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UNIVERSITÄT
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DISSERTATION

Cool Science

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der Technische Universität Wien
Fakultät für Physik

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Wien, am 05.05.2020

“The Setesh guard’s nose drips.”
TEAL’C

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¹ 1 Deflection Electronics

² 1.1 Demands on the setup

³ For the QuaK experiment it is paramount to be able to deflect the beam precisely
⁴ and with the right frequency. As previously mentioned, our deflection system simply
⁵ consists of two pairs of parallel plates between which a voltage is applied . Controlling
⁶ this voltage allows us to control the deflection of the beam. Various aspects are
⁷ important here (illustrated in fig. 1.1):

Optional: insert
Foto of CRT's
flection plates -
fig:DeflectionSe

⁸ **Offset:** Although the deflection of the beam is controlled by the voltage between the
⁹ plates, it is necessary to be able to set their mean potential as well. During
¹⁰ normal operation this offset voltage is at 96 V for the x-direction and at 78 V for
¹¹ the y-direction.

¹² **Amplitude:** The deflection coefficients in the x and y planes are 19 V cm^{-1} and
¹³ 11.5 V cm^{-1} respectively (see [1]). We therefore need to be able to supply approx-
¹⁴ imately 70 V.

¹⁵ **Frequency:** The final goal is to be able to deflect the beam at the hyperfine splitting
¹⁶ frequency of ${}^{39}\text{K}$, which is 461.7 MHz. This is likely to prove impossible with this
¹⁷ CRT-model, observations at the highest frequency we have tried so far will be
¹⁸ discussed in section (Missing).

Insert Reference
last section

¹⁹ **Waveform:** Ultimately we want the cold atoms to experience a field that oscillates like
²⁰ a sine wave. As a first try it is therefore reasonable to apply a sinusoidal voltage.

²¹ **Lissajous curves:** Having the ability to control the deflection in both the x- and the
²² y- axis, allows us to have our beam draw out Lissajous Curves. By applying sine
²³ waves of equal frequency to both pairs of deflection plates and by being able to
²⁴ control the phase between them we can have the beam oscillate on a straight
²⁵ line or a circle. This allows us to generate either a linearly or circularly polarized
²⁶ field.

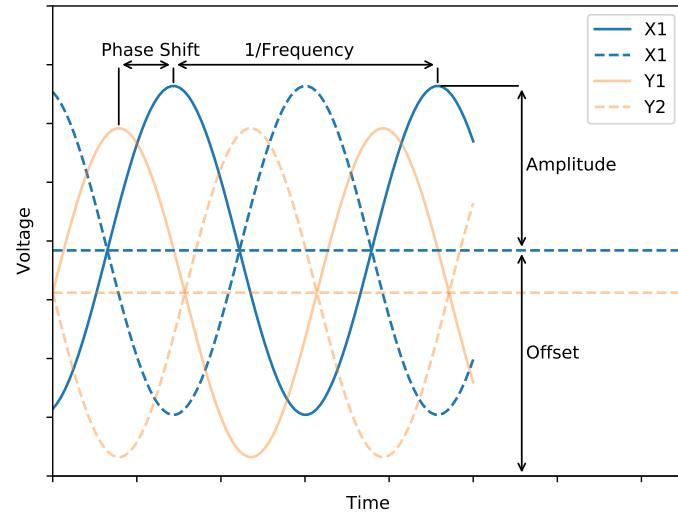


Figure 1.1

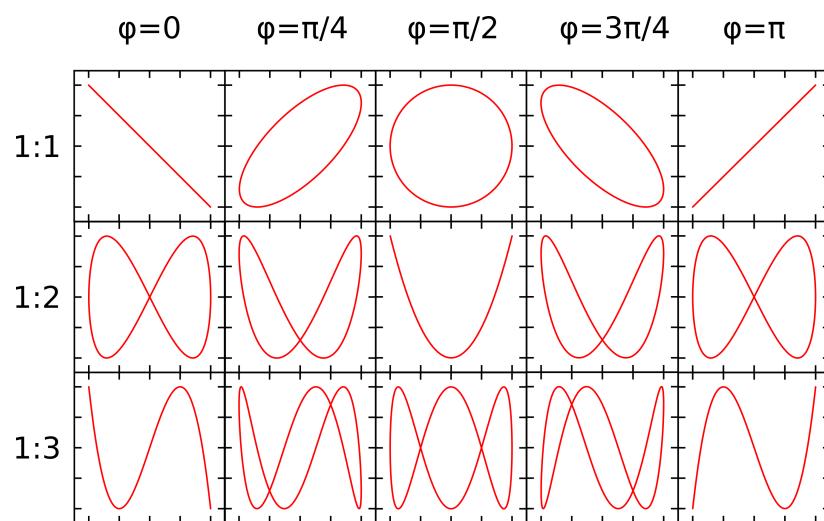


Figure 1.2: from [2]

¹ 1.2 Implementation

² A first setup with which we can try to obtain the desired voltages is depicted in
³ fig. 1.3. On the very left we have a signal generator that is capable of producing the
⁴ right frequency (461.7 MHz) this signal is then split up into an x-, and a y-branch.
⁵ One of the two branches is connected to a phase shifter, which is able to delay the
⁶ input signal by up to 200°, allowing us to set any desired phase shift between x-, and
⁷ y-deflection and to correct for inadvertent delays from the other electronics. Both the
⁸ x-, and y-signal are then amplified using (amplifier) . In the final step, a center tapped
⁹ transformer allows us to produce voltages for the plates X1 and X2 (or Y1 and Y2
¹⁰ respectively) with a phase shift of exactly 180° between them. By setting the center
¹¹ tap to the desired offset potential, we should get the voltage curves described above.
¹² To understand this setup in more detail, it is useful to examine its most important
¹³ parts more closely:

¹⁴ **Amplifier:** Up to now we have used the XXX and the YYY amplifier, they amplify
¹⁵ the signal by a fixed gain of (How much?) , inputs and outputs can simply be
¹⁶ connected via BNC cables, the amplifier is powered by a linear power supply
¹⁷ with a DC voltage of 24 V via two banana plugs in the front. Since we want to
¹⁸ control the Lissajous curves shapes (as the deflection coefficients for the x- and
¹⁹ y- plates differ), it is desirable to be able to adjust the amplifier gain in future
²⁰ versions of the setup.

²¹ **Center Tapped Transformer:** The center tapped transformer we use is the Mini-
²² Circuits TC8-1G2+ ([3]), a transformer for frequencies between 2 MHz to 500 MHz,
²³ with an impedance ratio of 8. Figure 1.6 shows how the center tapped transformer
²⁴ is implemented. The in- and outputs, as well as the bias voltage can be connected
²⁵ via BNC cables. As usual, the shields of all these cables are connected to ground,
²⁶ furthermore they are connected to each other and to the housing. As a safety
²⁷ feature, both outputs X1 and X2 are directly connected to the bias through
²⁸ an arrangement of diodes: Two connections, each with a normal diode and a
²⁹ Zener diode facing in opposite directions. The breakdown voltage of the Zener
³⁰ diode is 200 V, during normal operation the voltage on it stays below this value
³¹ and none of the connections let any current through as one of the two diodes is
³² always blocking it. However if one of the plates in the CRT accidentally comes in
³³ contact with high voltage, the connection with the appropriately oriented Zener
³⁴ diode opens up, preventing a voltage spike on the center tapped transformer and
³⁵ thereby protecting the electronics connected to its primary circuit. At the point of writing there are still some problems with the behavior of the
³⁶ center tapped transformer, the capacitance of the diodes introduces an undesired
³⁷ phase shift between the two signals. Figure 1.5a shows the circuit's behavior at
³⁸

Find out which
amplifier

which model?

which model?

Check amplifier
specifications

Optional: Go to
lab and measure
their performance
with an Oszil.

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

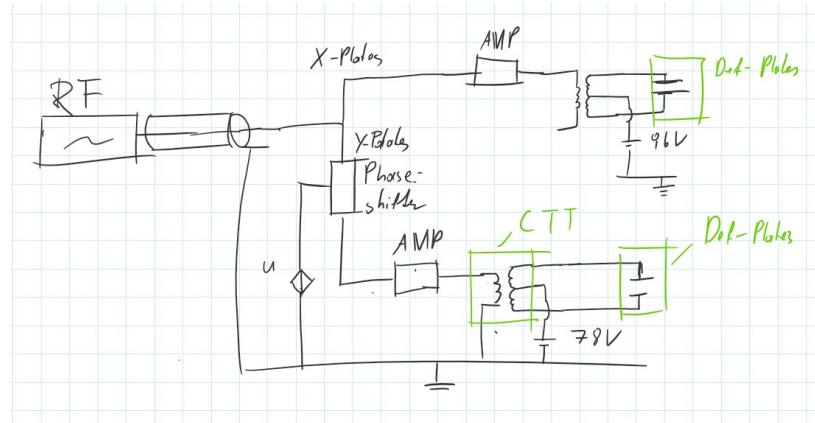


Figure 1.3: Deflection circuit

465 MHz without its diodes, here the signals are shifted by $120 \text{ ps} \cong 20^\circ = 0.35 \text{ rad}$. Additionally, applying a bias voltage leads to differing amplitudes, as can be seen in fig. 1.5b.

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 ([Hammond1455D601RD]) 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) _____
 (Performance) _____

1
2
3
Optional: Go to the Lab and the problem with the diodes?
4
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13 Insert fotos of finished circuits in
14 housings

Optional: Go to the Lab, set the whole thing up, look at its performance on the oscilloscope

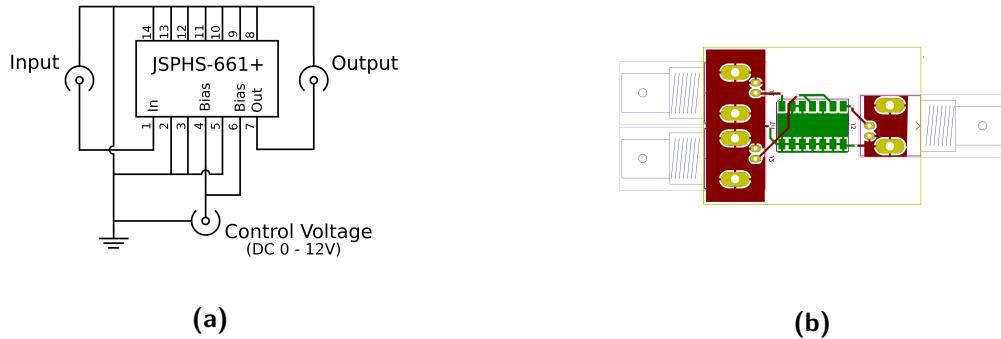


Figure 1.4

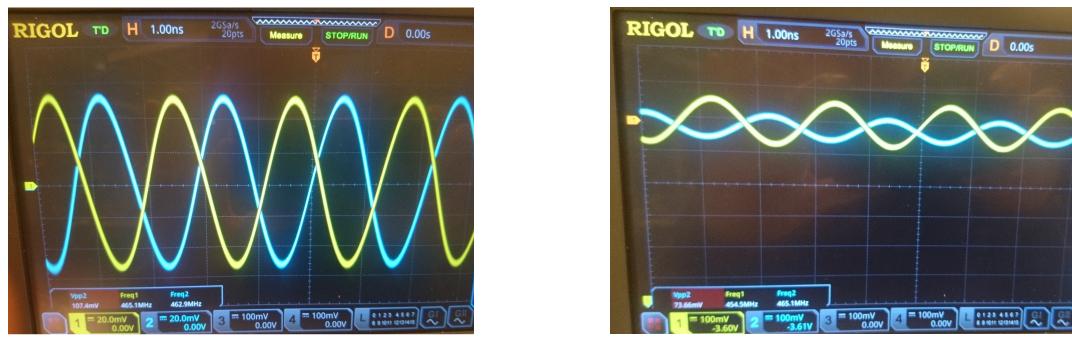


Figure 1.5

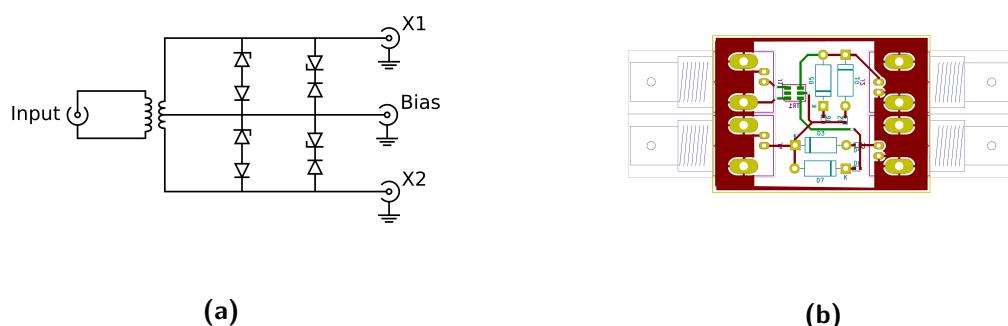


Figure 1.6

Todo list

1

- Optional: insert Foto of CRT's deflection plates - fig:DeflectionSetup 1 2
- Insert Reference to last section 1 3
- Find out which amplifier 3 4
- which model? 3 5
- which model? 3 6
- Check amplifier specifications 3 7
- Optional: Go to the lab and measure their performance with an Oszi. 3 8
- I don't really know whether a high resistance bias or a low resistance bias is better. 9 10
- Optional: Go back to the Lab and fix the problem with the diodes? 4 11
- Insert fotos of finished circuits in housings 4 12
- Optional: Go back to the Lab, set up the whole thing and look at its performance on the oszi 4 13
- 4 14

¹ References

- ² [1] Frank Philipse. *D14363GY123*. URL: [https://frank.pocnet.net/sheets/186/d/
³ D14363GY123.pdf](https://frank.pocnet.net/sheets/186/d/D14363GY123.pdf) (visited on 03/10/2020).
- ⁴ [2] Wikipedia contributors. *Lissajous-Figur*. URL: [https://de.wikipedia.org/wiki/
⁵ Lissajous-Figur](https://de.wikipedia.org/wiki/Lissajous-Figur) (visited on 05/05/2020).
- ⁶ [3] Mini-Circuits. *TC8-1G2+*. URL: [https://www.minicircuits.com/pdfs/TC8-
⁷ 1G2+.pdf](https://www.minicircuits.com/pdfs/TC8-1G2+.pdf) (visited on 05/05/2020).
- ⁸ [4] Mini-Circuits. *JSPHS-661+ Data Sheet*. URL: <https://www.minicircuits.com/pdfs/JSPHS-661+.pdf> (visited on 05/05/2020).
- ⁹ [5] Hammond Manufacturing. *1455D601RD*. URL: [https://www.hammfg.com/files/
¹⁰² parts/pdf/1455D801RD.pdf](https://www.hammfg.com/files/parts/pdf/1455D801RD.pdf) (visited on 05/05/2020). ¹⁰³