DISSERTATION

Cool Science

ausgeführt am Atominstitut

der Technische Universität Wien
Fakultät für Physik

unter der Anleitung von
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durch

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Wien, am 25.04.2020

"The Setesh guard's nose drips."
TEAL'C

Contents

1 Deflection Electronics

1.1 Demands on the setup

For the QuaK experiment it is paramount to be able to deflect the beam precisely and with the right frequency. As previously mentioned, our deflection system simply consists of two pairs of parallel plates between which a voltage is applied . Controlling this voltage allows us to control the deflection of the beam. Various aspects are important here (illustated in figure 1.1):

Optional: inser Foto of CRT's flection plates fig:DeflectionSe

Offset: Although the deflection of the beam is controlled by the voltage between the plates, it is necessary to be able to set their mean potential as well During normal operation this offset voltage is at 96 V for the x-direction and at 78 V for the y-direction.

Amplitude: The deflection coefficients in the x and y planes are $19\,\mathrm{V\,cm^{-1}}$ and $11.5\,\mathrm{V\,cm^{-1}}$ respectively (see [2]). We therefore need to be able to supply approximatety 70 V.

Frequency: The final goal is to be able to deflect the beam at the hyperfine splitting frequency of ^{39}K, which is 461.7 MHz. This is likely to prove impossible with this CRT-model, observaions at the highest frequency we have tried so far will be discussed in section (Missing).

Insert Referenc last section

Waveform: Ultimatey we want the cold atoms to experience a field that oscillates like a sine wave. As a first try it is therefore reasonable to apply a sinusoidal voltage.

Lissajous curves: Having the ability to control the deflection in both the x- and the y- axis, allows us to have our beam draw out Lissajous Curves. By applying sine waves of equal frequency to both pairs of deflection plates and by being able to control the phase between them we can have the beam oscillate on a straight line or a cricle. This allows us to generate either a linearly or cirularly polarized field.

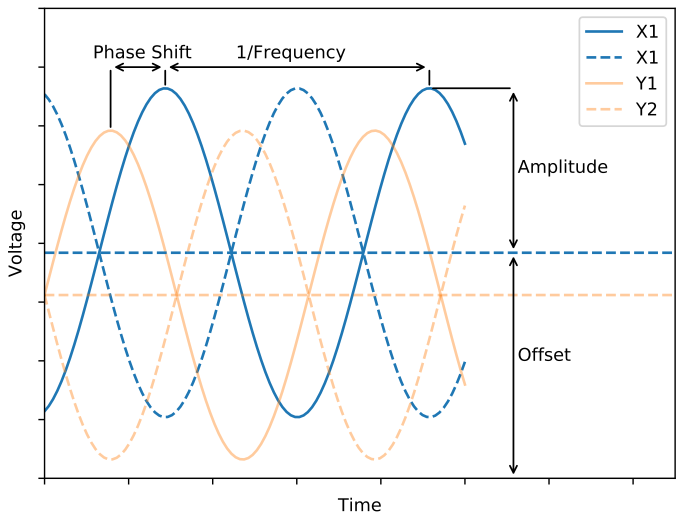

Figure 1.1

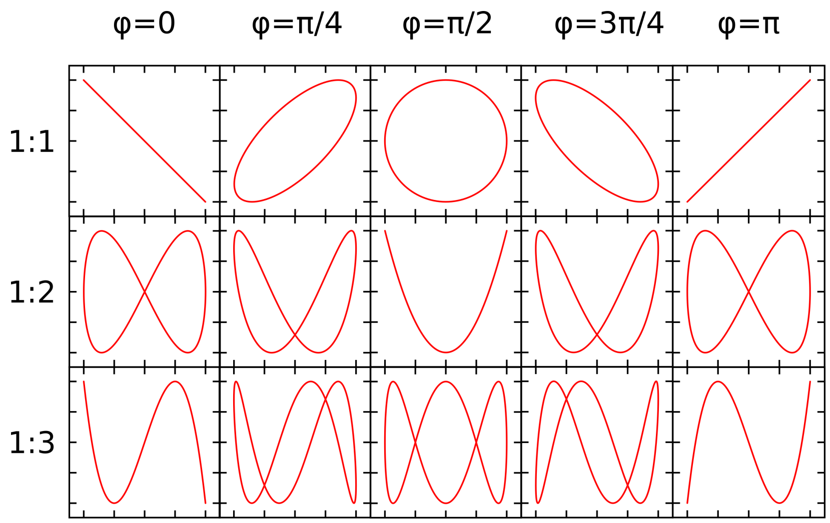

Figure 1.2: from [**Wikipedia Lissajous**]

1.2 Implementation

A first setup with which we can try to obtain the desired voltages is depicted in figure 1.3. On the very left we have a signal generator that is capable of producing the right frequency (461.7 MHz) this signal is then split up into an x- and a y-branch. One of the to branches is connected to a phase shifter, which is able to delay the input signal by up to 200°, allowing us to set any desired phase shift between x- and y-deflection and to correct for inadvertent delays from the other electronics. Both the x- and the y-signal are then amplified using (amplifier) . In the final step, a center tapped transformer allows us to produce to voltages for the plates X1 and X2 (or Y1 and Y2 respectively) with a phase shift of exactly 180° between them. By setting the center tap to the desired offset potential, we should get the voltage curves described above. To understand this setup in more detail, it is useful to examine its most important parts more closely:

Find out which
plifier

Amplifier: Up to now we have used the XXX and the YYY amplifier, they amplify the signal by a fixed gain of (How much?) , intputs and outputs can simply be connected via BNC cables, the amplifier is powered by a linear power supply with a DC voltage of 24 V via two banana plugs in the front. As we want to be control the shapes of the Lissajous curves (and as the deflection coefficients for the x- and y- plates differ) it is desireable to be able to adjust the gain of the amplifiers in future versions of the setup.

which model?

which model?

Check amplifie
specifications

Optional: Go t
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with an Oszi.

Center Tapped Transformer: The center tapped transformer we use is the Mini-Circuits TC8-1G2+ ([**TC8-1G2**]), a transformer for frequencies of 2 MHz to 500 MHz, with a winding ratio of 1 to 8. Figure 1.6 shows how the center tapped transformer is implemented. The in- and outputs, as well as the bias voltage can be connected via BNC cables. As usual, the shields of all of these cables are connected to ground, furthermore they are connected to each other and to the housing. As a safety feature, both outputs X1 and X2 are directly connected to the bias through an arrangement of diodes: Two connections, each with a normal diode and a Zener diode facing in opposite directions. The breakthrough voltage of the Zener diode is 200 V, during normal operation the voltage on it stays below this value and none of the connections let any current through as one of the two diodes is always blocking it. However if one of the plates in the CRT accidentally comes in contact with high voltage, the connection with the appropriately oriented Zener diode opens up, preventing a voltage spike on the center tapped transformer and thereby protecting the electronics connected to its primary circuit.

At the point of writing there are still some problems with the behaviour of the senter tapped transformer, the capacitances of the diodes introduce an undesired

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is better.

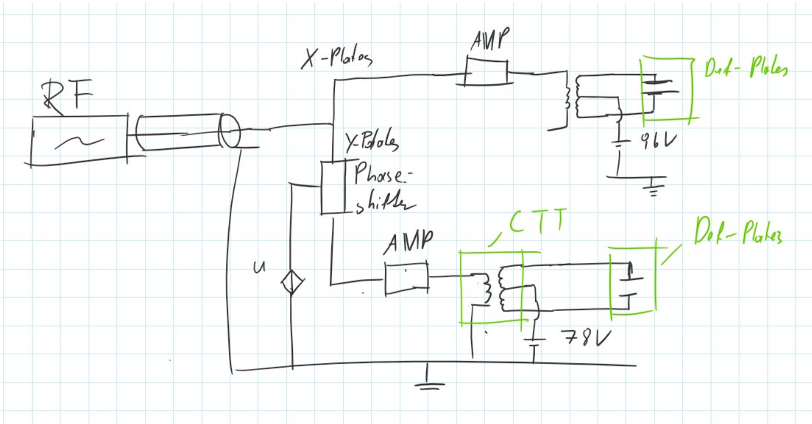

Figure 1.3: Deflection circuit

phaseshift between the two signals. Figure 1.5a shows the circuit's behaviour at 465 MHz without its diodes, here the signals are shifted by 120 ps = 20° = 0.35 rad. Additionally, applying a bias voltage leads to differing amplitudes, as can be seen in figure 1.5b.

Optional: Go b to the Lab and the problem wi the diodes?

Phase Shifter: To control the phase shift between the x- and y-deflection plates, we use a Mini-Circuits [**JSPHS-661**] phase shifter. This part was put in a housing ([**Hammond1455D601RD**]) on a separate PCB and can be connected via BNC cabels. Figure 1.4a shows how the phase shifter is connected and figure 1.4b shows the corresponding PCB layout. Note that again the shields of the BNC cables are connected among each other and to the housing. The JSPHS-661+ is designed for frequencies in the range 400 MHz to 600 MHz. By applying a DC voltage of 0 V to 12 V to the bias connector, it is possible to introduce a phase shift of up to 200° to the signal.

(figure)

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(Performance)

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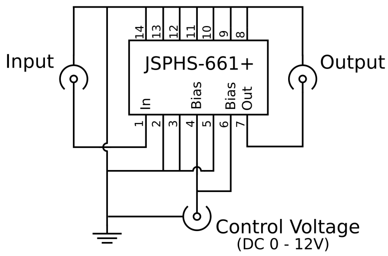
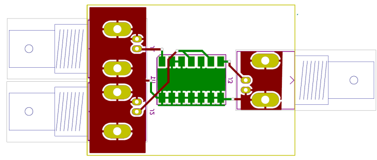
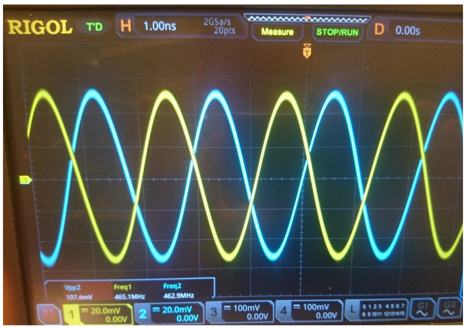


(a)



(b)

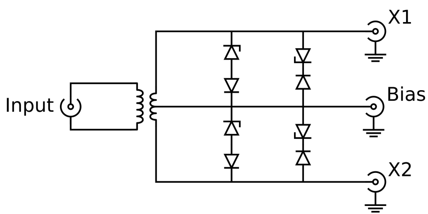
Figure 1.4



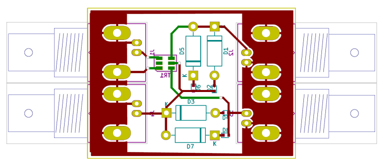
(a) Signal of center tapped transformer without diodes, unbiased at 465 MHz

(b) Signal of center tapped transformer without diodes, unbiased at 465 MHz

Figure 1.5



(a)



(b)

Figure 1.6

Todo list

References

[1] Wolfgang Demtröder. *Experimentalphysik 3*. Springer-Lehrbuch. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg, 2009. Chap. 2.6.1.

[2] Frank Philipse. *D14363GY123*. URL: https://frank.pocnet.net/sheets/186/d/D14363GY123.pdf (visited on 03/10/2020).

[3] Jerry C. Whitaker and Fla. [Verlag] CRC Press Boca Raton. *Power vacuum tubes handbook*. Third edition. Electronics handbook series. Boca Raton, FL: CRC Press. Chap. 3.5.2.1.

[4] Chuck deVere. *Cathode-Ray Tubes*. 1969.