VP Bericht - Elektronik D

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***Abstract*—**

CONTENTS

I. INTRODUCTION

In this experiment, some of the basic concepts of digital circuits are explored. Digital circuits contain logic gate. The gates transform a digital input signal into some digital output signal following a well defined functionality. The input and output signal are either "high/1" or "low/0". This is a main difference compared to the analogous circuits, which have a continuous range of input/output signals. In today's world gates play an important role in. Every digital circuit contains a few up to multiple billions of them.

TODO: Write something about IC.

Gates can be categorized by gate-family, that they belong to (e.g. TTL or CMOS) and some other specific properties. Gates perform different operations to "compute" the output signal based on some input signal. Also, gates differ in terms of propagation delay, which is the delay a change in one of the input signals takes to cause a change in the output signal. The propagation delay is very important when designing digital circuits.

In the following, the performed experiments are presented. The experiments describe how to determine the operation performed by a digital circuit and it's propagation delay, how a pulse generator is build and how to implement a very simple bit shifter logic.

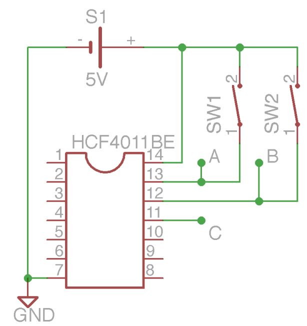

Fig. 1: Circuit diagram to measure truth table.

4011			4001		
A	B	C	A	B	C
0	0	1	0	0	1
0	1	1	0	1	0
1	0	1	1	0	0
1	1	0	1	1	0

Fig. 2: Truth table measuring IC HCF40011BE and HCF4001BE

II. EXPERIMENT SIMPLE LOGIC GATE

A. Samples and measurement setup

The circuit was setup as shown in figure 1. Based on the different input signals at A and B, different values for the output signal C were measured using a oscilloscope. As for the ICs, a HCF4001BE and HCF4011BE were used.

To measure the propagation delay, input signal A was connect to a square wave voltage generator. Input signal B was connected to ground. The IC HCF4001BE was used for this measurement. The voltage of the generator was set to 2.9V and the frequency to 1Hz. The input signal A and output signal C was visualized using a oscilloscope. The oscilloscope's trigger signal was connected to the voltage generator.

B. Results

For different input signals A and B, the truth-table was measured as shown in table 2.

The propagation delay was measured to be around 50ns as seen in figure 3.

C. Analysis and Discussion

Based on the measurements, the IC HCF4001BE seems to be a logic NOR gate, whereas the IC HCF4011BE seems to function as a NAND gate. This fits with the specified functionality of the gates.

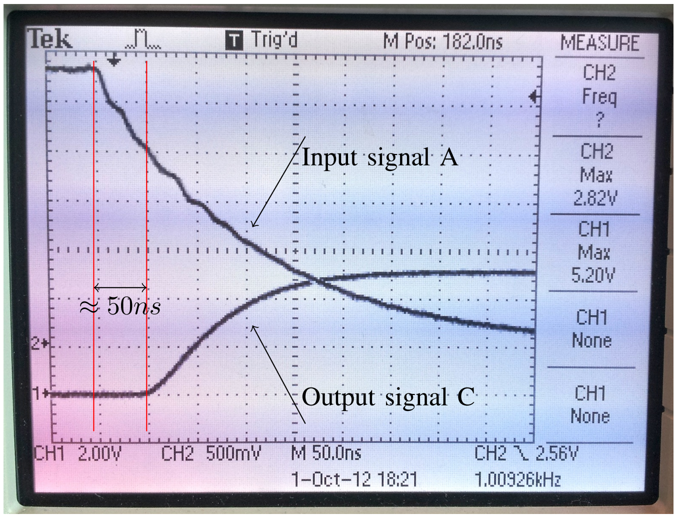

Fig. 3: Propagation delay measurement.

Looking up the propagation delay from the data sheet, it is said to be typically around 40ns and up to 75ns. This fits with the here measured delay.

III. Pulse Generator

A pulse generators are used to create rectangular, periodic voltage signals. In this experiment, such a generator was build and its properties examined.

A. Samples and measurement setup

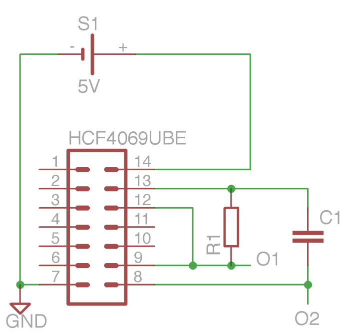

Fig. 4: Circuit diagram of astable multivibrator.

The circuit was assembled as shown in figure 4. Here, the IC HCF4069UBE was used, which contains six NOT gates. The voltage difference between the output signals $O1$, $O2$ and the ground was quantified using an oscilloscope. This also allowed to visualize and measure the period of the oscillations. Different values for the resistance $R1$ and the capacity $C1$ were chosen and the resulting period of the voltage signals determined.

B. Functionality explanation

A schematic drawing of the circuit is presented in figure 5. The explanation follows the one given in [BOOK]. Let's assume the voltage at $O1$ is set to be *high* and the capacitor is uncharged. Due to the *high* signal at $O1$, the signal at $O2$ is

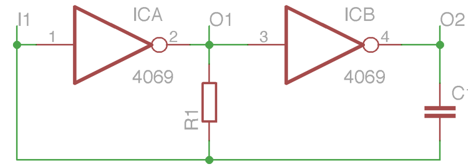

Fig. 5: schematic drawing of the astable multivibrator circuit.

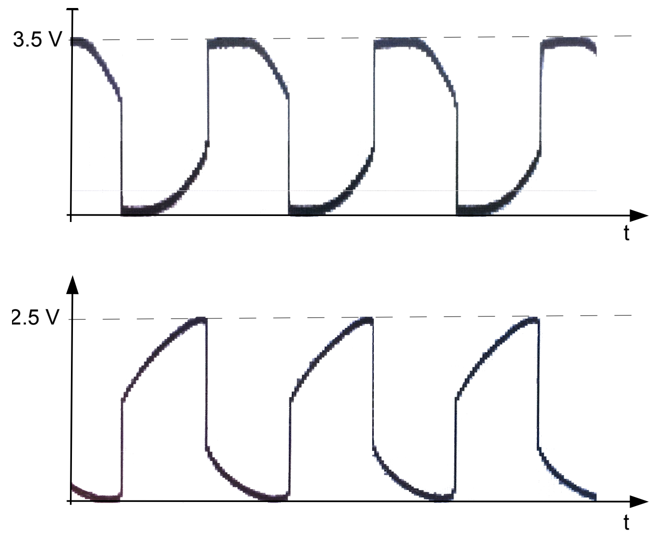

Fig. 6: Timing diagram. Up: Voltage signal at $O1$; bottom: Voltage signal at $O2$.

low. Over the resistance $R1$ the capacitor is charged. At some point, the voltage at $I1$ is high enough, such that the input signal of ICA is recognized as *high*. This causes the signal at $O1$ to become *low* and therefore the signal at $O2$ to be *high*. The charged capacitor discharges, which keeps the *high* signal at the $I1$ input for some time until the voltage on the capacitor is to low, such that the signal at $I1$ is recognized as a *low* signal, the signal at $O1$ becomes a *high* one and things start over again.

C. Results

The time diagram for the voltage at $O1$ and $O2$ is visualized in figure 6. In table 7 different period times t due to different choices of resistance R and capacity C are listed. The values for the resistances and the capacities shown here are excluding a manufacturing error of roughly up to 10%. Some of the capacities were more precise measured and are listed in the $C*$ column.

D. Analysis and Discussion

The k-value is defined as

$$k = \frac{t}{R \cdot C} \tag{1}$$

where t is the period time, R is the resistance of the resistor R *and* C *is the capacity of the capacitor* C. Based on the measurements, the k-values are computed in table 7 in the k column. For the more precisely measured capacities $C*$, the k-value $k*$ was computed using the $C*$ value.

R [kOm]	C [nF]	C* [nF]	t [us]	k [s/(Om F)]	k* [s/(Om F)	Lit – <k*>
1.0	56	59.7	178	3.18	2.98	
1.0	100	90	265	2.65	2.94	
1.0	220	216	638	2.90	2.95	0.76
1.0	1000		2788	2.79		
1.8	56	59.7	288	2.86	2.68	
1.8	100	90	430	2.39	2.65	
1.8	220	216	1040	2.63	2.67	0.48
1.8	1000		4600	2.56		
3.3	56	59.7	468	2.53	2.38	
3.3	100	90	700	2.12	2.36	
3.3	220	216	1690	2.33	2.37	0.17
3.3	1000		7700	2.33		
39.0	1000		69760	1.79		
47.0	220	216	19600	1.90	1.93	-0.27
120.0	220	216	47520	1.80	1.83	-0.36
120.0	1000		212200	1.77		
150.0	220	216	58370	1.77	1.80	-0.40
*) = Corrected			**Average:**	2.37	2.46	
			Std. Deriv.:	0.45	0.43	

Fig. 7: Measurement of period time t as function of resistance R and capacity C.

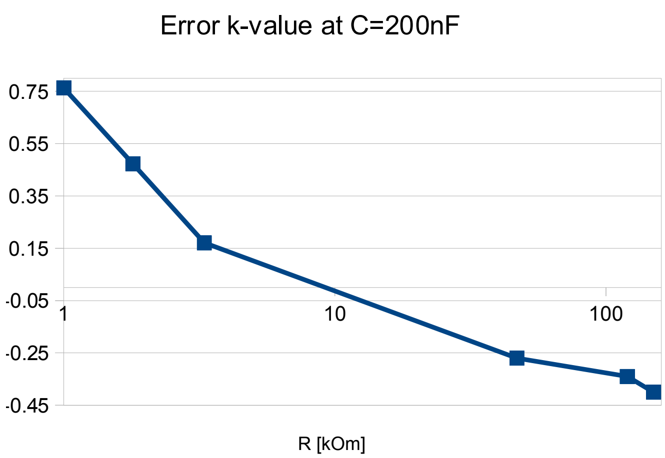

Fig. 8: Measurement of period time t as function of resistance R and capacity C.

As mentioned in [BOOK], the relation between t and the other quantities is given by

$$t = 2\ R\ C\ \ \ln(3) \approx 2.2\ R\ C \tag{2}$$

which gives the value of k using 1

$$k = 2\ \ln(3) \approx 2.2 \tag{3}$$

The average values of k and $k*$ given in table 7 match very well with the expected values for k. Using the standard derivation of the average as an indicator for the uncertainty of the here measured k and $k*$ values, the literal value is within the range of average +- standard derivation. However, the standard derivation is larger then 1/10 of the average value. This indicates a high uncertainty.

The last column $Lit - k*$ holds the difference between the literature value 3 and the calculated $k*$ value and therefore a simple error estimation between measurement and literature value. The error is calculated for the same capacitor $C = 200nF$. A plot of these errors is shown in 8. The X-axis is plotted logarithmically. The shape of the curve suggests a exponential relation between R and the error. As the $k*$ values are roughly the same for different choices of C, this might be an indication, that the error is mostly related to the choice of the resistance. The reason for this correspondence remained unclear to the author.

E. *Schlussfolgerung und Ausblick*

IV. Die Messmethode und der experimentelle Aufbau

V. Die Messergebnisse

References

[BOOK] U. Tietze, C. Schenk *Halbleiter-Schaltungstechnik*. Springer, sechste, neue Überarbeitete und erweiterte Auflage (1983), pp 176-177