(Conference Paper):

Things needing to change:

- **In your diagrams showing the mappings from the DFT block to the IDFT block, the symbols *c* should really be the outputs of the DFT block, not the inputs.**
- **Don't use IFFT or IDFT BEFORE using the full English explanation (Inverse Fast Fourier Transform)**
- **Mention OTHER (PAPR) reduction techniques (just *briefly*)**
- **Don't continuously say "DFT-spread" or "with DFT-spread, it is seen…". Instead, introduce an acronym. For example, "DFT-S".**
- **Use more acronyms to avoid length repetitions**
- **Matrix variables (e.g. F_{Tx} or F_{Rx}) should be in boldface.**
- **Acronyms must be spelled out the first time that they are used.**
- **Let s_m be the m-th OFDM symbol transmitted; let r_m be the m-th OFDM symbol received.**
- **Include many of the salient points that you have mentioned in your analysis of "ODFM-Spread OFDM MIMO Radar - An Alternative for Reduced Crest Factors"**
  In fact, in the case where an OFDM system is being used *purely* for radar, data rates are not important… at all really.
- **Add a LAYOUT section *after* the Introduction**
- **Mention how, in the radar case, the CP *should* be chosen to be larger than the maximum delay that is expected…**
- **Data rate is lower in DFT-s-OFDM, *but* for radar applications this does not matter so much…**
- **DFT-s-OFDM is efficiently implemented…**
- **The range resolution is governed by:**

  range resolution = c/(2B)

  The bandwidth is equal to NΔf; since **N** is greater with DFT-s-OFDM, does the resulting radar have better resolution?

References here:
[1] Comparison of Correlation-based OFDM Radar Receivers
[2] Evaluation of the ambiguity function for passive radar with OFDM transmissions
[3] A unifying approach for disturbance cancellation and target detection in passive radar using OFDM

General plan:

(1) Get all the text and diagrams that will be needed first.
(2) Transfer all the text and diagrams into the LaTex document.
(3) Fix any compilation or formatting errors.

All of the above is to be done by 12 o'clock tomorrow (midday)

(Key points that we want to get across in the abstract - order them according to priority; points at the top being the most important)

(1) OFDM radar is an active area of research, and for good reason; it **could allow** for the combination of a communication and radar system. This would entail less hardware, and allow for more efficient use of the frequency spectrum. (reword some of the points mentioned in the beginning of Braun Martin's paper)
(2) Mention that the high peak-to-average power (PAPR) ratio is one of the main drawbacks of the OFDM scheme. Include some lines about **why** it is a drawback.
(3) Mention how DFT spreading is used to help reduce the PAPR in OFDM communications. Mention some standards that use DFT-spread OFDM as the **uplink** modulation scheme.
(4) Introduce the main speaking or talking point for the paper: DFT-spread with OFDM radar receivers.

Abstract:
OFDM radar has become an active area of research in recent years. The possibility of combining a communication and radar system is promising for a few reasons. Firstly, the combined system would most likely entail less hardware. And secondly, it could allow for more efficient use of the frequency spectrum. This paper investigates the effect of using DFT-spread or DFT precoding on an OFDM radar's performance. DFT-spread is used to help reduce the PAPR of the OFDM waveform before transmission, thus reducing the demand placed on the high-power amplifier (HPA). The OFDM radar receiver is implemented as a reciprocal filter in this paper.

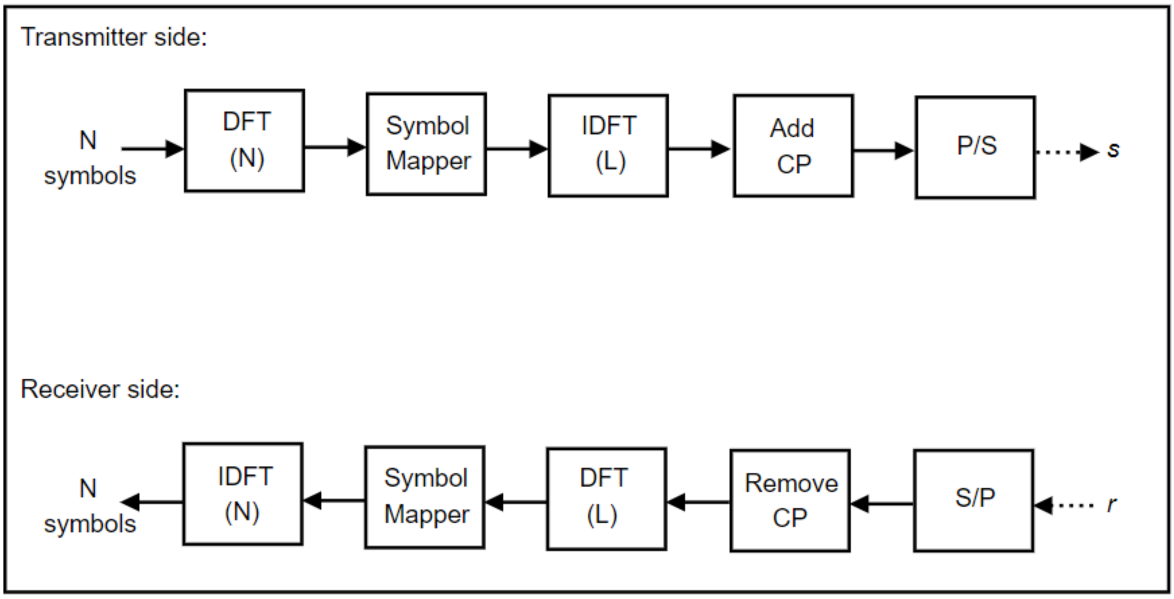
(Key points that we want to get across in the Introduction - order them according to priority; points at the top being the most important)

- High PAPR is a principal disadvantage of the OFDM waveform. And **why** this is so.
- How this is combated using DFT-spread. And general idea about **why** it works (mitigates the effect of the Tx-side IDFT block).
- Show block diagram of DFT-spread.
- Discuss relationship between the size of the IDFT block and the DFT block: L = KN // K is an integer…
- Briefly introduce the two main mapping techniques that you studied, and mention some of the benefits of each.
- Give two diagrams showing output symbols from DFT being mapped to inputs of IDFT.

Background:

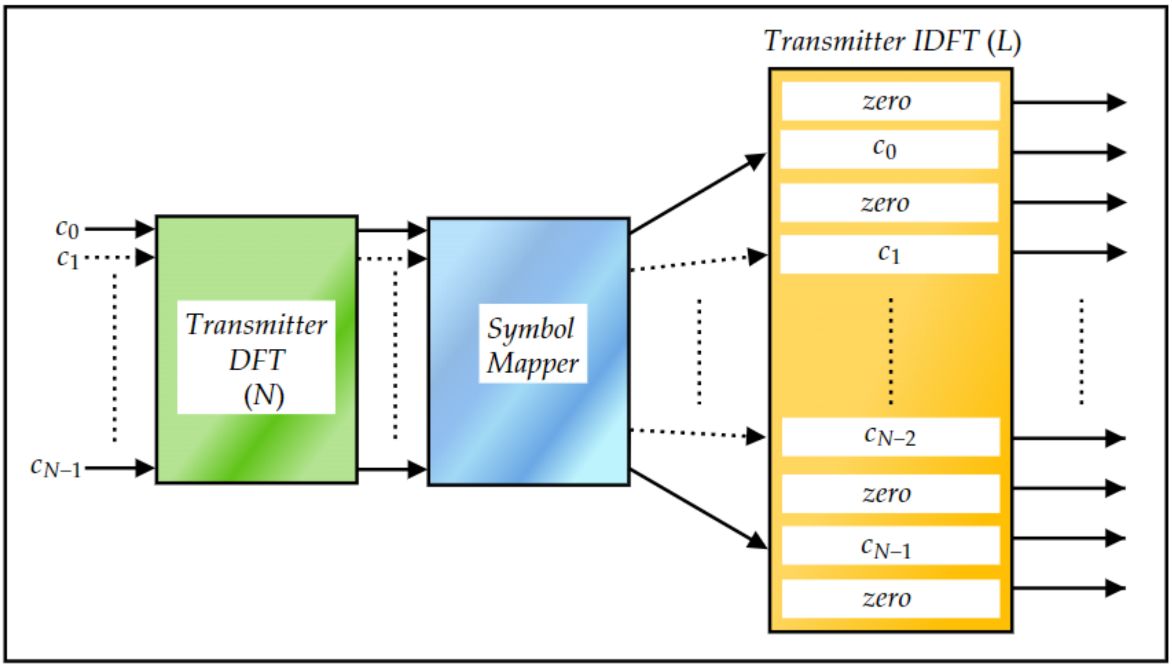
DFT-spread:

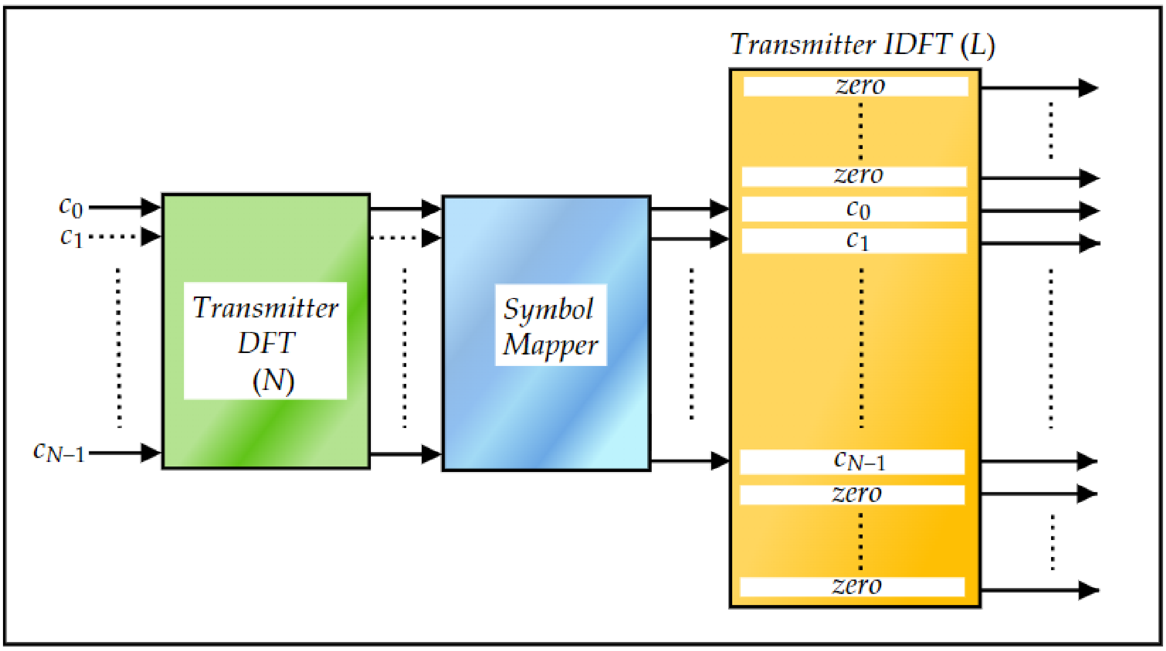
One of the main drawbacks of the OFDM waveform is that it has a high peak-to-average power (PAPR) ratio. This can cause unwanted distortions at the output of the transmitter's high-power amplifier (HPA), thereby leading to an increase in the communication system's bit error rate (BER) (**give reference here**). The high PAPR also leads to high power consumption in the user equipment (UE) in the uplink transmissions. This can lead to a short battery life. The high PAPR of the waveform is caused by the IDFT operation on the transmit side. As a result, the DFT-spread technique first passes the transmit symbols through a DFT block in order to mitigate the effect of the IDFT block (OFDM modulator). The outputs from this DFT block are then mapped to the inputs of the IDFT block. Figure 1 shows a basic block diagram for an DFT-spread OFDM system:



The DFT spreading technique works on the basis that the size of the DFT and IDFT blocks are different - if they were the same then the IDFT operation would cancel or negate the DFT's effect. The size of the IDFT block (L) is chosen to be an integer multiple of the size of the DFT - i.e., L = KN.

This means one has some choice when mapping the N DFT outputs to the L IDFT inputs. Two commonly employed mapping rules are **interleaving** and **localised** (**give some references**). A diagram showing the basic characteristic of interleaving and localised mapping can be seen in figure 2:





When interleaving mapping is used, the N output symbols from the DFT block are mapped over the whole set of IDFT inputs, and the data symbols (c) are equally spaced out, with an appropriate number of zero rows in between.

OFDM Transmit and Receive Sequence:
An OFDM signal is typically a burst of OFDM symbols, where each OFDM symbol is itself composed of a number of mutually orthogonal sub-carrier signals. Some subcarrier channels are often left idle, such as the DC subcarrier, while most are loaded with complex symbols. These are either carrying information, or acting as pilot symbols to be used for purposes such as channel estimation. Mathematically, an OFDM signal with M symbols, each using N subcarriers, may be represented in discrete time by the following
Equation is **here**:

$$\boxed{s[l] = \sum_{m=0}^{M-1} \left(\frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} c_{n,m} e^{-j2\pi \frac{n}{N}(l-mP)} \right)}$$

The received sequence (r) is a delayed and shifted in frequency version of s, and can be described by the following equation (**change the variables - use Z for noise, for example**):

$$\boxed{r[p] = \alpha \exp(j2\pi f_{\mathrm{D}} p/L) s[p - l_0] + w[p]}$$

The reciprocal filter expression is attained by making
In [1], [2], and [3], a correlation-based receiver that uses the reciprocal of the transmit sequence has been studied, and presented under names such as *reciprocal* filter, *MCC*, and *CHAD*. In order to arrive at the correlation-based equation, consider the OFDM transmit sequence s, given by:

25/03/2022:

- I have more or less finished the first draft of the conference paper. Although the formatting is a little bit off in some places, owing to my inexperience with using LaTeX and Overleaf. I am going to first settle on the content that the final version will have, before doing all the LaTeX again in order to improve the formatting. First I will watch some tutorials to better understand what “good” practice is.

Alter title of the Paper too: “*DFT-spread OFDM Joint Communication-Radar*”
Revised Introduction:
The prospect of combining radar and communication functionality into a single system is attractive for a few reasons. Firstly, the combined system would likely require **less hardware**, since both services - radar and communications - could **share certain hardware components**, such as transmit and receiver antennas, modulators, RF oscillators etc. The reduced amount of hardware would also help to **reduce production cost**, something which is especially important when it comes to mass production. Secondly, by combining the two systems into one, there is the opportunity to **more efficiently use the frequency spectrum.** This potential benefit is promising given the investment in the **Internet-of-Things (IoT)** sector, where more and more devices are **wireless-based**, and **integrated** into single systems. And this question about the feasibility of combining the two functions into a single system is a somewhat natural one; **many** of the **systems** that use **radar technology *also* require communications capabilities**, like with the automobile industry or industrial automation sector. And radar and wireless communication systems are **both based** on the principle of **transmitting** and **receiving electromagnetic (EM) waves**. For wireless communications, orthogonal frequency-division multiplexing (OFDM) is a method of data transmission that is very commonly employed. This is because OFDM has many advantages, such as an efficient implementation using the Fast Fourier Transform (FFT) algorithm, a high spectral efficiency, and its robustness to interference and frequency-selective channels. Due to the widespread use of the OFDM waveform in 4G and 5G communication systems, its use in radar applications has been an active area of research for many years (**give references here**).

***Paper Layout*:**
In section 2, some background information about the method of DFT spreading and reciprocal filtering is given. In section 3 a comparison and discussion of simulation results is presented. Section 4 discusses the conclusions, and offers some possible avenues to explore in future work.

Section 2:

- Discuss DFT-spreading; what it is, and **why** it might benefit the radar application; e.g., reduce PAPR and power needed during transmission; increases bandwidth and **range resolution**; better performance with smaller number of subcarriers in use;

lower PAPR means the system hardware is likely to be cheaper, as the amplifiers do not need to be as linear…
- Give some background on correlation-based radar receivers, and what the difference is with the reciprocal filter

Section 3:
- Presents results; compare and discuss

Section 4:
- Short conclusion, and discuss possible areas of future research/work