



NORDIC
SEMICONDUCTOR

Smarter Things

Why I work with electronics

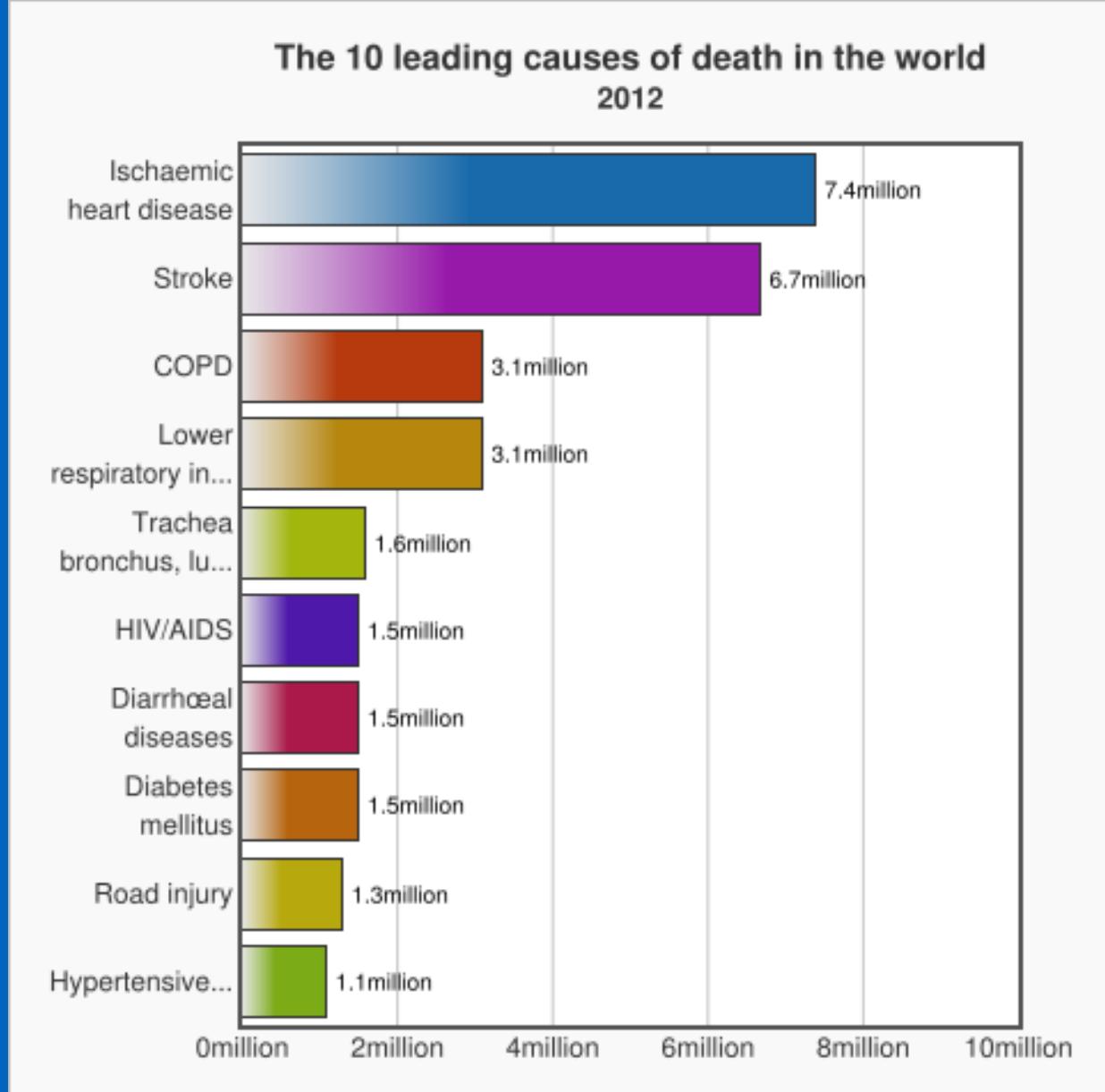
With sprinkles of IC design, complex math, transistors, and Minecraft

Carsten Wulff, Wireless Group Manager, 2016-09-07

W
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I want to make the world better!

Challenge Number 1



... cardiovascular diseases killed **17.5 million** people in 2012, that is 3 in every 10 deaths ... WHO

"PAI is NOT an exercise prescription. It does NOT tell you how to exercise in a specific way, but measures the physical activity that you already do and adds it up over a course of a week. **As long as you keep your weekly PAI score above 100, you are doing enough to protect yourself from disease and early death."**

Heart-rate monitoring without a chest strap

A newly available *Bluetooth* low energy sportswatch uses optical technology to measure heart rate without requiring a conventional chest strap.

The MIO ALPHA stores the exercise information and wirelessly transmits it after training to any *Bluetooth* v4.0-enabled smartphone or computer.

The sportswatch, which employs a Nordic μ Blue™ nRF8001 *Bluetooth* low energy single-chip connectivity IC, is designed for serious amateur and professional athletes alike. The device uses an electro-optical cell on the underside of the watch with a pair of optical sensors tracking blood flow in the wrist as the heart beats to extrapolate heart rate.

"This technology enables the MIO ALPHA sports watch to measure a user's heart rate without an uncomfortable strap at speeds up to 12mph [19kmph], with the same accuracy as traditional EKG/ECG [electrocardiogram] based heart-rate straps," comments Emily Rothwell, VP of Sales and Marketing at Physical Enterprises Inc., the company behind the MIO ALPHA.

"Achieving this level of end-user simplicity without compromising accuracy compared to a



The MIO ALPHA measures a user's heart rate from blood flow in the wrists

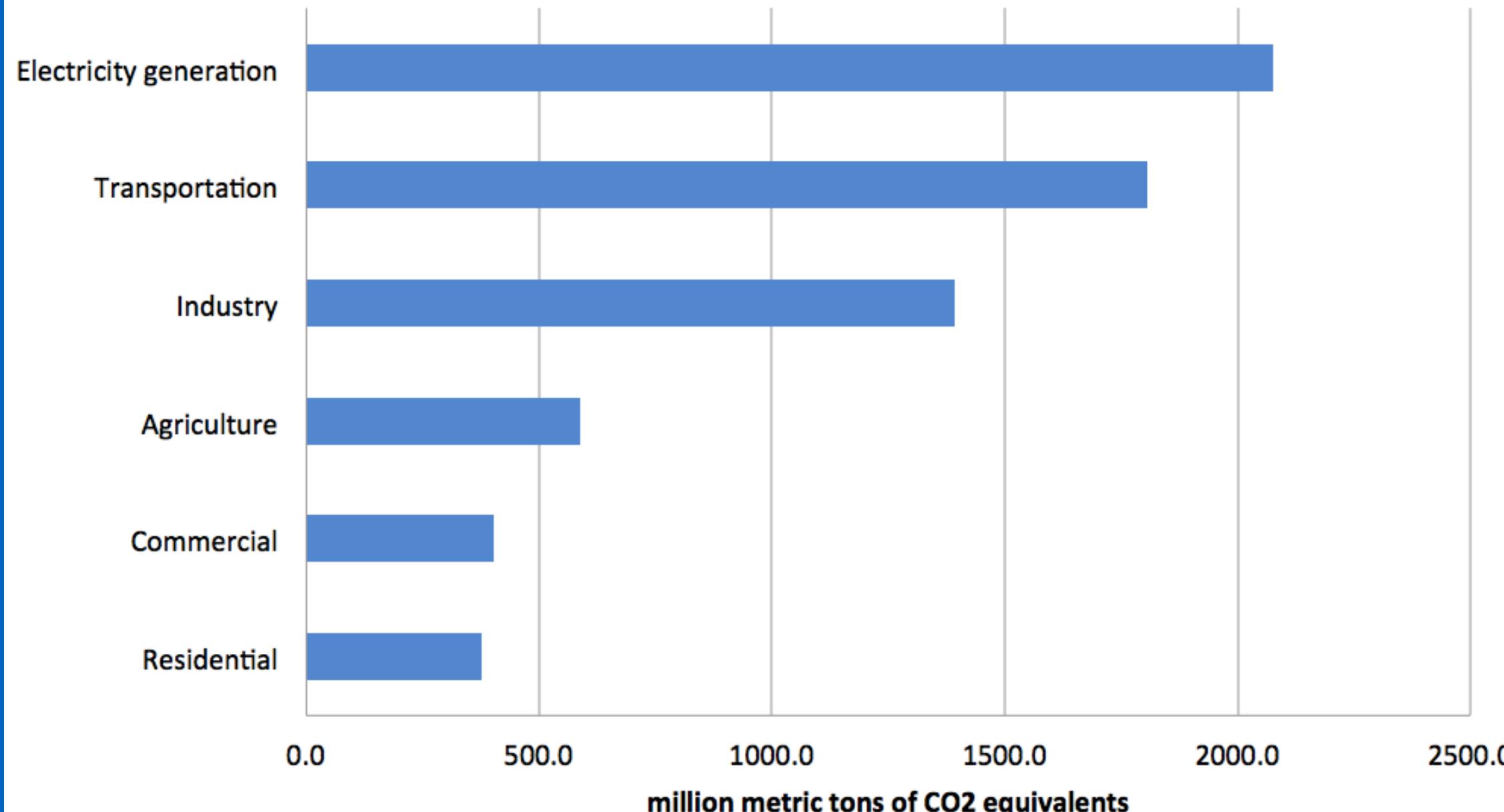
traditional heart-rate strap wasn't easy," admits Rothwell. "An onboard motion detector and built-in noise filtration software developed by consumer electronics giant Philips compensate for arm movements and perspiration typical of fast running and cycling, which can all interfere with blood flow measurements."

The MIO ALPHA can be used as a standalone device or in conjunction with popular smartphone apps such as MapMyRun, RunKeeper, and Wahoo Fitness.

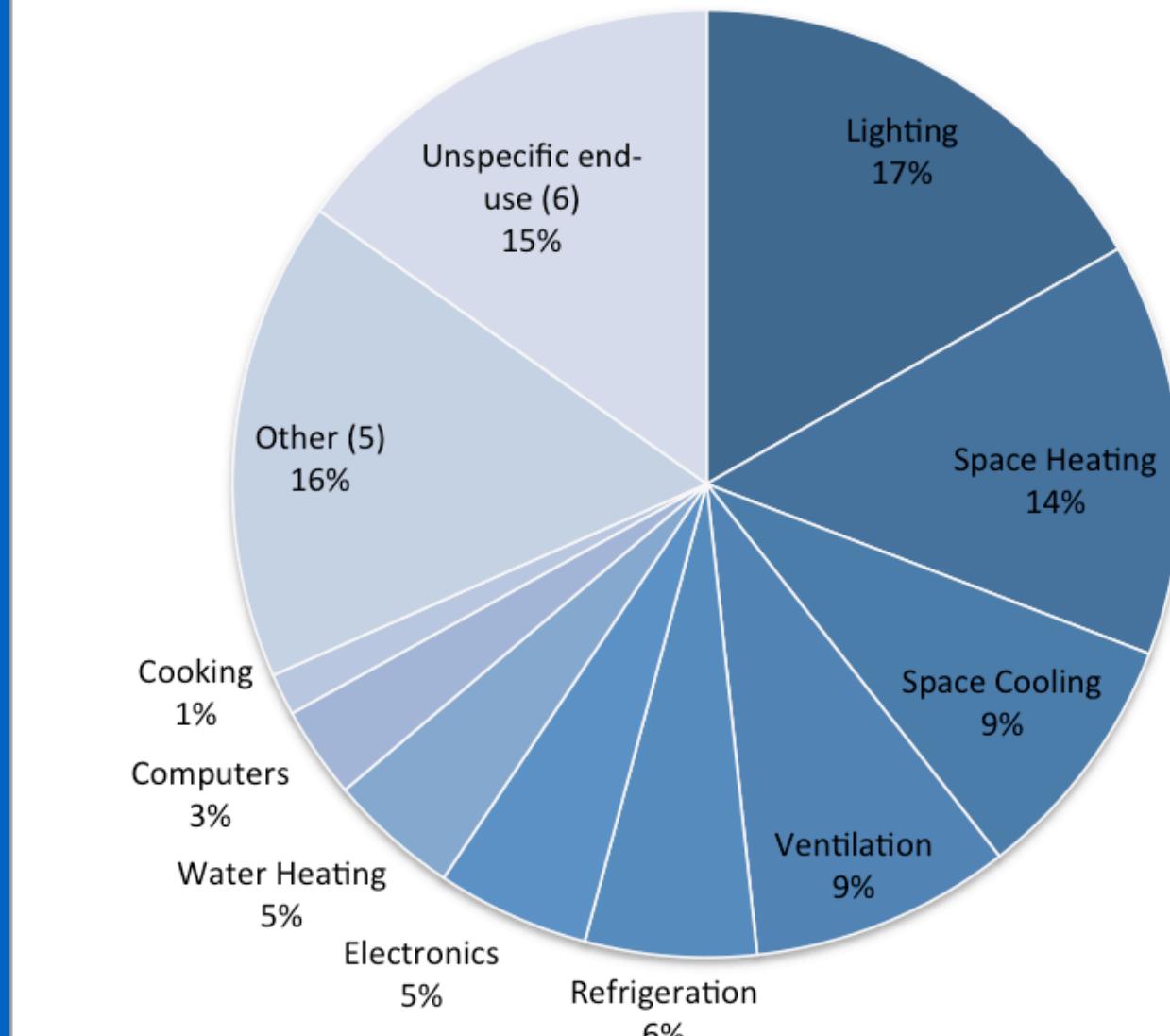


Challenge Number 2

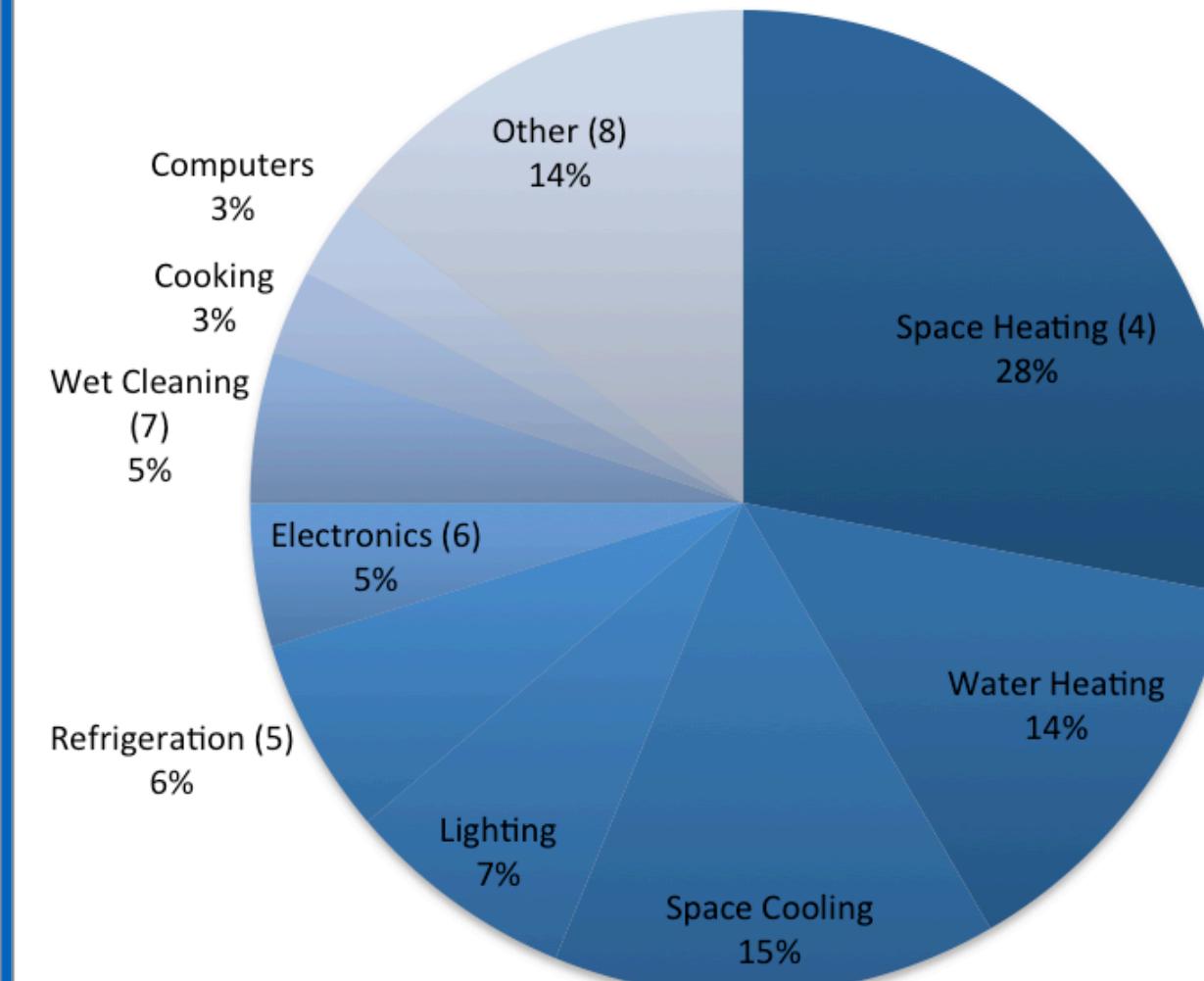
CO2 emissions by source US



Commercial electricity usage U.S 2015



Residential electricity usage U.S. 2015



The primary way that IoT can help battle climate change is by reducing global energy consumption, which will in turn reduce carbon emissions.

– Michael Miller, *The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World*

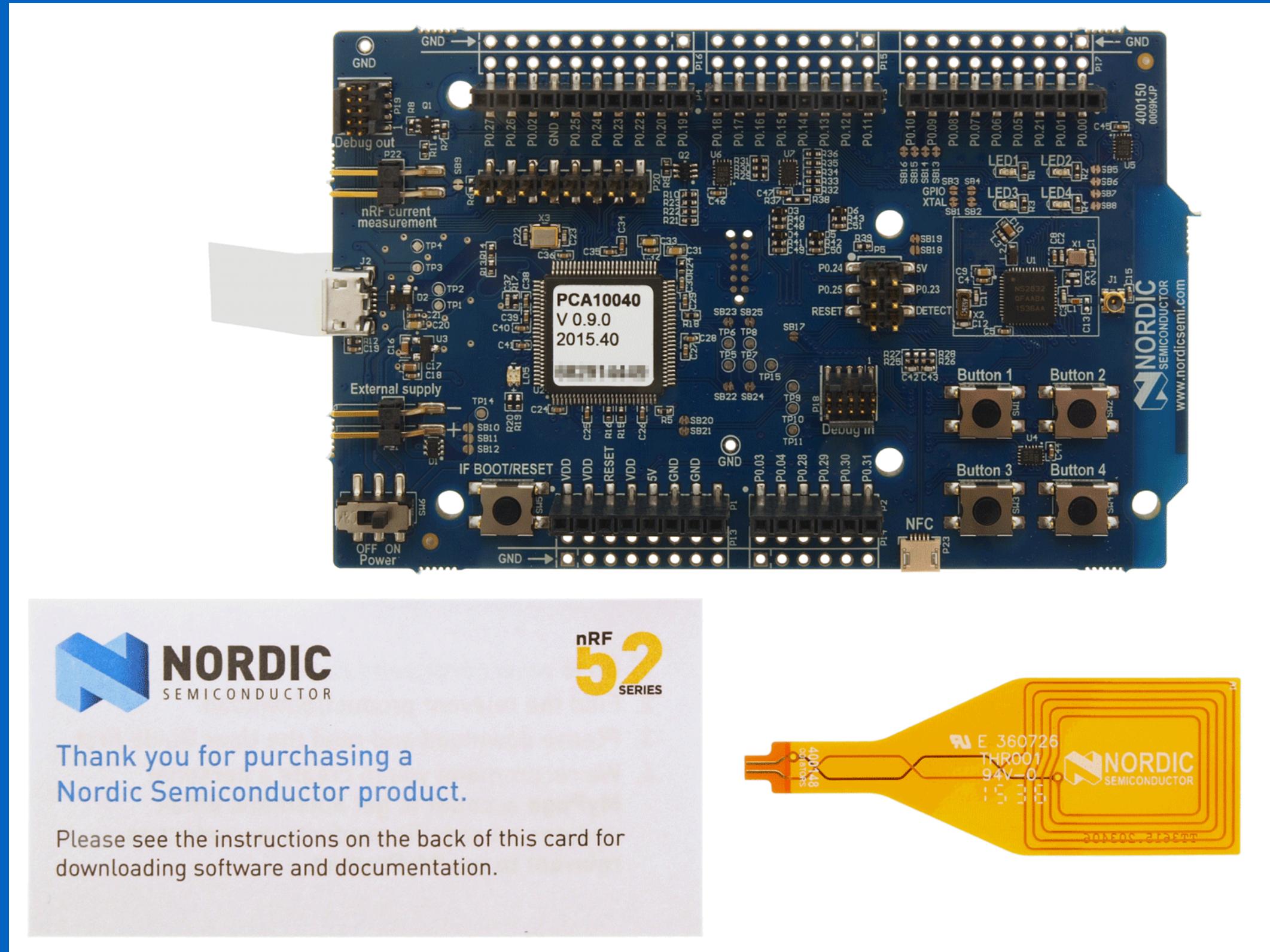


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Smarter Things

*Passionately committed to ultra-low-power wireless technology that
will benefit the lives of billions worldwide*



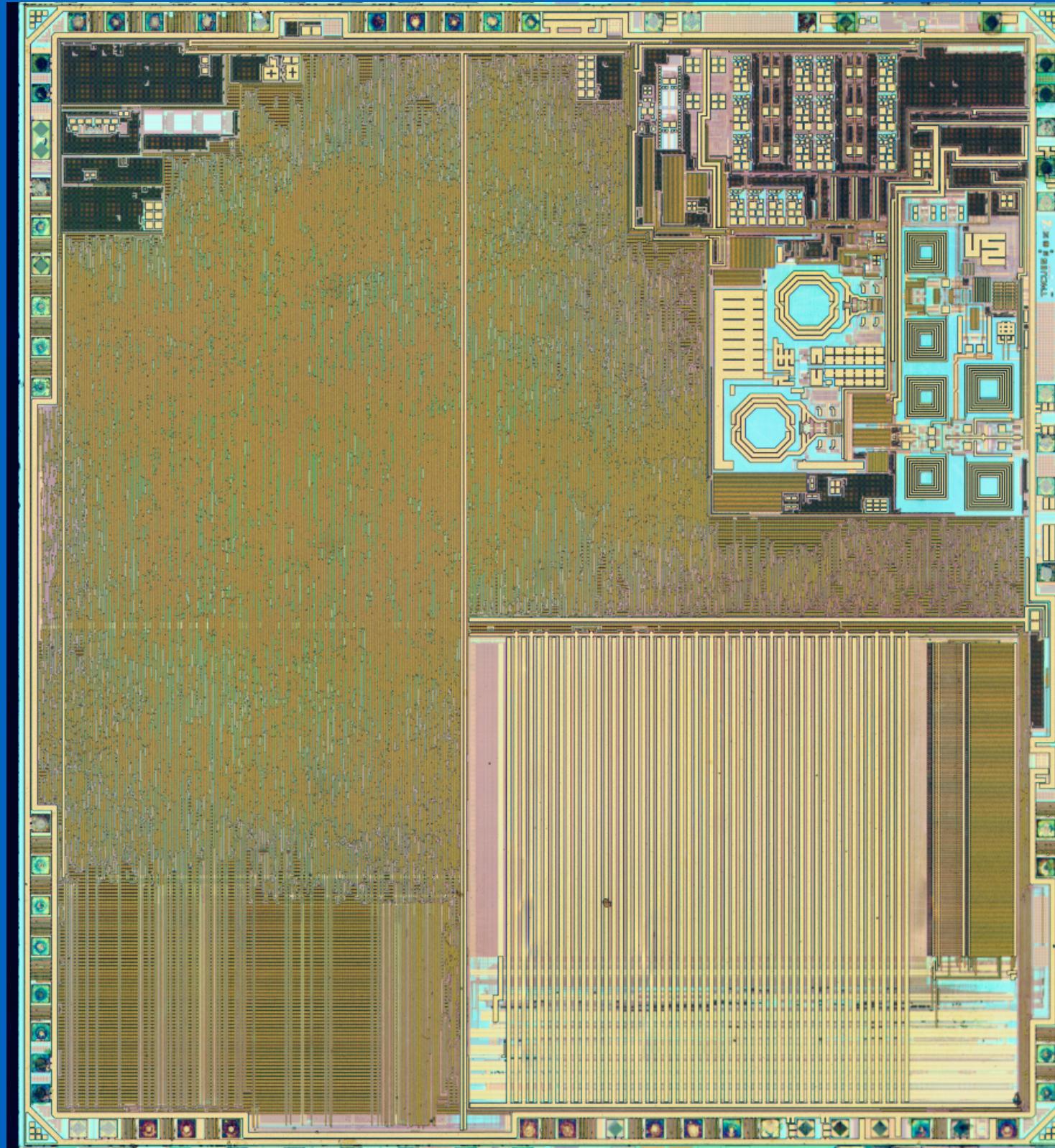


analog/RF: oscillators, bandgaps, noise generators, temperature sensor, linear voltage regulators, switch-mode voltage regulators, pad drivers, ADC, comparator, NFC, 2.4GHz radio

digital: CPU, memory, signal processing, I2S, crypto, RTC, timers, clocks, power control, SPI, TWI, UART, quadrature decoder, random number generator, pulse density modulator, event generators, pulse width modulators

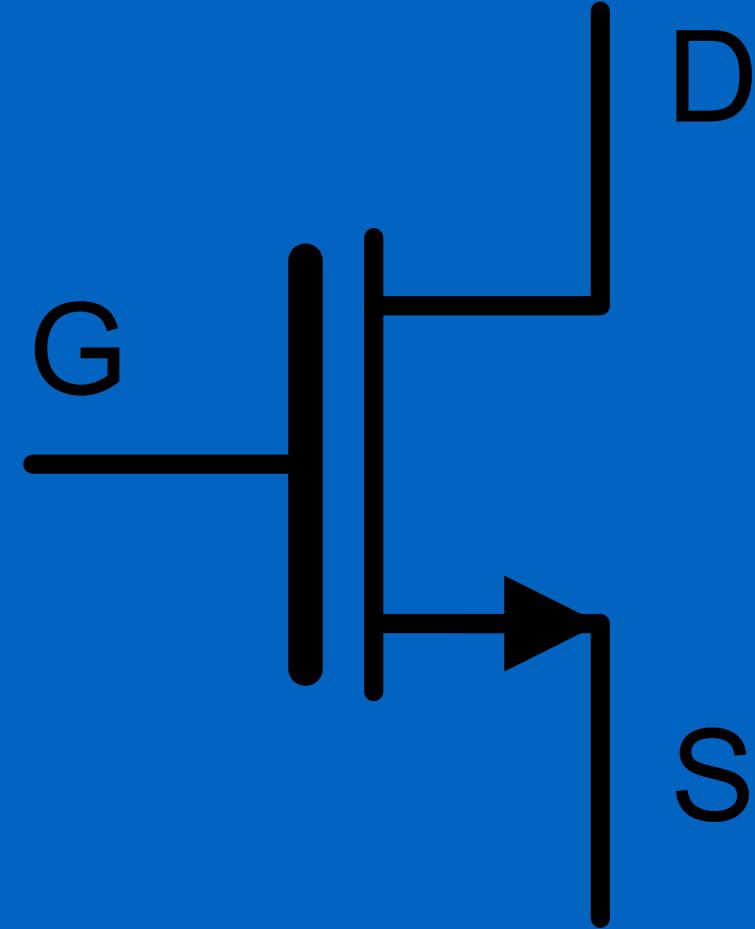
software: MDK, SDK, build servers, ANT stack, BTLE stack, iOS apps, Android apps, developer tools, IPV6 SDK, HomeKit SDK, sniffer

applications: beacon, smart remote, keyboard, toys



We digress: Complex math

Search for "Complex signal processing is not complex"



Simple model

$$I_D = \begin{cases} \text{high} & \text{if } V_{GS} > V_{TH} \\ 0 & \text{if } V_{GS} < V_{TH} \end{cases}$$

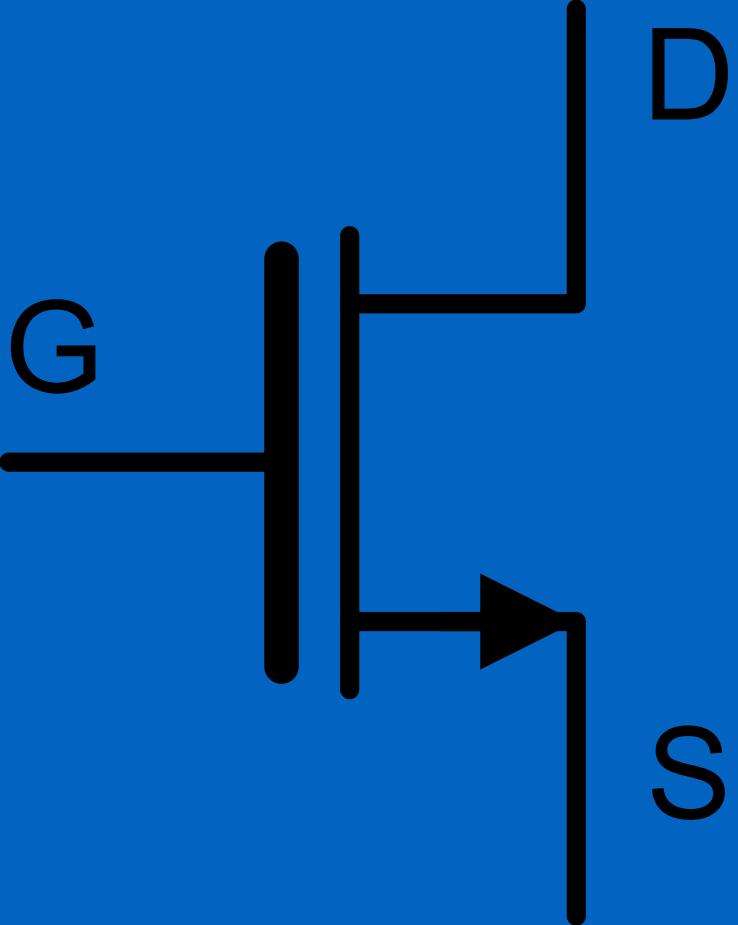
What you learn

$$I_D = \mu_n C_{ox} W/L (V_{GS} - V_{TH})^2$$

The truth

$$I_D = f(W, L, \mu_n, t_{ox}, sa, sb, sca, scb, scc, ad, as, pd, ps, \dots, V_{GS}, V_{DS})$$

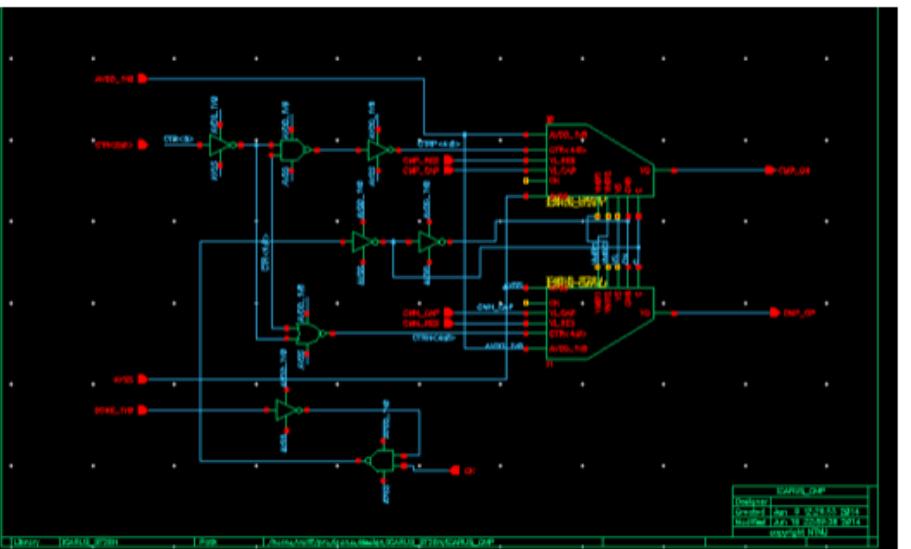
284 parameters in BSIM 4.5



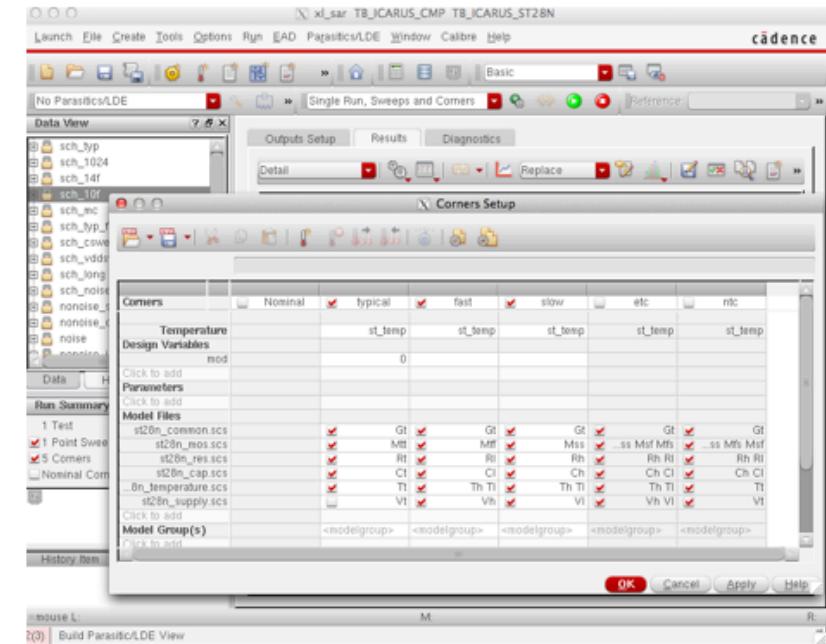
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CAPMOD=2 IGCMOD=1 IGBMOD=1 GEOMOD=1 DIOMOD=1 RDSMOD=0 RBODYMOD=0 RGATEMOD=3
PERMOD=1 ACNQSMOD=0 TRNQSMOD=0 TEMPMOD=0 TNOM=27 TOXE=1.8E-009
TOXP=10E-010 TOXM=1.8E-009 DTOX=8E-10 EPSROX=3.9 WINT=5E-009 LINT=1E-009
LL=0 WL=0 LLN=1 WLN=1 LW=0 WW=0 LWN=1 WWN=1 LWL=0 WWL=0 XPART=0
TOXREF=1.4E-009 SAREF=5E-6 SBREF=5E-6 WLOD=2E-6 KU0=-4E-6 KVSAT=0.2
KVTH0=-2E-8 TKU0=0.0 LL0DKU0=1.1 WLODKU0=1.1 LL0DVTH=1.0 WLODVTH=1.0
LKU0=1E-6 WKU0=1E-6 PKU0=0.0 LKVTH0=1.1E-6 WKVTH0=1.1E-6 PKVTH0=0.0
STK2=0.0 LODK2=1.0 STETA0=0.0 LODETA0=1.0 LAMBDA=4E-10 VSAT=1.1E 005
VTL=2.0E5 XN=6.0 LC=5E-9 RNOIA=0.577 RNOIB=0.37
LINTNOI=1E-009 WPEM0D=0 WEB=0.0 WEC=0.0 KVTH0WE=1.0 K2WE=1.0 KU0WE=1.0
SCREF=5.0E-6 TVOFF=0.0 TVFBSDOFF=0.0 VTH0=0.25 K1=0.35 K2=0.05
K3=0 K3B=0 W0=2.5E-006 DVT0=1.8 DVT1=0.52 DVT2=-0.032 DVT0W=0 DVT1W=0
DVT2W=0 DSUB=2 MINV=0.05 VOFFL=0 DVTP0=1E-007 DVTP1=0.05 LP0=5.75E-008
LP0B=2.3E-010 XJ=2E-008 NGATE=5E 020 NDEP=2.8E 018 NSD=1E 020 PHIN=0
CDSC=0.0002 CDSCB=0 CDSCD=0 CIT=0 VOFF=-0.15 NFACTOR=1.2 ETA0=0.05
ETAB=0 UC=-3E-011 VFB=-0.55 U0=0.032 UA=5.0E-011 UB=3.5E-018 A0=2
AGS=1E-020 A1=0 A2=1 B0=-1E-020 B1=0 KETA=0.04 DWG=0 DWB=0 PCLM=0.08
PDIBLC1=0.028 PDIBLC2=0.022 PDIBLCB=-0.005 DROUT=0.45 PVAG=1E-020
DELTA=0.01 PSCBE1=8.14E 008 PSCBE2=5E-008 RSH=0 RDSW=0 RSW=0 RDW=0
FPROUT=0.2 PDITS=0.2 PDITSD=0.23 PDITSL=2.3E 006 RSH=0 RDSW=50 RSW=150
RDW=150 RDSWMIN=0 RDWMIN=0 RSWMIN=0 PRWG=0 PRWB=6.8E-011 WR=1
ALPHA0=0.074 ALPHA1=0.005 BETA0=30 AGIDL=0.0002 BGIDL=2.1E 009 CGIDL=0.0002
EGIDL=0.8 AIGBACC=0.012 BIGBACC=0.0028 CIGBACC=0.002 NIGBACC=1
AIGBINV=0.014 BIGBINV=0.004 CIGBINV=0.004 EIGBINV=1.1 NIGBINV=3 AIGC=0.012
BIGC=0.0028 CIGC=0.002 AIGSD=0.012 BIGSD=0.0028 CIGSD=0.002 NIGC=1
POXEDGE=1 PIGCD=1 NTOX=1 VFBSDOFF=0.0 XRCRG1=12 XRCRG2=5 CGSO=6.238E-010
CGDO=6.238E-010 CGBO=2.56E-011 CGDL=2.495E-10 CGSL=2.495E-10
CKAPPAS=0.03 CKAPPAD=0.03 ACDE=1 MOIN=15 NOFF=0.9 VOFFCV=0.02 KT1=-0.37
KT1L=0.0 KT2=-0.042 UTE=-1.5 UA1=1E-009 UB1=-3.5E-019 UC1=0 PRT=0
AT=53000 FNOIMOD=1 TNOIMOD=0 JSS=0.0001 JSWS=1E-011 JSWGS=1E-010 NJSS=1
IJTHSFWD=0.01 IJTHSREV=0.001 BVS=10 XJBVS=1 JSD=0.0001 JSWD=1E-011
JSWGD=1E-010 NJD=1 IJTHDFWD=0.01 IJTHDREV=0.001 BVD=10 XJBVD=1 PBS=1 CJS=0.0005
MJS=0.5 PBSWS=1 CJSWS=5E-010 MJSWS=0.33 PBSWGS=1 CJSWGS=3E-010 MJSWGS=0.33
PBD=1 CJD=0.0005 MJD=0.5 PBSWD=1 CJSWD=5E-010 MJSWD=0.33 PBSWD=1
CJSWGD=5E-010 MJSWGD=0.33 TPB=0.005 TCJ=0.001 TPBSW=0.005 TCJSW=0.001 TPBSWG=0.005
TCJSWG=0.001 XTIS=3 XTID=3 DMCG=0E-006 DMCI=0E-006 DMDG=0E-006 DMCGT=0E-007 DWJ=0.0E-008 XGW=0E-007
XGL=0E-008 RSHG=0.4 GBMIN=1E-010 RBPB=5 RBPD=15 RBPS=15 RBDB=15 RBSB=15 NGCON=1
JTSS=1E-4 JTSD=1E-4 JTSSWS=1E-10 JTSSWD=1E-10 JTSSWGS=1E-7 JTSSWD=1E-7 NJTS=20.0
NJTSSW=20 NJTSSWG=6 VTSS=10 VTSD=10 VTSSWS=10 VTSSWD=10 VTSSWGS=2 VTSSWD=2
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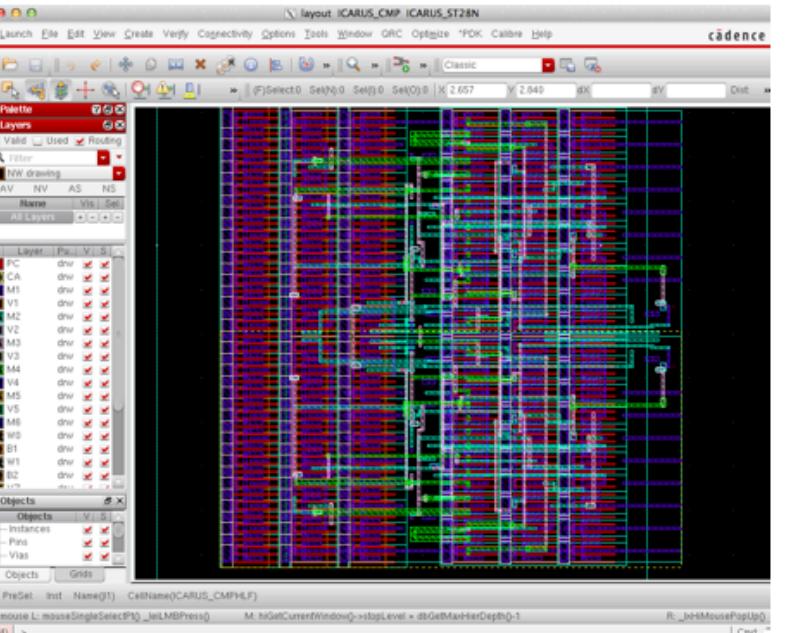
Schematic



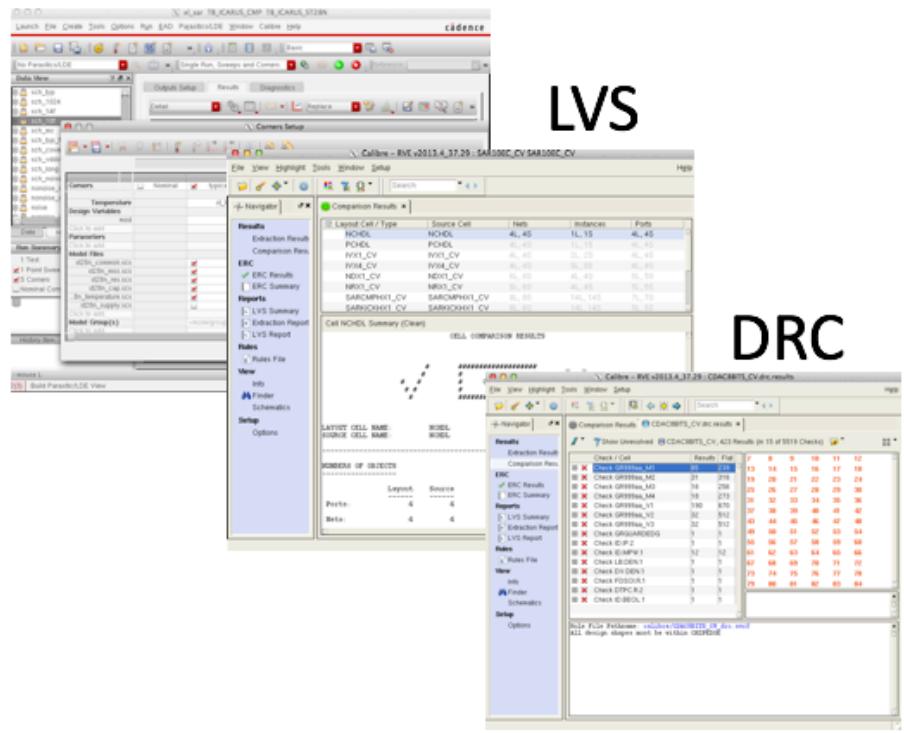
Simulation



Layout

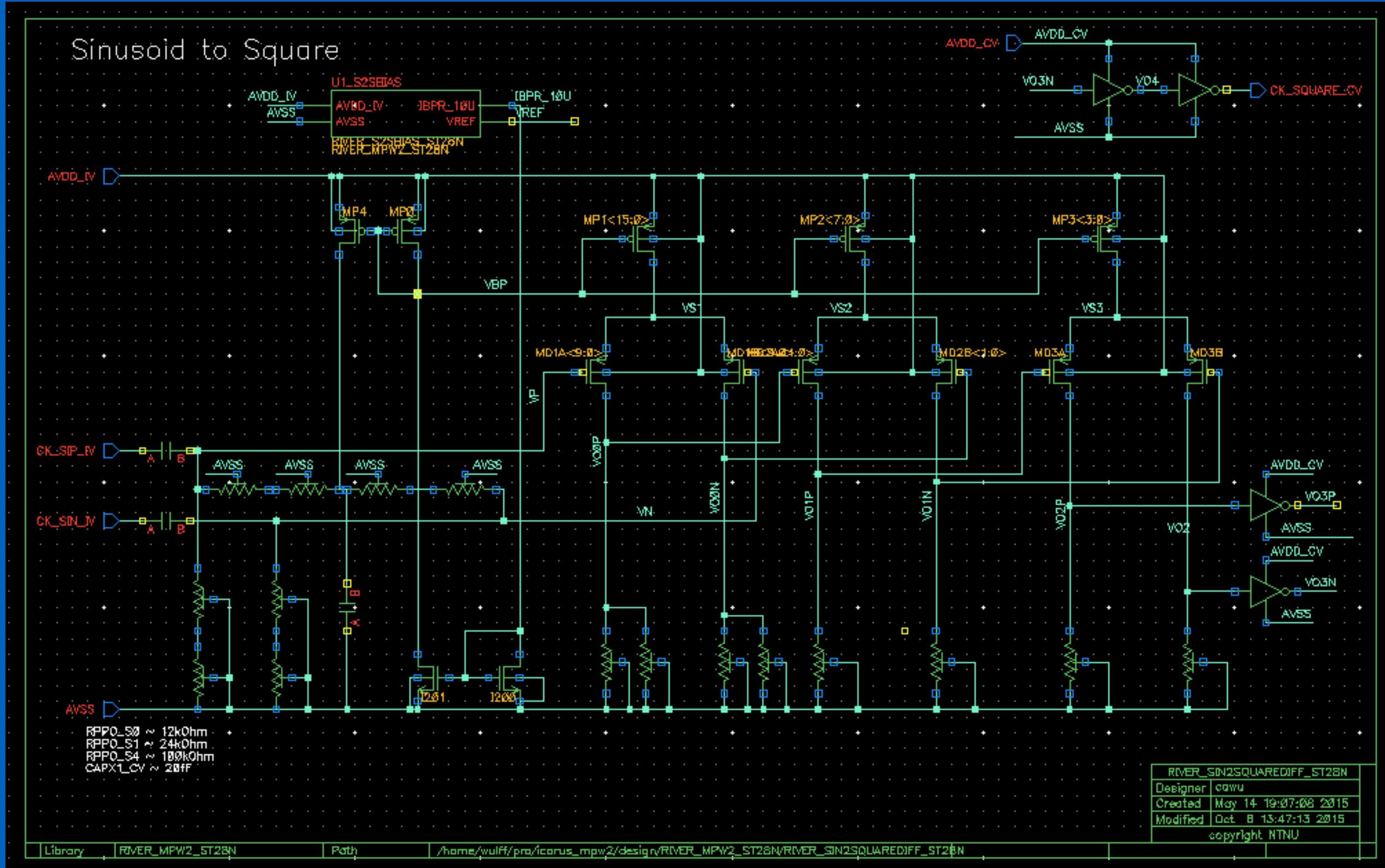


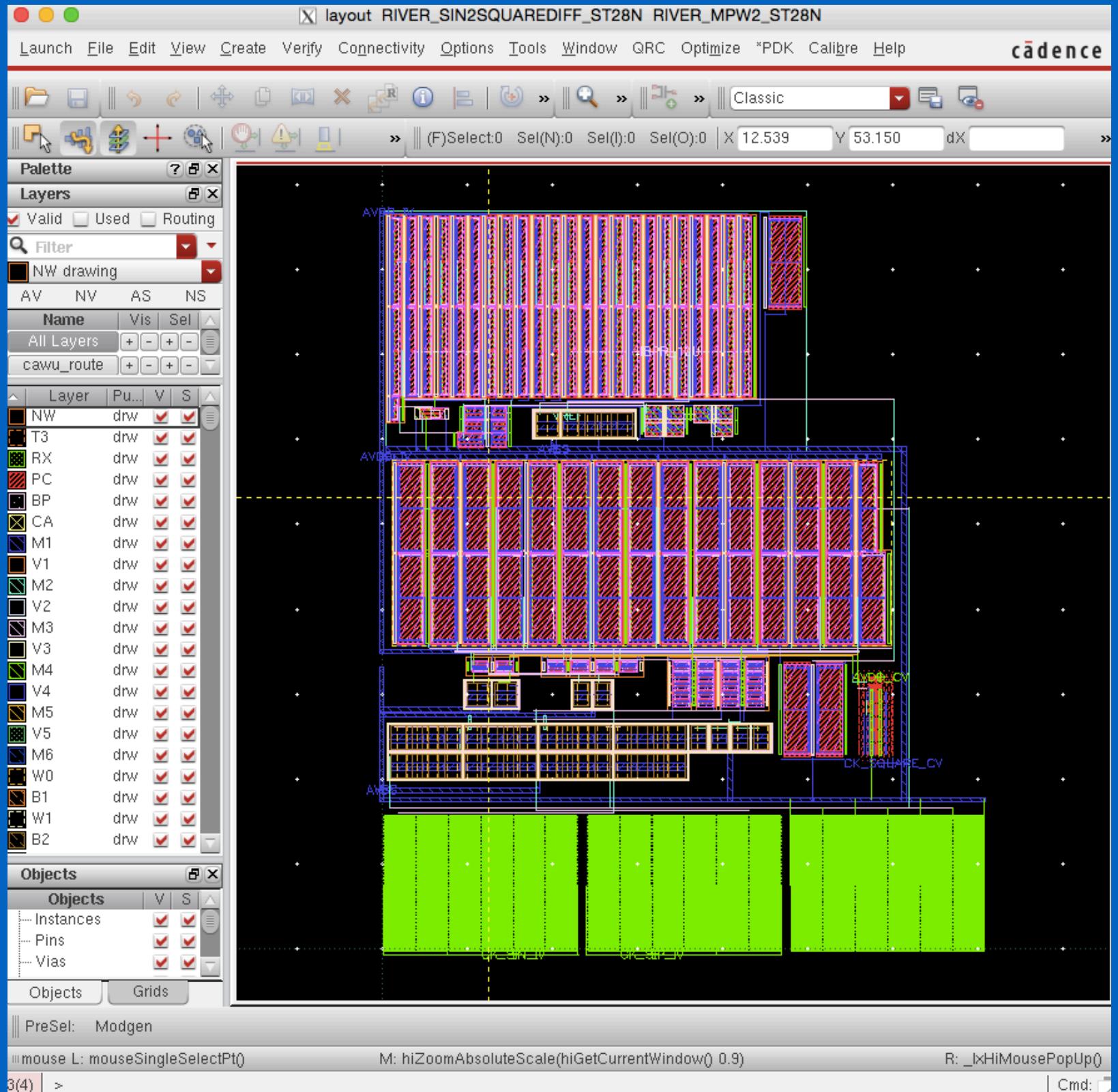
Simulation



LVS

DRC





Game menu



Software you should know

Schematic/Layout (Mentor graphics, Cadence, Synopsys, Tanner tools)

Simulation (Eldo, Spectre, Hspice, SMASH)

Scripting (Bash, Python, Perl, TCL, LISP)

Editors (Emacs)

Math software (Matlab, Maple, Octave)

Information sources

<http://ieeexplore.ieee.org>

<http://webcast.berkeley.edu/>

EE240 spring 2007 to spring 2010

For new tricks, scan JSSC (all papers) each month

Don't panic!

Want to help me make a better
world? Why wait?



NORDIC
S E M I C O N D U C T O R

Smarter Things

We are looking for a student with
programming skills in Python, Perl, C
or C++ and electronics interest to join our
team in Trondheim part time.
<https://goo.gl/Wxb6bC>

More info

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