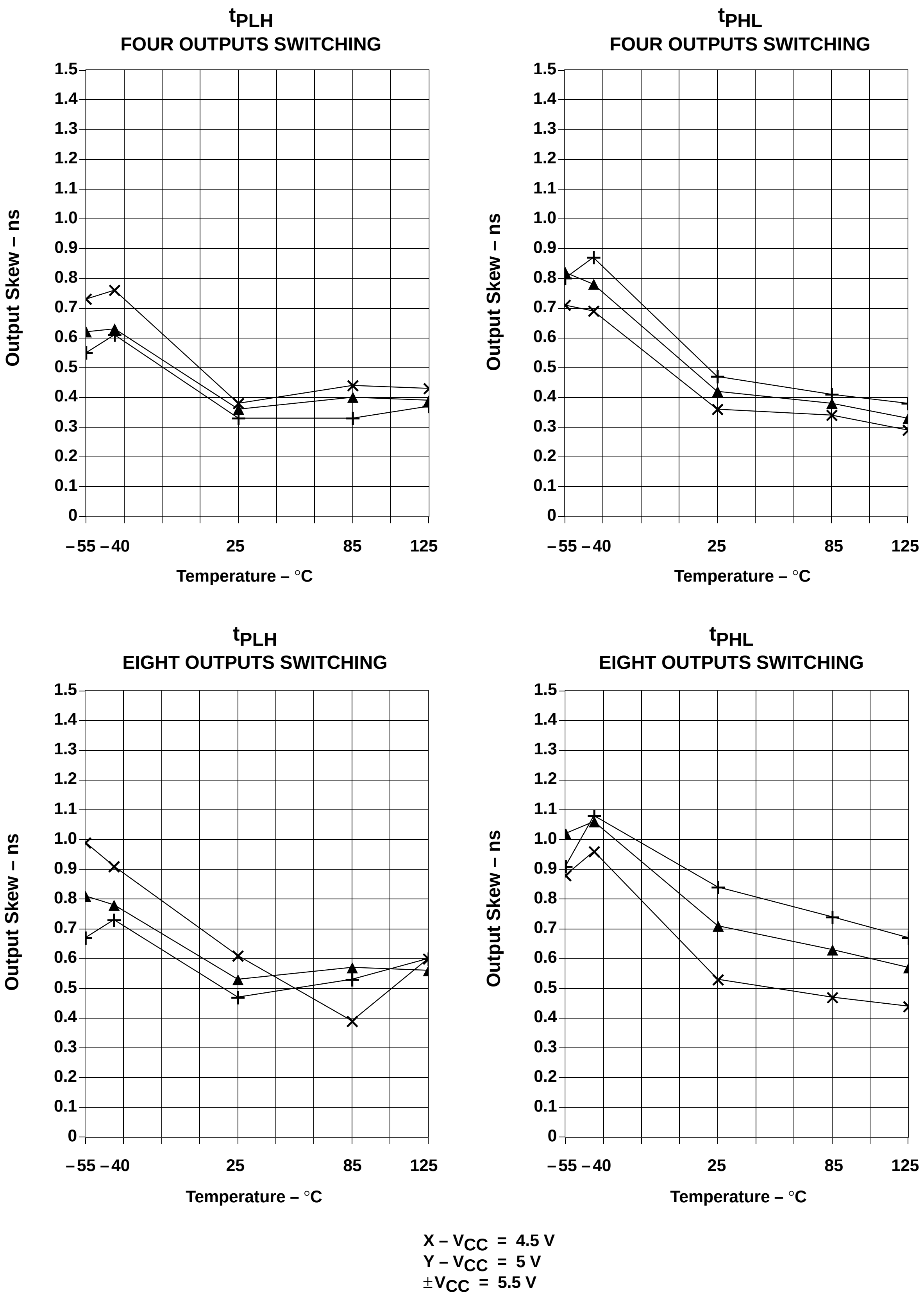


Figure 9. ′ABT244 – Multiple-Output Switching