DISSERTATION

Cool Science

ausgeführt am Atominstitut

der Technische Universität Wien
Fakultät für Physik

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durch

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

Contents

1 Deflection Electronics **1**
1.1 Demands on the setup 1
1.2 Implementation 2

Todo list **6**

References **7**

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 (illustrated in fig. 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 [1]). We therefore need to be able to supply approximately 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, observations at the highest frequency we have tried so far will be discussed in section (Missing).

Insert Referenc last section

Waveform: Ultimately 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 (fig. 1.2). 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 circle. This allows us to generate either a linearly or circularly polarized field.

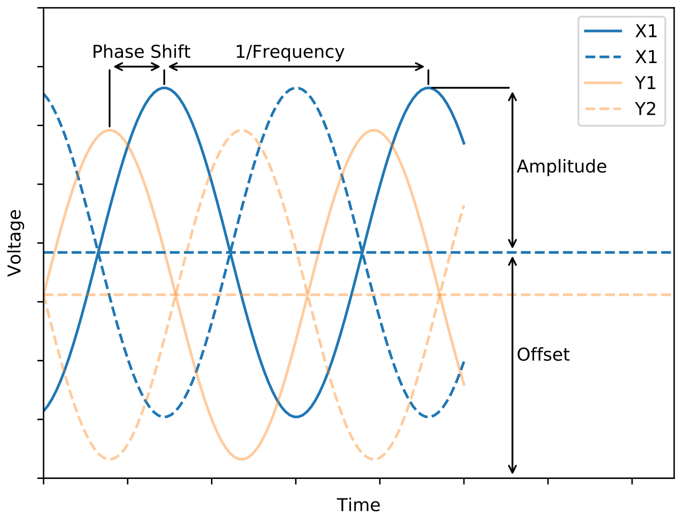

Figure 1.1

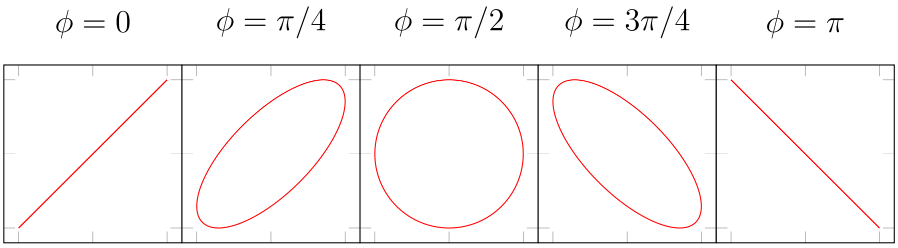

Figure 1.2: Lissajous Curves

1.2 Implementation

A first setup with which we can try to obtain the desired voltages is depicted in fig. 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 two 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 y-signal are then amplified using (amplifier) . In the final step, a center tapped transformer allows us to produce 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.

Find out which plifier

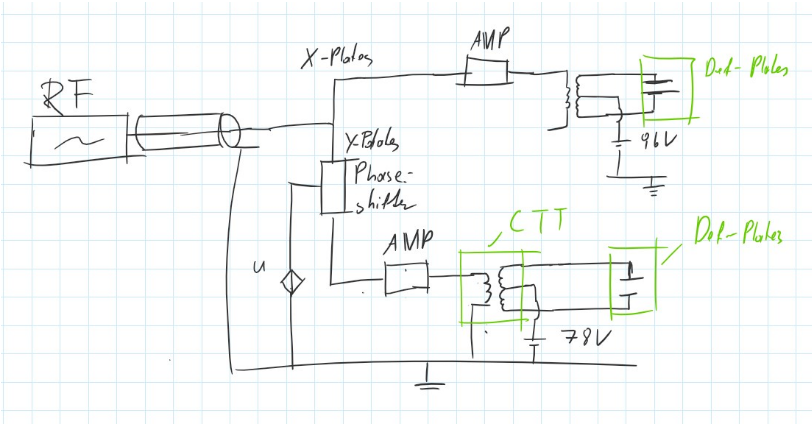

Figure 1.3: Deflection circuit

To understand this setup in more detail, it is useful to examine its most important parts more closely:

Amplifier: Up to now we have used the XXX and the YYY amplifier, they amplify the signal by a fixed gain of (How much?) , inputs 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. Since we want to control the Lissajous curves shapes (as the deflection coefficients for the x- and y- plates differ), it is desirable to be able to adjust the amplifier gain in future versions of the setup.

which model?

which model?

Check amplifier specifications

Optional: Go t lab and measur their performan with an Oszi.

Center Tapped Transformer: The center tapped transformer we use is the Mini-Circuits TC8-1G2+ ([3]), a transformer for frequencies between 2 MHz to 500 MHz, with an impedance ratio of 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 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.

I don't really k whether a high sistance bias or low resistance is better.

At the point of writing there are still some problems with the behavior of the

(a) **(b)**

Figure 1.4

center tapped transformer, the capacitance of the diodes introduces an undesired phase shift between the two signals. Figure 1.5a shows the circuit's behavior at 465 MHz without its diodes, here the signals are shifted by 120 ps $\hat{=}$ 20° = 0.35 rad. Additionally, applying a bias voltage leads to differing amplitudes, as can be seen in fig. 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 [4] phase shifter. This part was put in a housing ([5]) on a separate PCB and can be connected via BNC cables. Figure 1.4a shows how the phase shifter is connected and fig. 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)

Insert fotos of f ished circuits in housings

(Performance)

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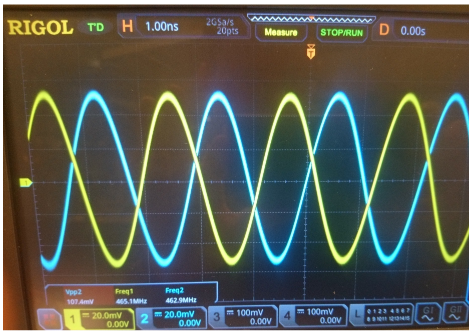
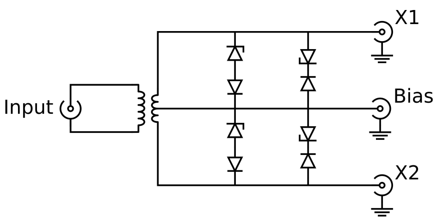


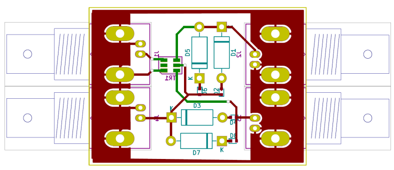
(a) Signal of center tapped transformer without diodes, unbiased at 465 MHz

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

Figure 1.5



(a)



(b)

Figure 1.6

Todo list

- Optional: insert Foto of CRT's deflection plates - fig:DeflectionSetup 1
- Insert Reference to last section 1
- Find out which amplifier 2
- which model? 3
- which model? 3
- Check amplifier specifications 3
- Optional: Go to the lab and measure their performance with an Oszi. 3
- I don't really know whether a high resistance bias or a low resistance bias is better. 3
- Optional: Go back to the Lab and fix the problem with the diodes? 4
- Insert fotos of finished circuits in housings 4
- Optional: Go back to the Lab, set up the whole thing and look at its performance on the oszi 4

References

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

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[4] Mini-Circuits. *JSPHS-661+ Data Sheet*. URL: https://www.minicircuits.com/pdfs/JSPHS-661+.pdf (visited on 05/05/2020).

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