Imperial College London

SIGNAL OPTIMIZATION FOR WIRELESS INFORMATION AND POWER TRANSMISSION

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MOTIVATION

Energy-constrained wireless networks are conventionally powered by batteries with limited operation time and inconvenient recharging. As a promising alternative, Radio-Frequency (RF) wave is typically with lower power level (μW to W) and decent coverage (up to hundreds of meters) (**Ng2019**). Interestingly, it has been widely used in wireless communications and can be extended to Wireless Information and Power Transfer (WIPT). With the significant drop of power consumption in electronics, RF signal is expected to power billions of mobile devices wirelessly while keeping them connected to the network.

RECTENNA MODEL
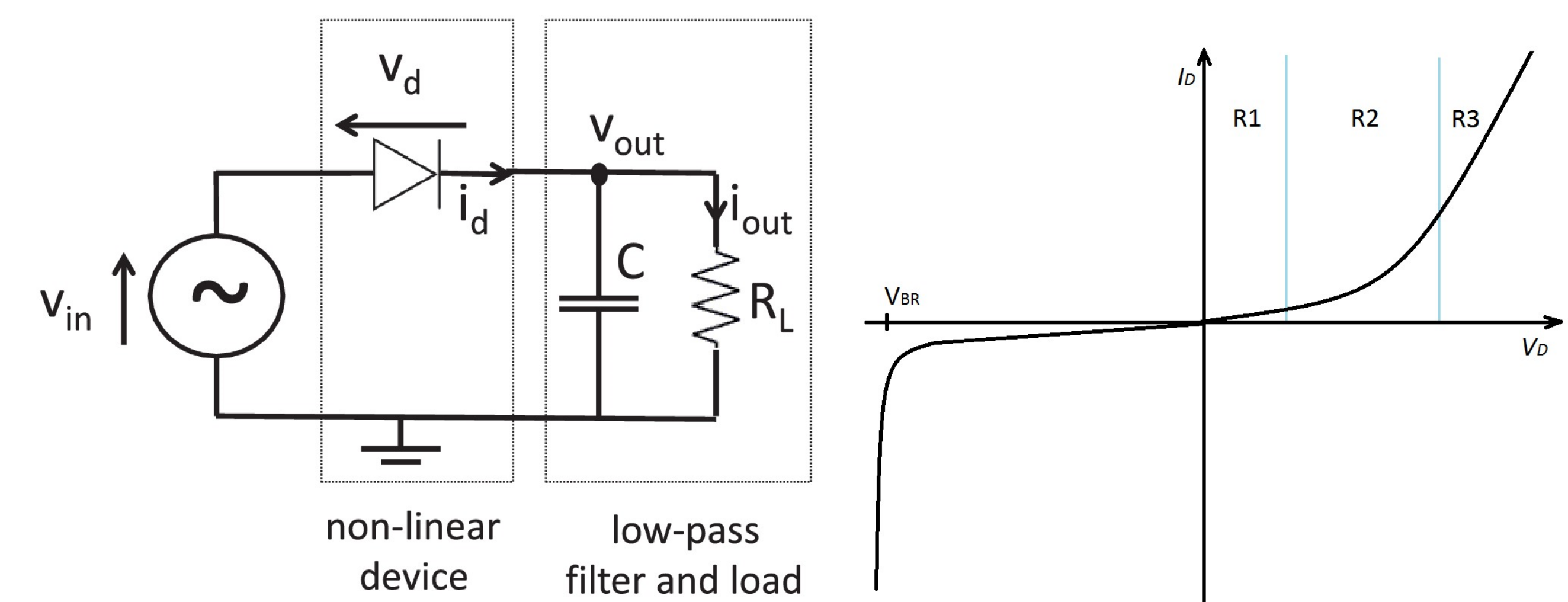
► Rectenna = antenna + rectifier

Figure: Single diode rectifier (left) and diode $I - V$ characteristics (**Clerckx2019**). The diode accounts for harvester nonlinearity. R1 and R2 correspond to the diode linear and nonlinear model. The diode behaves as a resistor in R3.

We approximate the diode characteristic equation by Taylor series and truncate the result to n_o-th order to obtain:

► **Diode linear model** ($n_o = 2$): assume the total harvested power equals the sum in each subband and is proportional to the rectifier input power.
► **Diode nonlinear model** ($n_o > 2$): capture the diode nonlinear behavior with the product terms that consist of contributions from different frequencies.

RECEIVER ARCHITECTURES

► **Time Switching (TS)**: divide the transmission block into orthogonal power and data slots, then optimize the signal individually.
► **Power Splitting (PS)**: split a portion of the signal to information decoding (ID) receiver and the rest to energy harvesting (EH) receiver. The waveform is jointly optimized for WIPT.
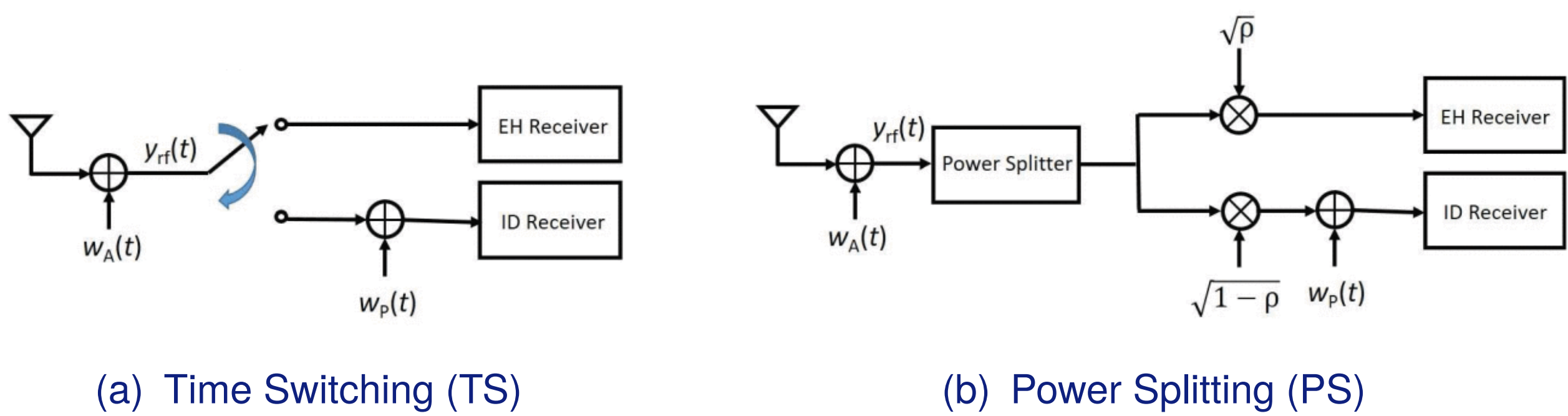

(a) Time Switching (TS)   (b) Power Splitting (PS)

Figure: Receivers (**Clerckx2019**): (a) TS switches between energy harvester and information decoder; (b) PS splits the signal into separate portions.

SIGNAL DESIGN

► Superposed waveform = multi-carrier **multisine** + **modulated**
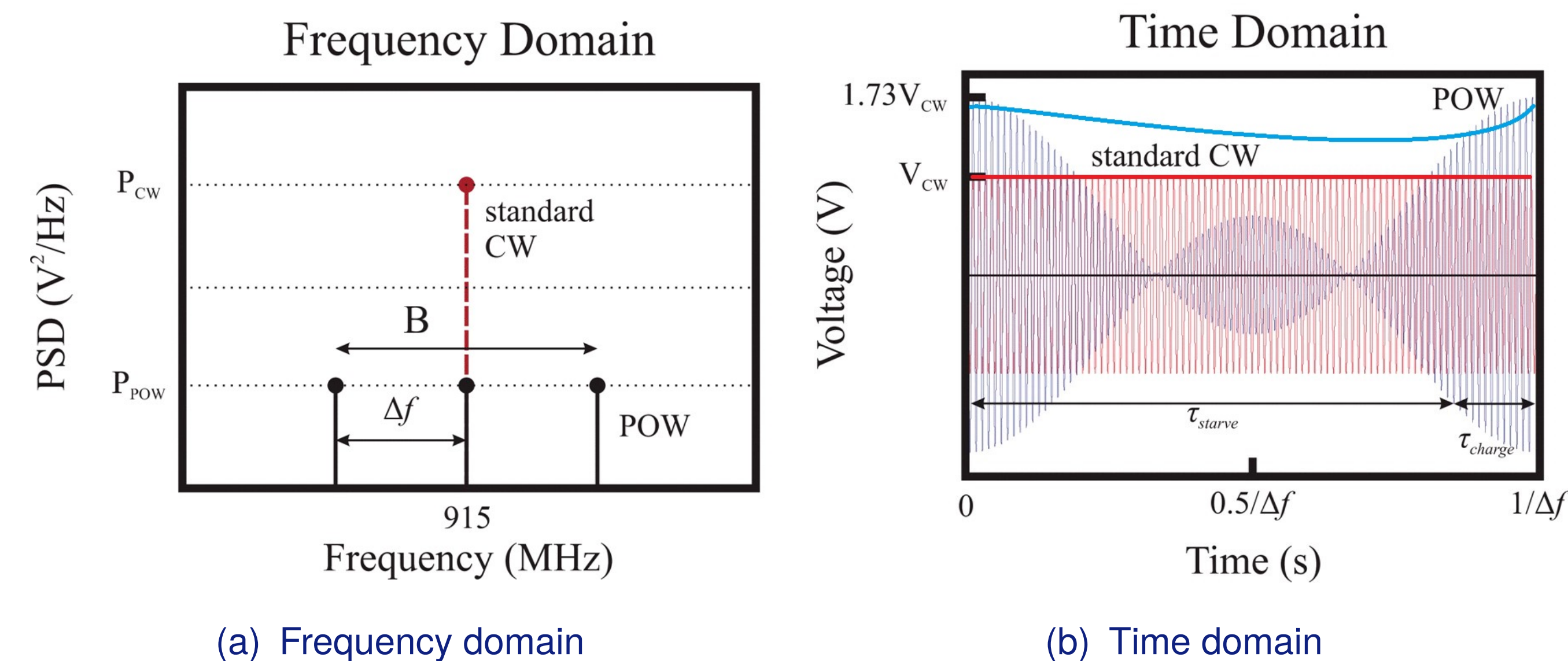► Multisine: deterministic, high PAPR, concentrated power

(a) Frequency domain   (b) Time domain

Figure: Comparison of 3-subcarrier multisine (POW) and single-sine (CW) (**Trotter2009**). The thick lines indicate the rectifier output voltage.

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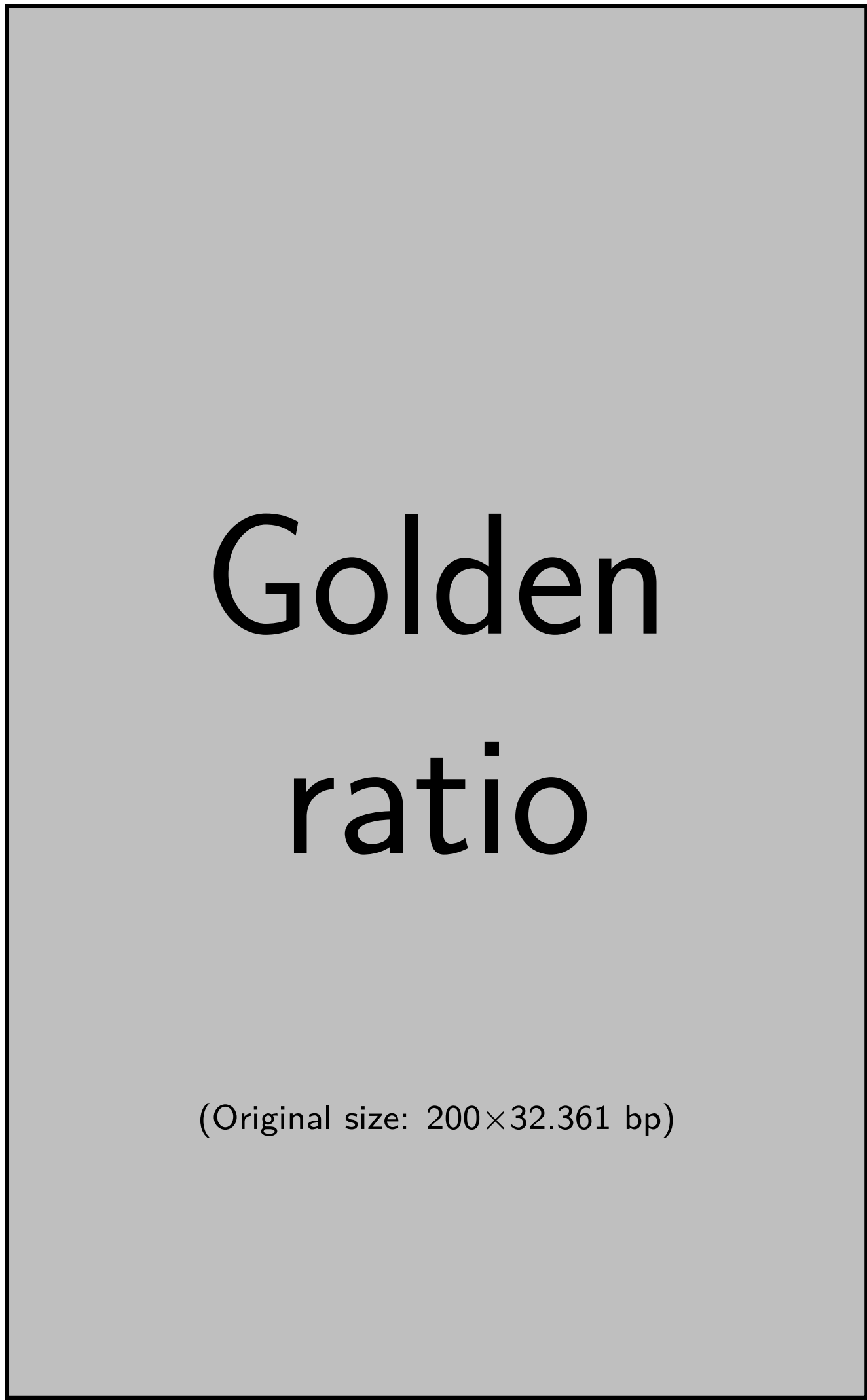
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TABLE 3

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FIGURE 4

Golden ratio

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