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Analoge Verzögerungsregelschleife für die digitale HF-Pulsweitenmodulation im Frequenzbereich von 170 MHz bis 2,8 GHz in 28 nm FDSOI CMOS

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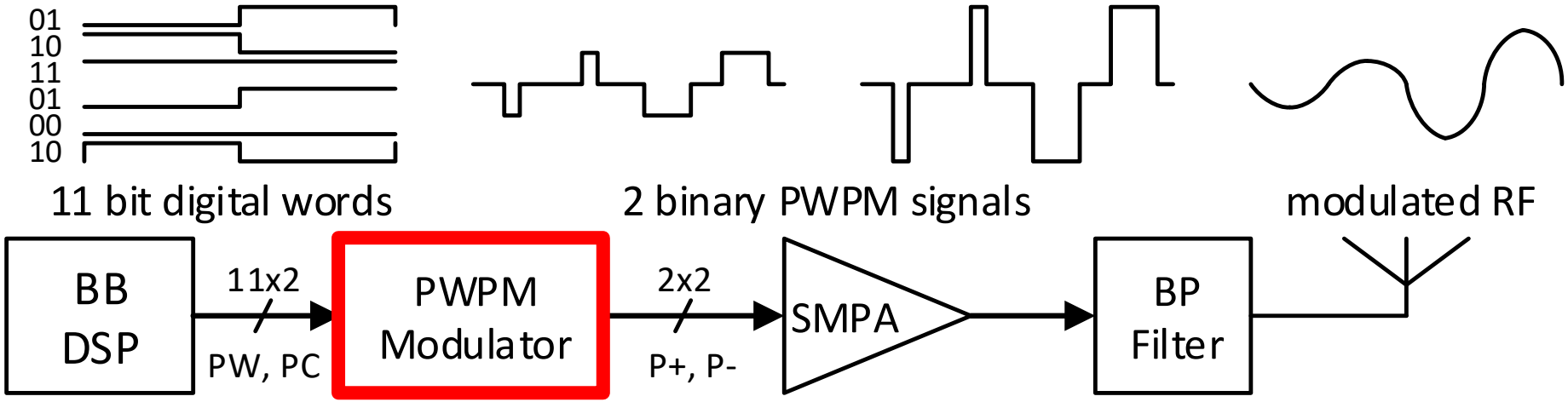
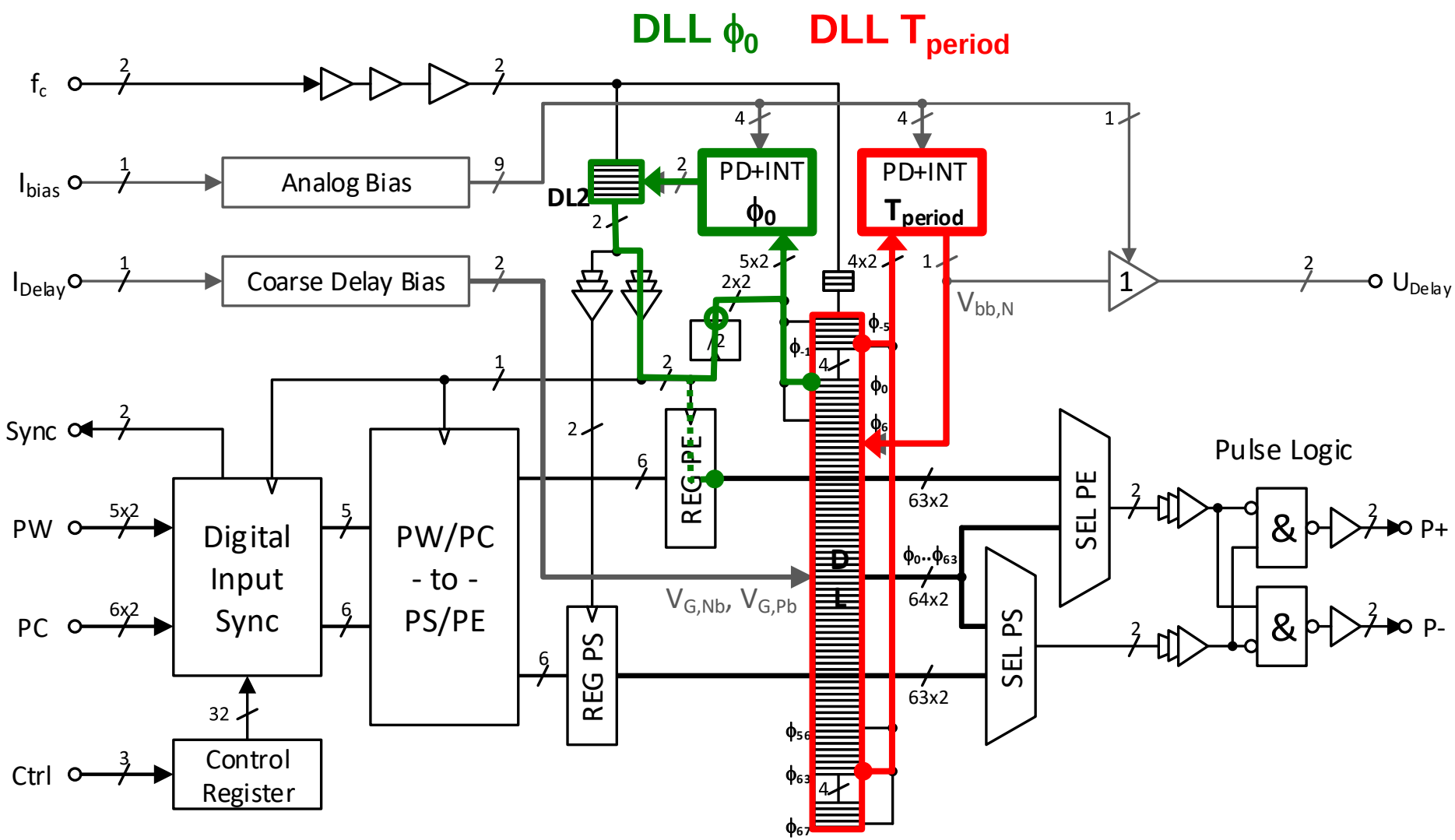
Zielanwendung: HF-Sender mit PPWM und Schaltverstärker



Digitaler Pulspositions- und Pulsweiten-Modulator



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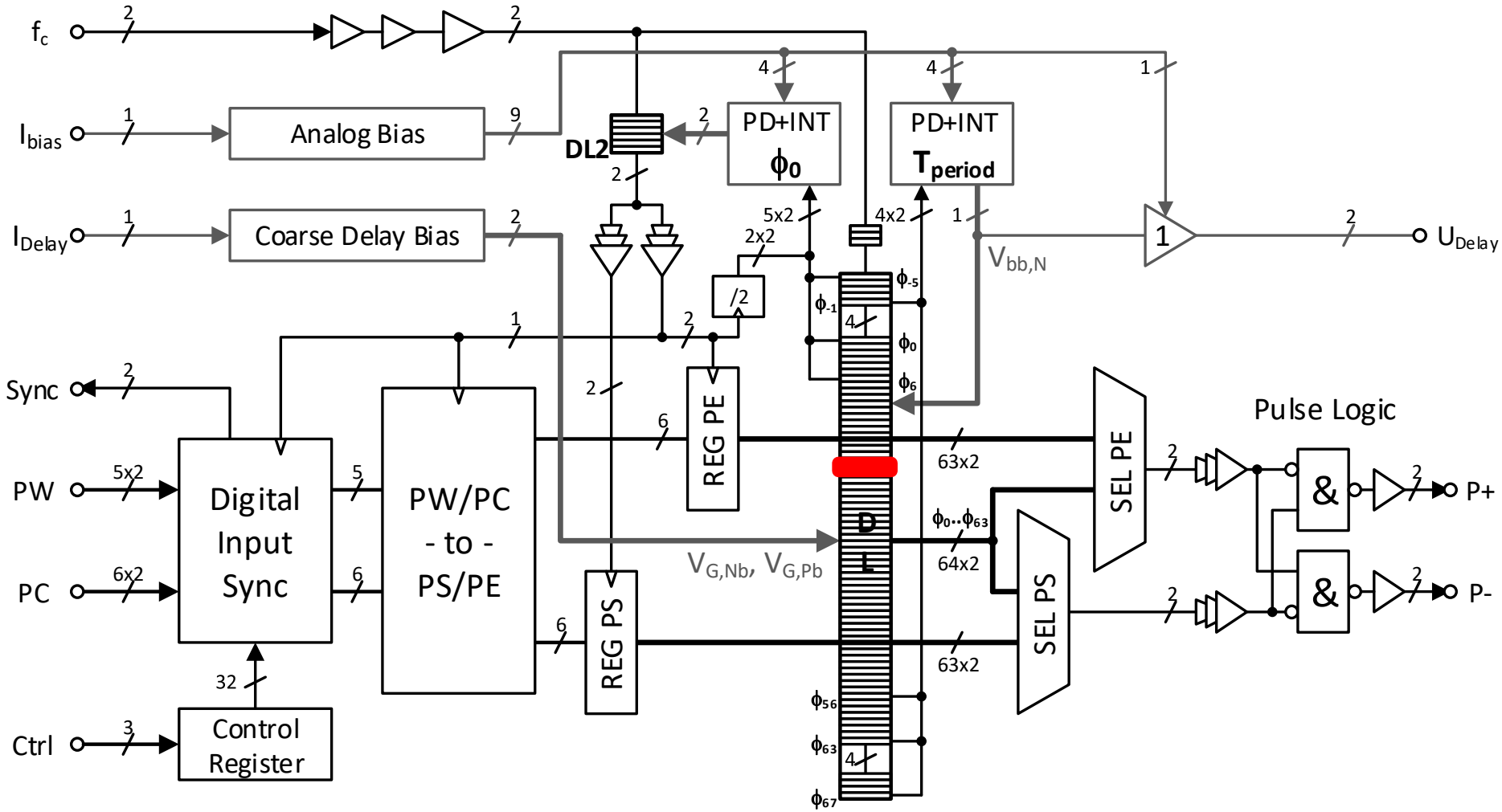
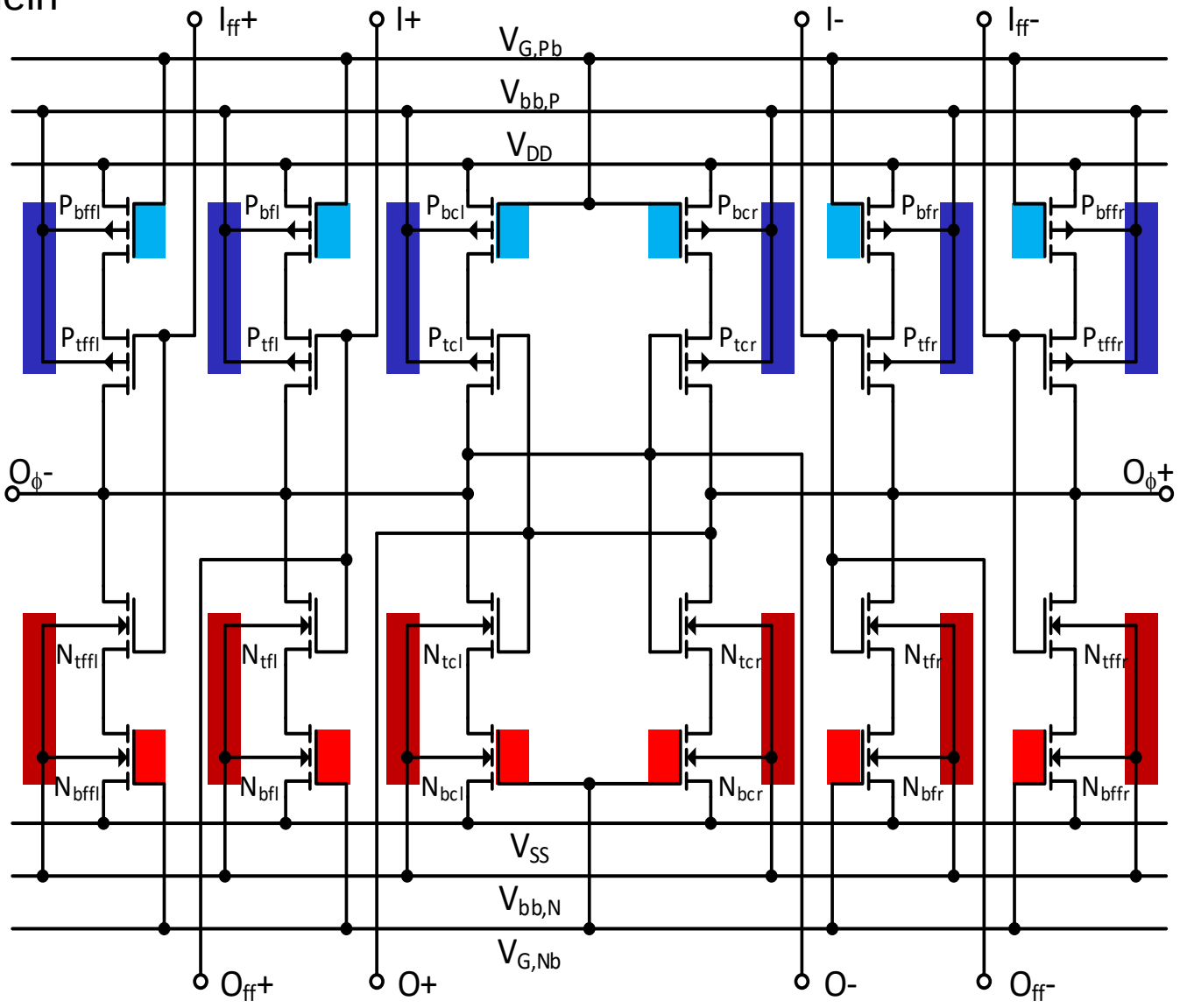
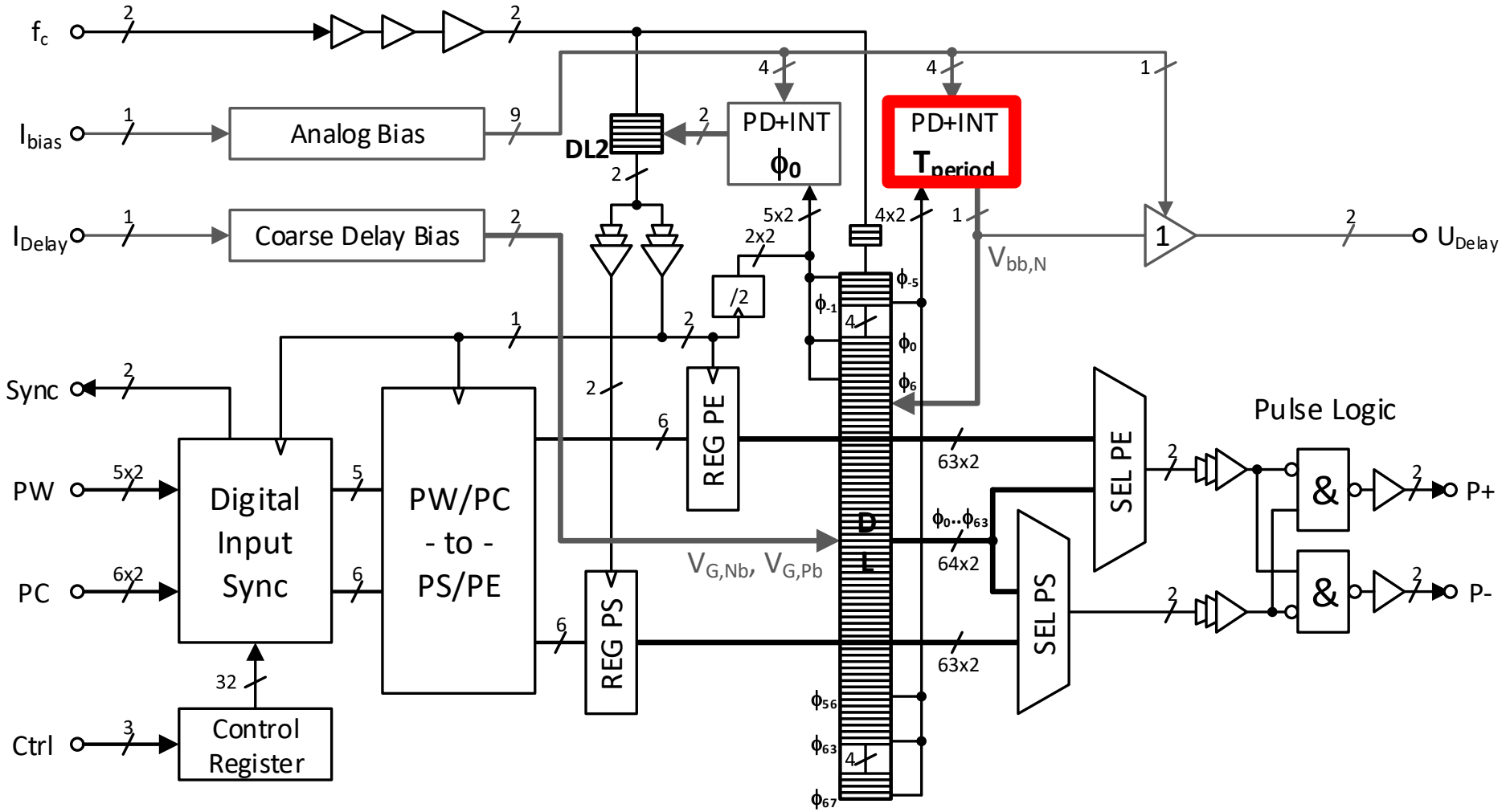


Schaltplan Verzögerungszelle in FDSOI CMOS

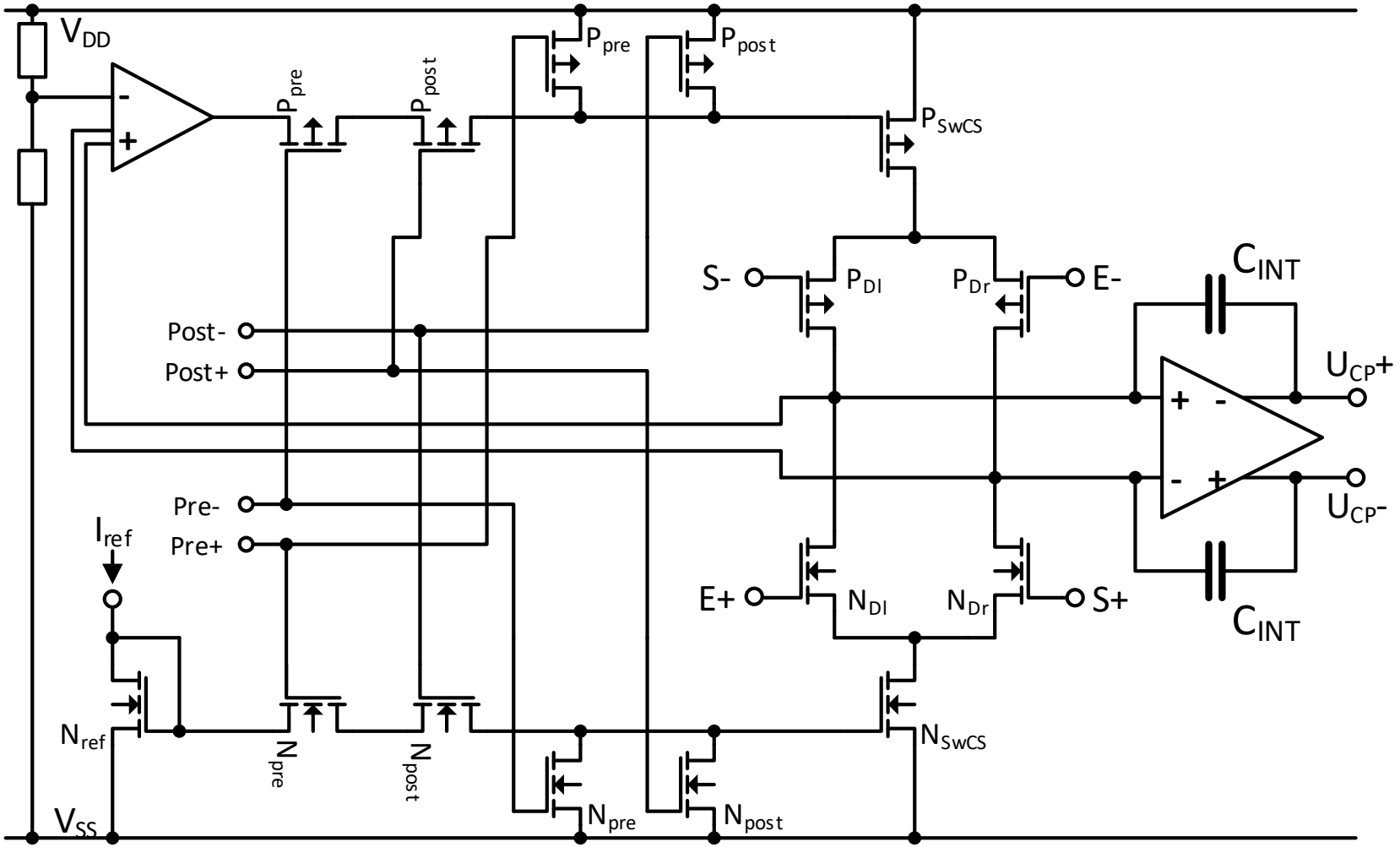
Spg.	Einst. Δt groß..klein	
$V_{G,Pb}$	grob	1V..0V
$V_{bb,P}$	fein	1V..0V
V_{DD}		1V
V_{SS}		0 V
$V_{bb,N}$	fein	0V..1V
$V_{G,Nb}$	grob	0V..1V



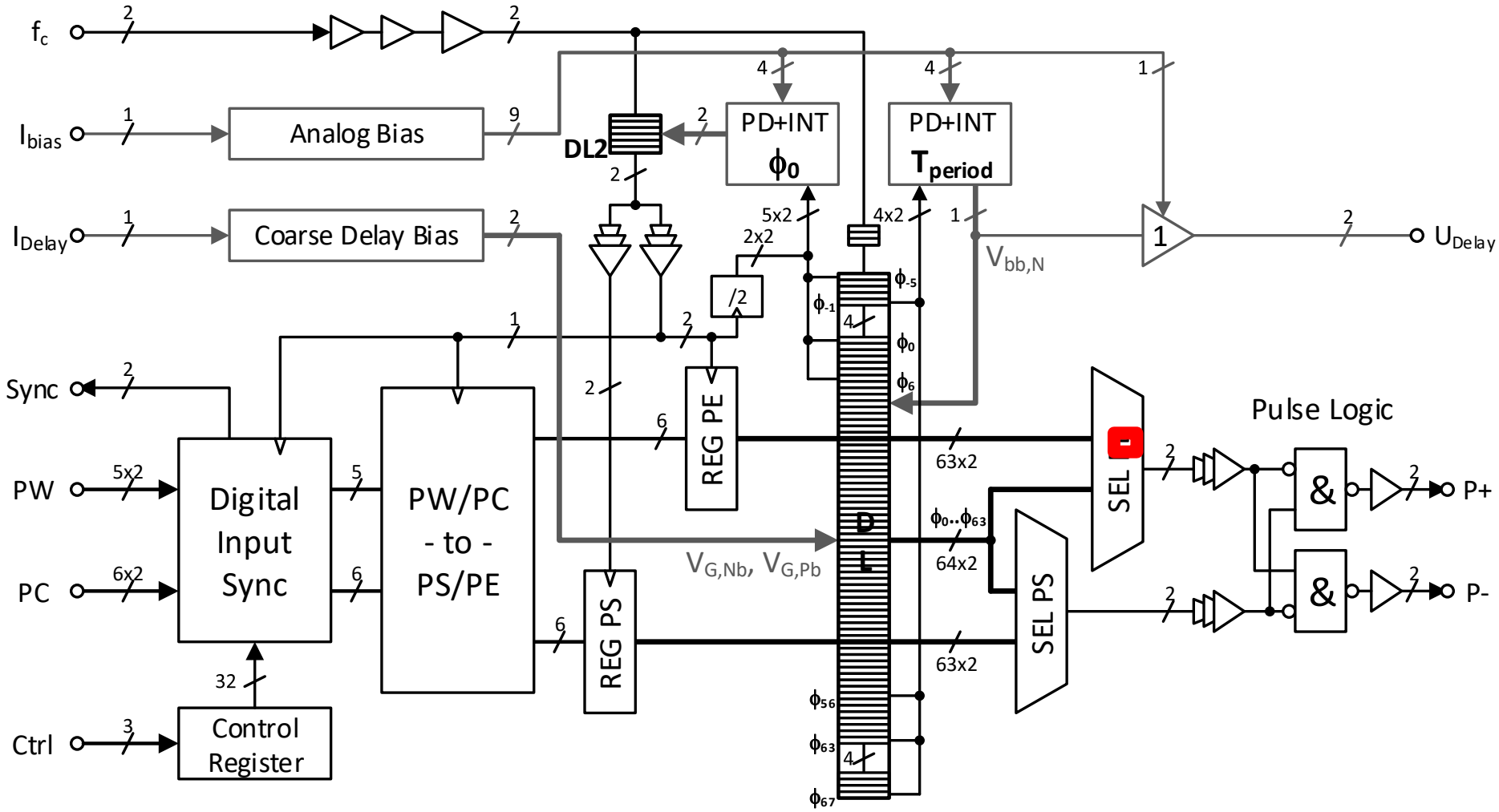
Digitaler Pulspositions- und Pulsweiten-Modulator



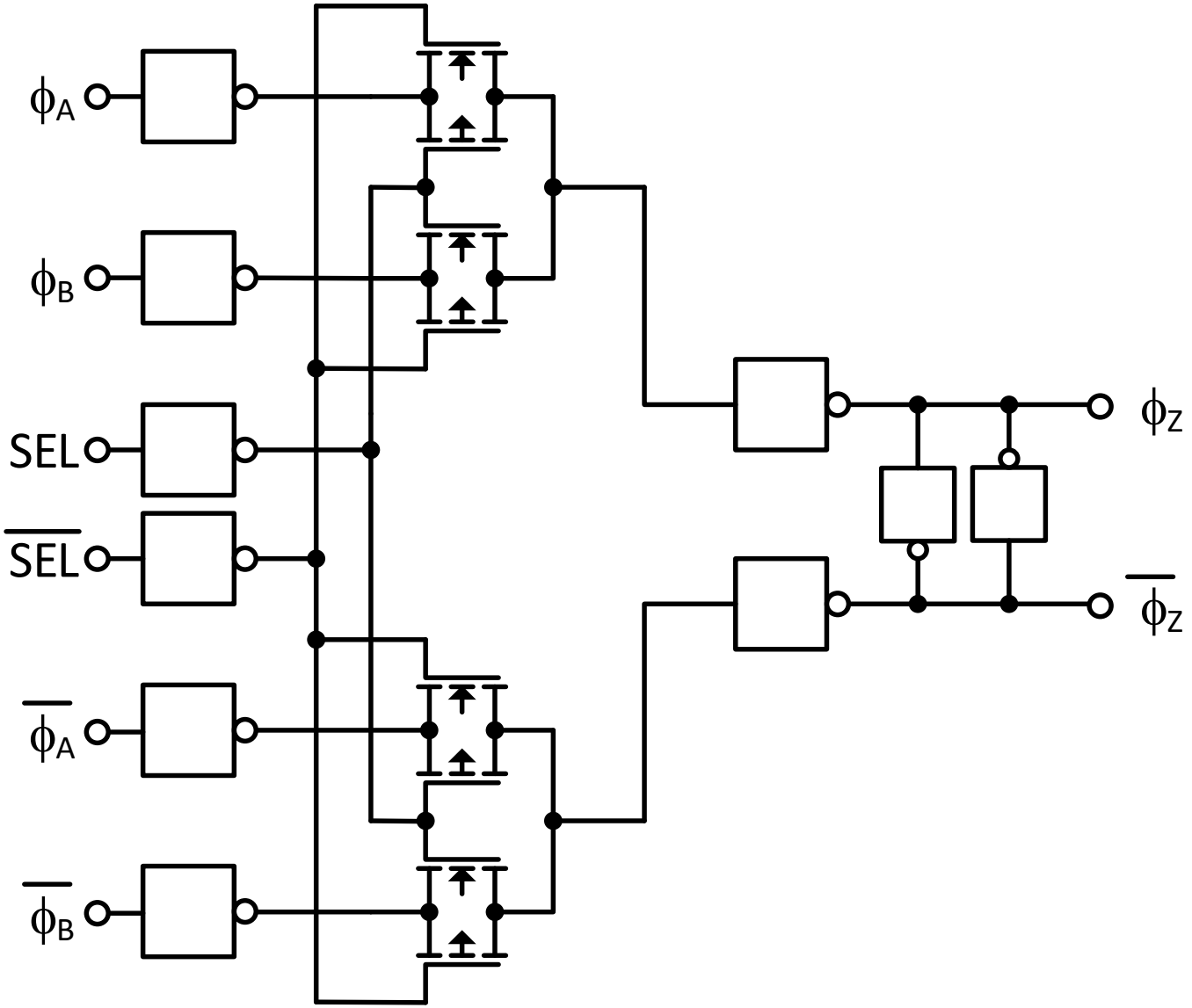
Integrierender Stromschalter-Phasendetektor



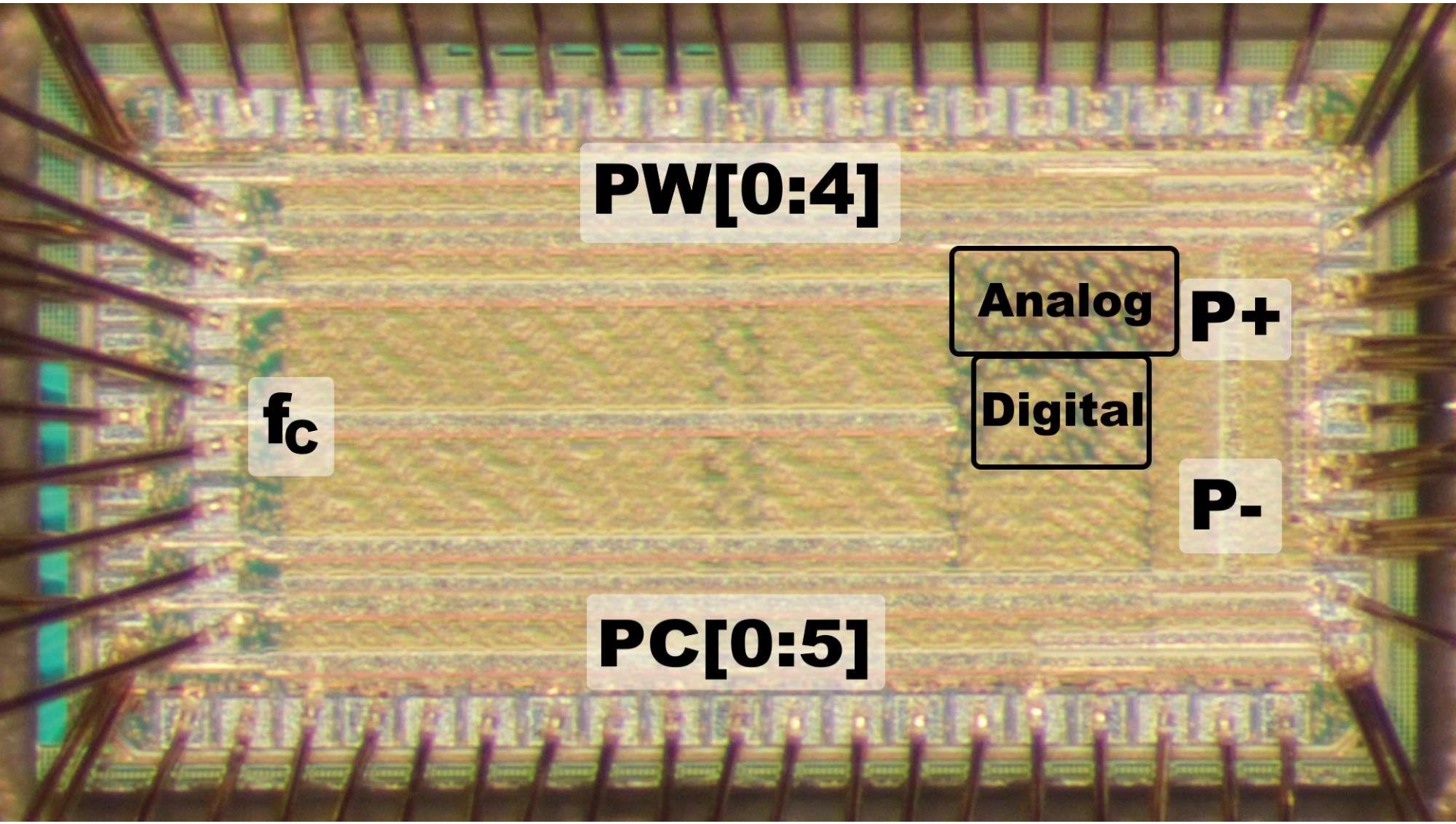
Digitaler Pulspositions- und Pulsweiten-Modulator



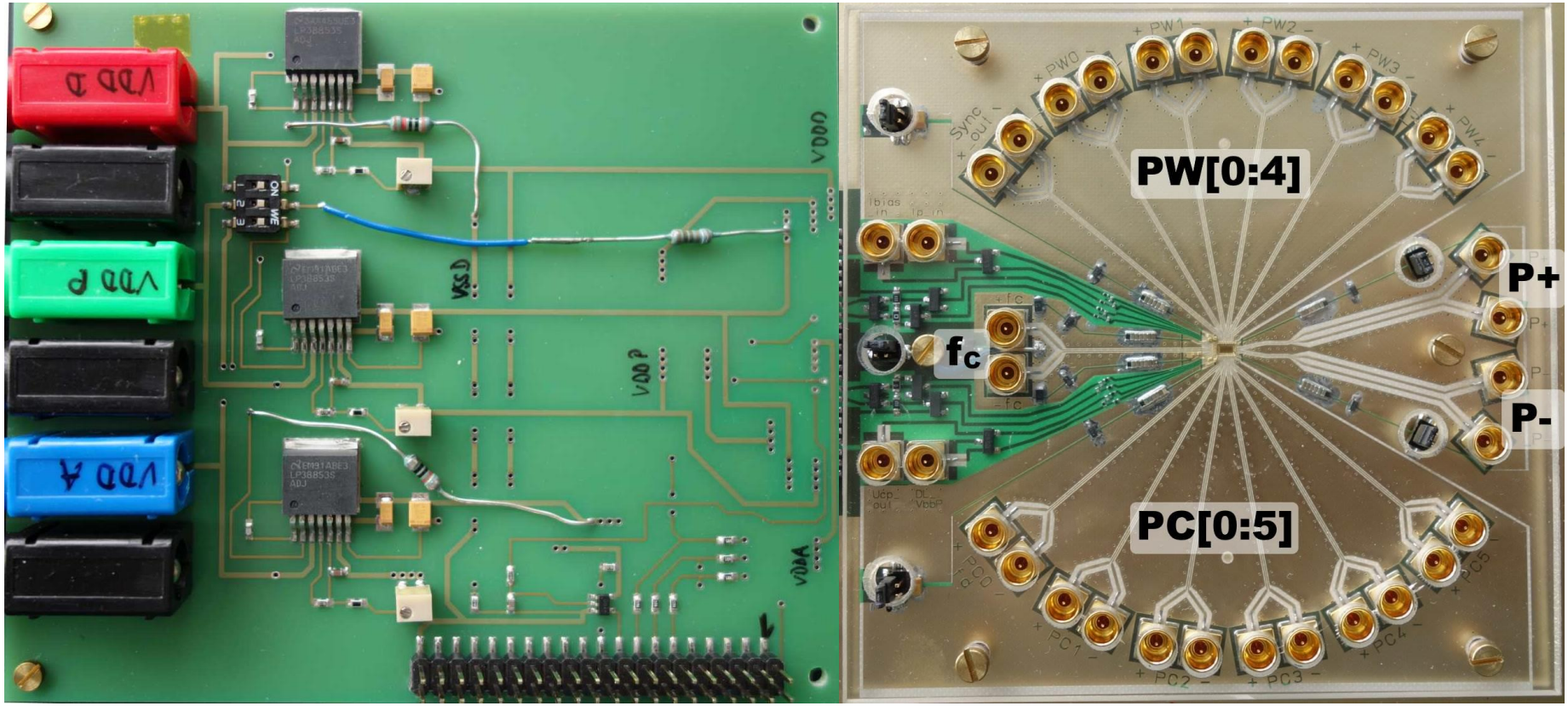
Schaltplan 2-zu-1 Selektor



Chipfoto HF PPWM IC: 1.9 mm x 1.0 mm

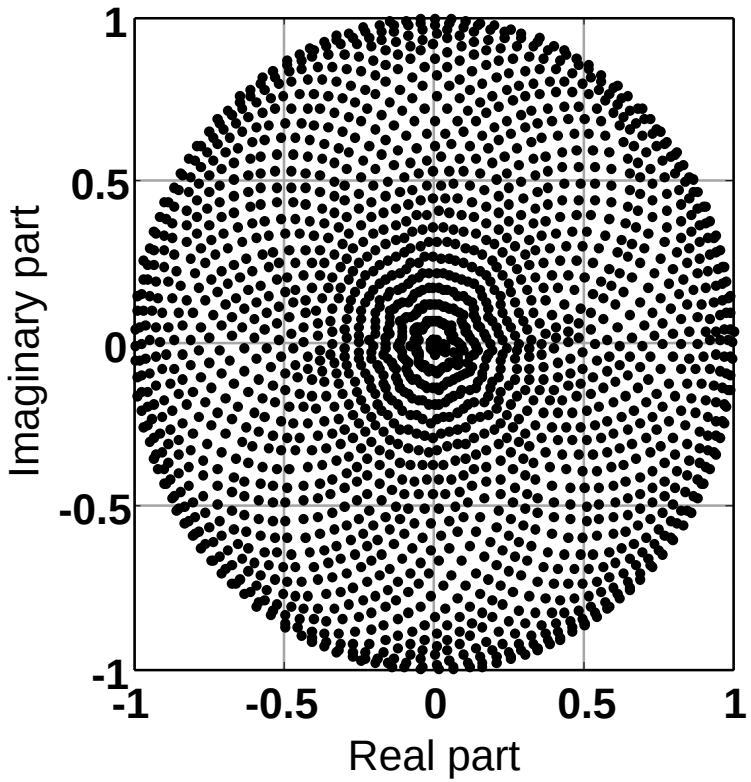


Spannungsversorgungs- und HF-Platine

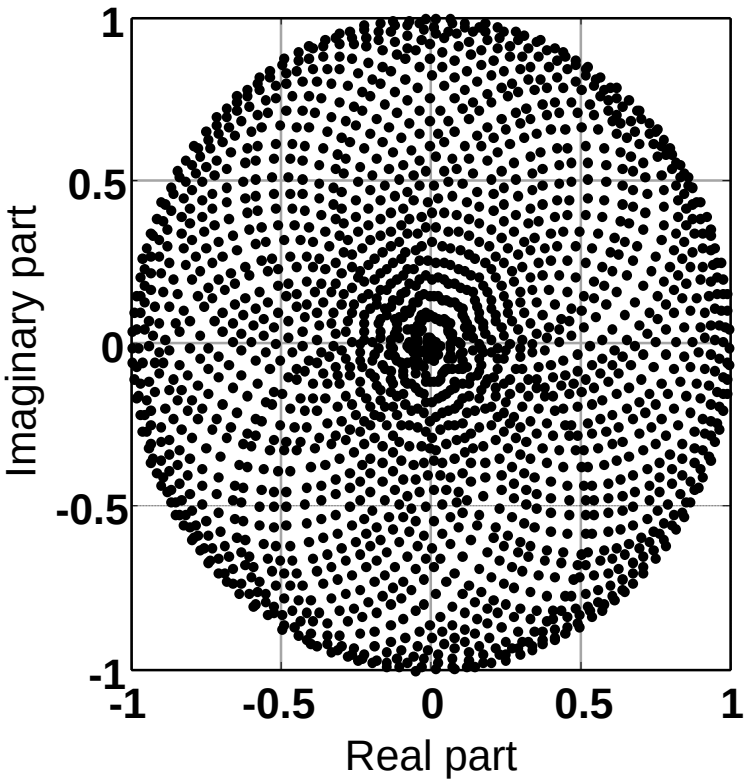


Gemessene statische Konstellationsdiagramme

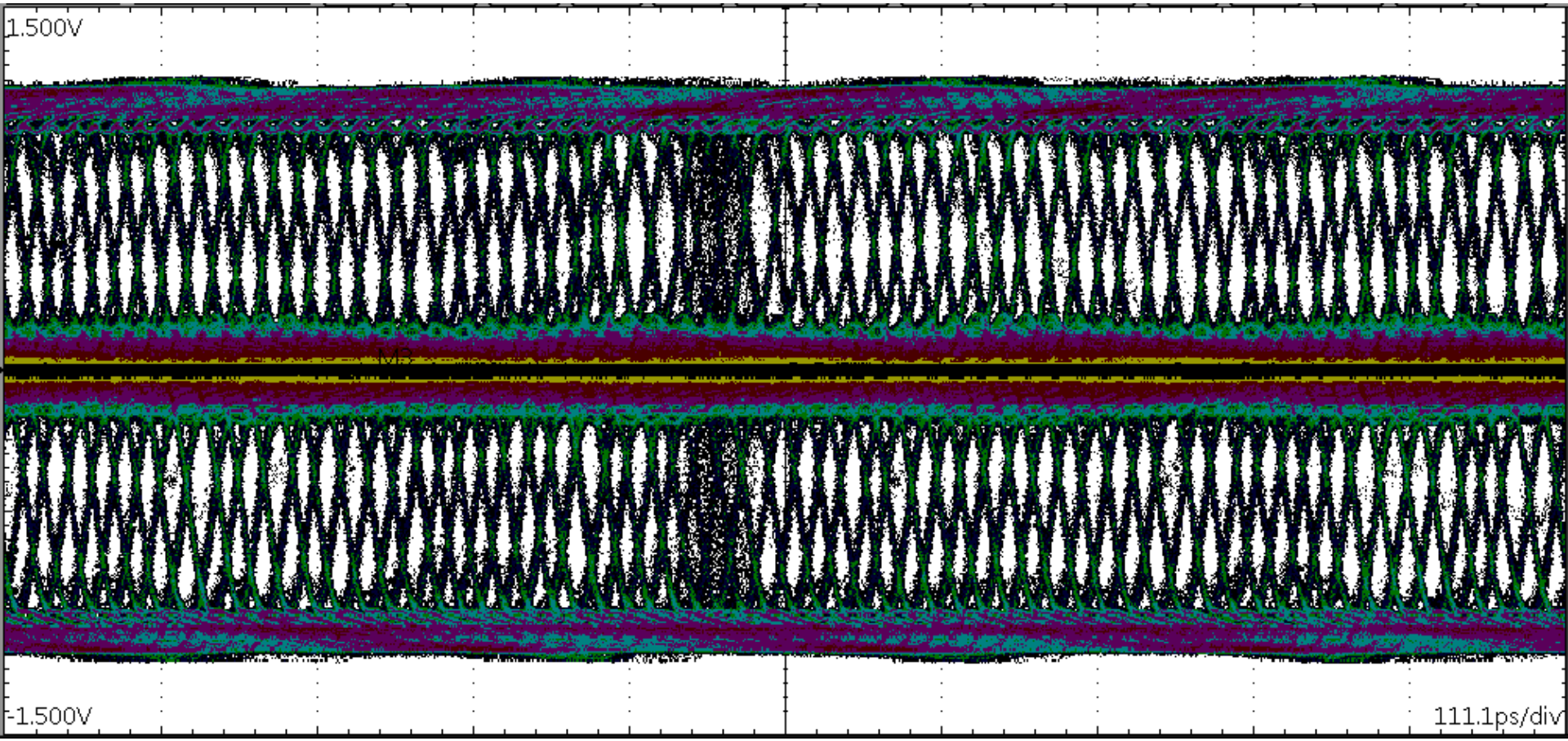
900 MHz



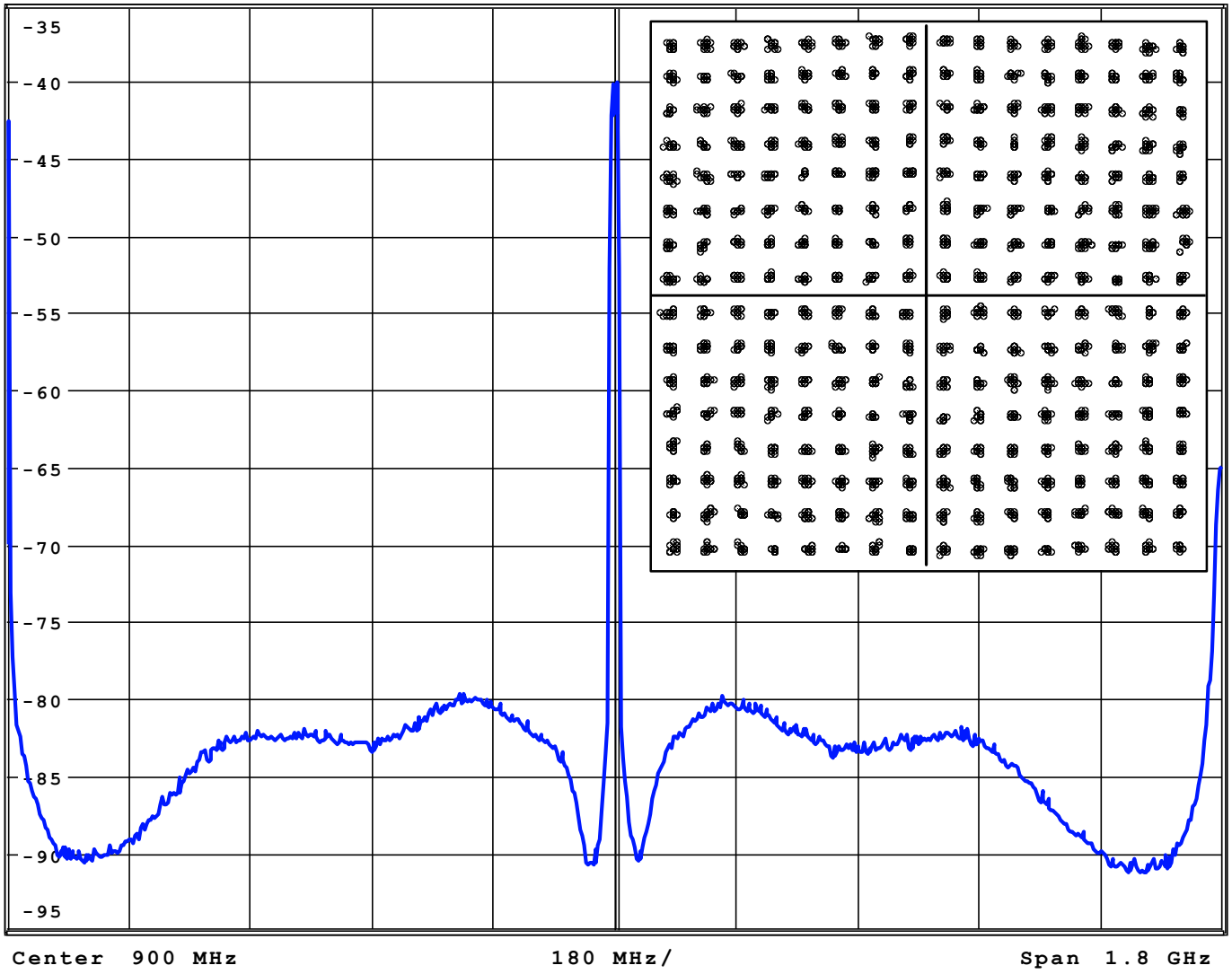
2016 MHz



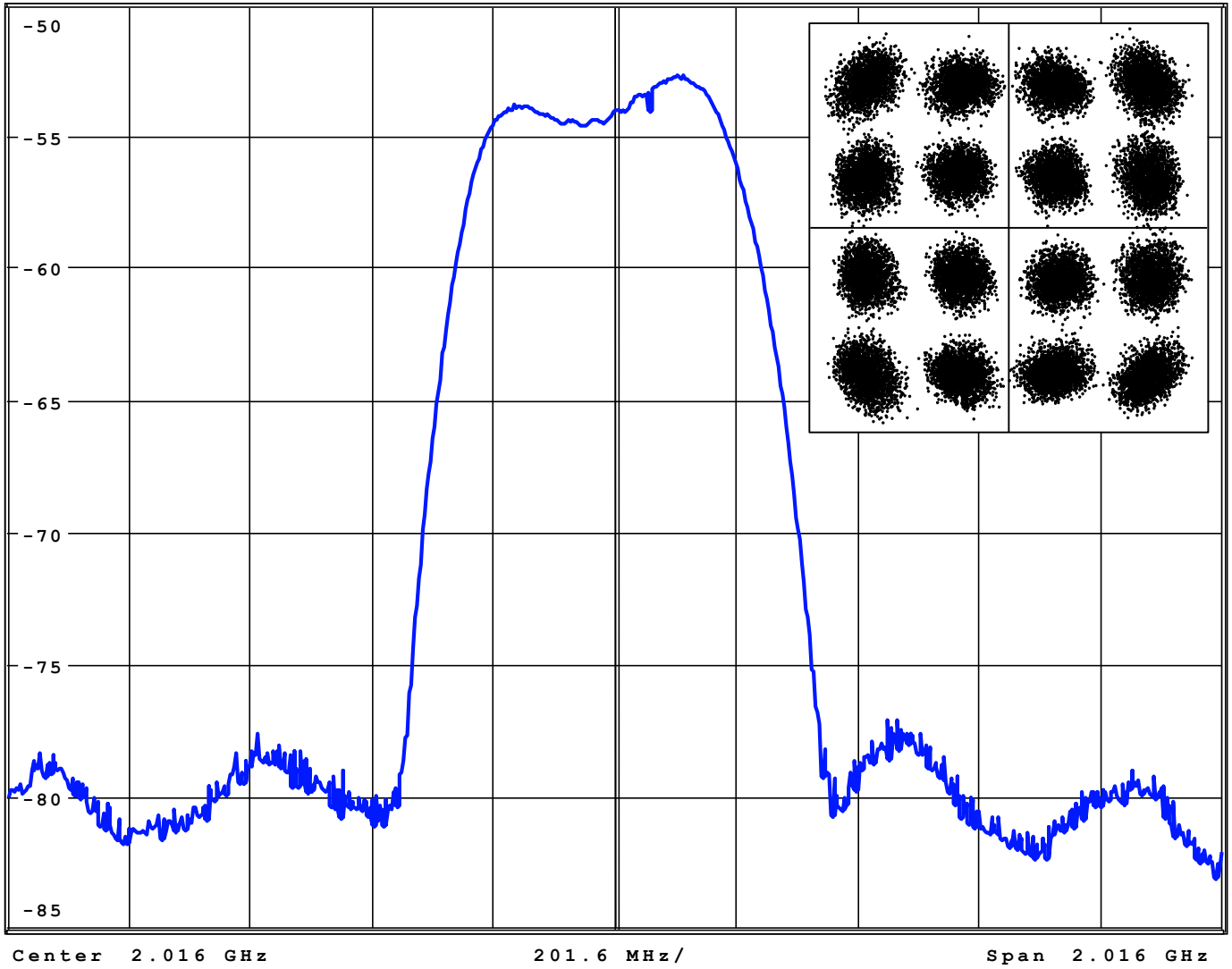
Augendiagramm bipolares Σ-Ausgangssignal bei 900 MHz



900 MHz-HF-Signal moduliert mit 14 MBd QAM-256 (112 Mb/s)



2016 MHz-HF-Signal mod. mit 504 MBd QAM-16 (2016 Mb/s)



ZUSAMMENFASSUNG MESSERGEBNISSE

Property	**Unit**	**1**	**2**	**3**	**4**	**5**
Carrier freq.	MHz	**900**	2016	2016	2016	**2016**
Symbol rate	MBd	**14.06**	15.75	31.50	63.00	**504.0**
Modulation	QAM	**256**	256	256	64	**16**
Data rate	Mb/s	**112.5**	126.0	252.0	378.0	**2016**
EVM	%	**1.83**	2.36	2.47	3.97	13.5
SNDR	dB	**34.7**	32.5	32.1	28.0	17.4
BER *		$< 10^{-8}$	$1 \cdot 10^{-6}$	$3 \cdot 10^{-6}$	$1 \cdot 10^{-8}$	$1.5 \cdot 10^{-4}$ **
Ch. BW	MHz	18.0	22.5	45.0	90.0	720
Ch. spacing	MHz	20.0	25.0	50.0	100.0	800
BW efficiency	b/Hz	6.22	5.6	5.6	4.2	2.8
$ACLR1_{,Lower}$ $ACLR1_{,Upper}$	dB dB	**-44.8** **-44.8**	-42.9 -41.8	-42.2 / -40.7	-38.4 -36.1	-24.7 -25.1
$ACLR2_{,Lower}$ $ACLR2_{,Upper}$	dB dB	**-49.2** **-48.6**	-49.0 -47.1	-45.7 / -43.6	-36.1 -37.3	-20.1 -23.7

*) estimated [6] **) measured

VERGLEICH MIT DEM STAND DER TECHNIK

Property	Unit	[7]	[8]	[9]	[10]	This Work
CMOS techn.	nm	32	40	45	28	28
carrier frequen. range	GHz	2.4	0.9 - 2.6	1.0 - 3.0	0.35 - 2.6	0.17 - 2.8
max signal BW[1]	MHz	40	40	N/A	400	**504**
binary outputs		yes	yes	yes	no	**yes**
carrier freq.	MHz	2400	2000	2400	2000	2016
DC power	mW	82	91	35	670	58
signal type		WLAN	WLAN	GMSK	OFDM	SC RC[2]
QAM order		64	64	4	64	**256**
data rate	Mb/s	54	54	20	120	126
bandwidth	MHz	20	20	N/A	20	**22.5**
EVM	dB	-32	-29	-33.5	-29	**-32.5**
PAPR	dB	N/A	8[3]	0	8	**6.5**
ACLR1	dBc	N/A	-30[3]	N/A	-40	-42

[1]) demonstr. by experiment [2]) single carrier raised cosine with $\beta = 0.5$
[3]) 20 MHz BW DMT signal

ZUSAMMENFASSUNG

- Technologie: 28 nm FDSOI CMOS (STM)
- Versorgungsspannung: 3x 1.0 V (Digitalteil, Analoge DLL, Ausgang)
- Leistungsaufnahme: 38 mW bei 900 MHz
  58 mW bei 2016 MHz
- Verzögerungszelle
  - Voll-Differenziell
  - Gestapelte MOSFETs zur Verzögerungszeit-Kontrolle
  - Grob-Einstellung über Gate-Spannung
  - Fein-Einstellung über Backgate-Spannung
- Integrierender Phasendetektor
  - Neue Topologie
  - Ohne Latch / Gedächtnis
  - Sehr geringe Jitter-Erzeugung
- PPWM-HF-Ausgangssignale mit
  - größter Signalbandbreite (504 MBaud bei QAM-16)
  - höchster Modulationsordnung (QAM-256, bei 14 MBaud)
  - gutes EVM (1,83 %) für Modulation mit veränderlicher Einhüllender/Amplitude (PAPR = 6.5 dB, QAM-256) bei 14 MBaud
- Sauberes Spektrum fern vom Träger
  wegen hoher Update-Rate für PW&PC ($f_{Update} = f_{RF}$)

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