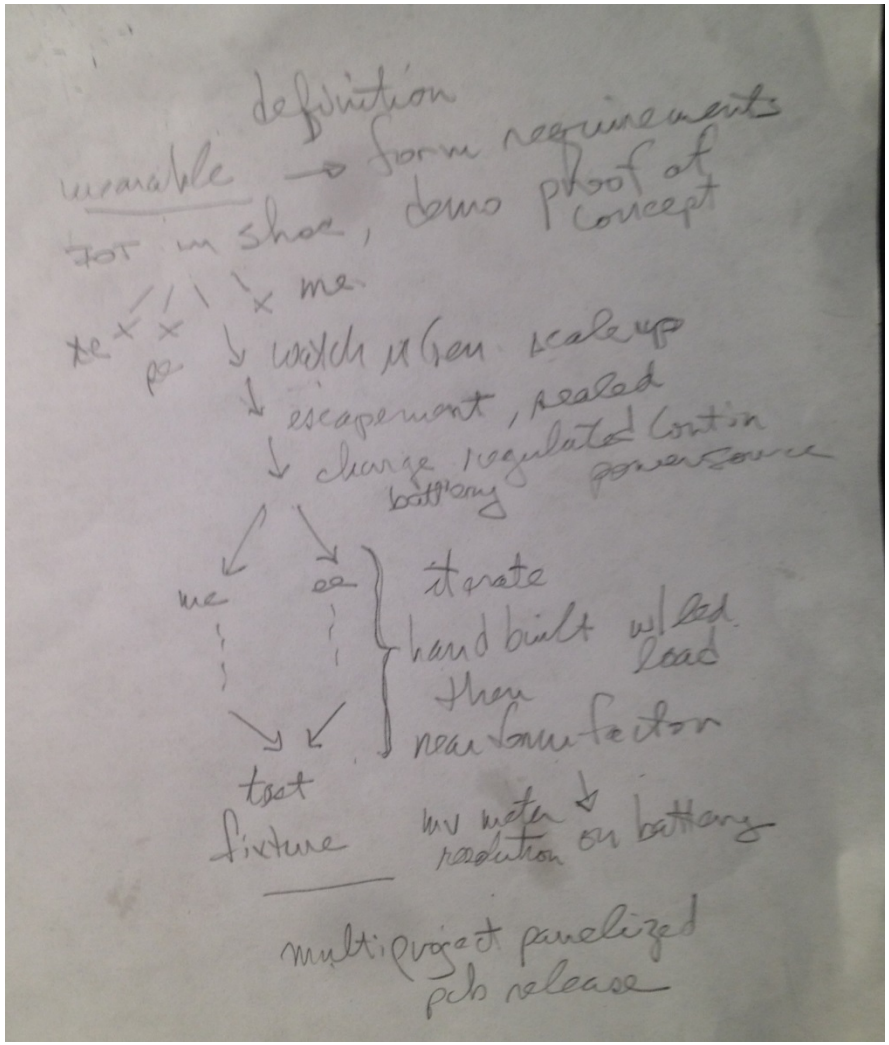
Projects Preso
Tuesday, 2/19/21

Dyke Shaffer

EE / ME / CS / MP / ….

Energy Harvesting / Bidirectional Fiber Optics

Concept to Product



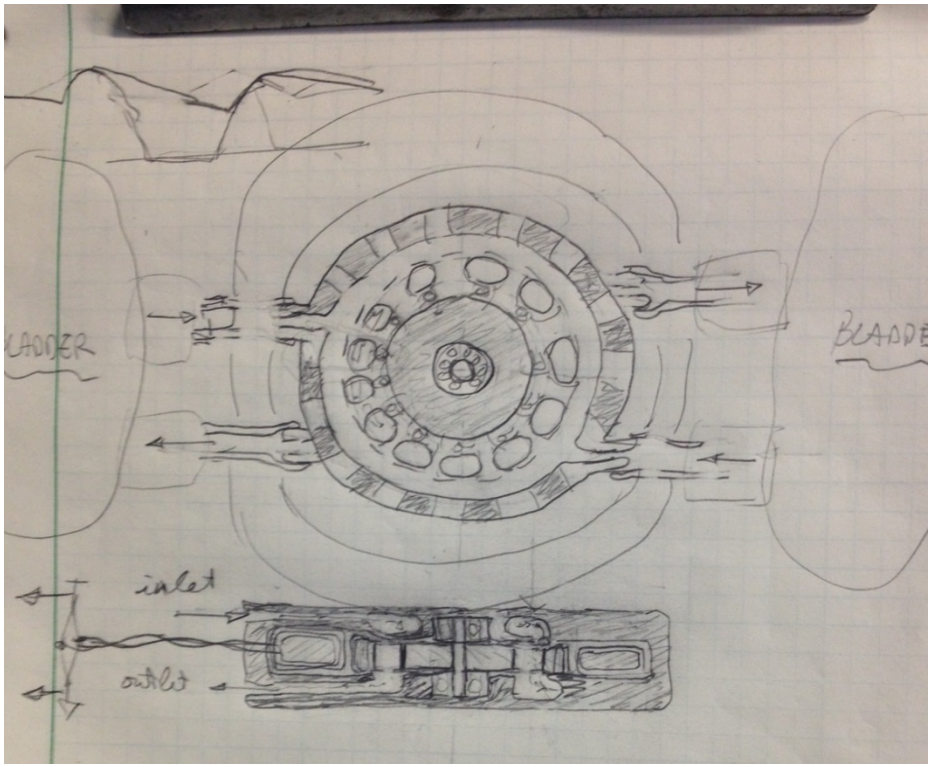
- explore alternatives
- socialize to refine ideas
- pick the most promising

- develop prototype(s)

- build and bench test
- iterate near form factor
- draw conclusions

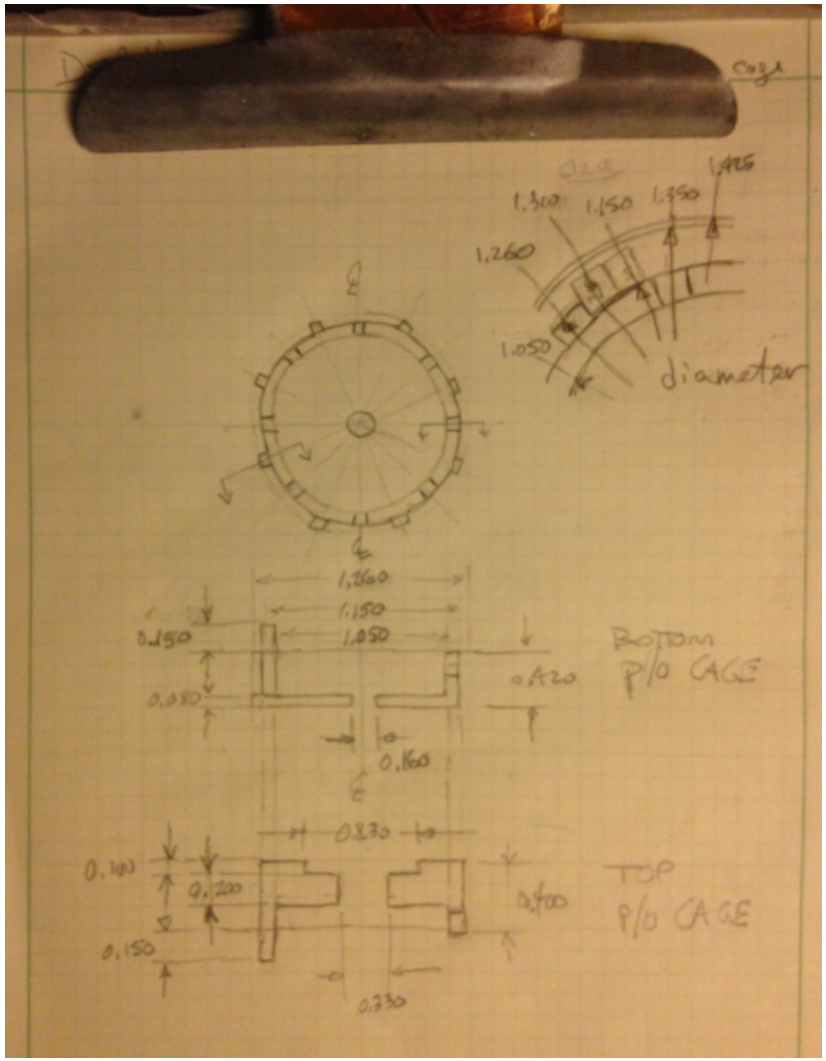
Foot Fall Power Source

- pneumatic turbine
- pancake configuration

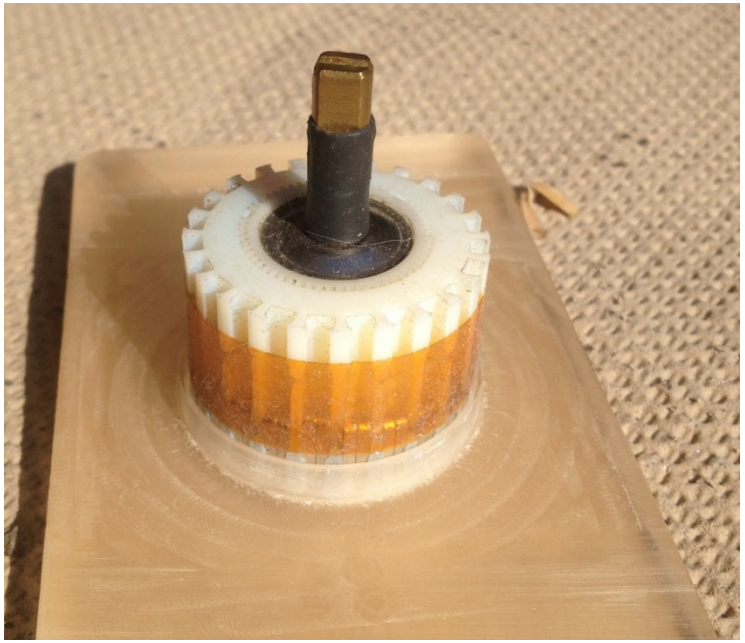


- www.kinetron.eu
- micro generator

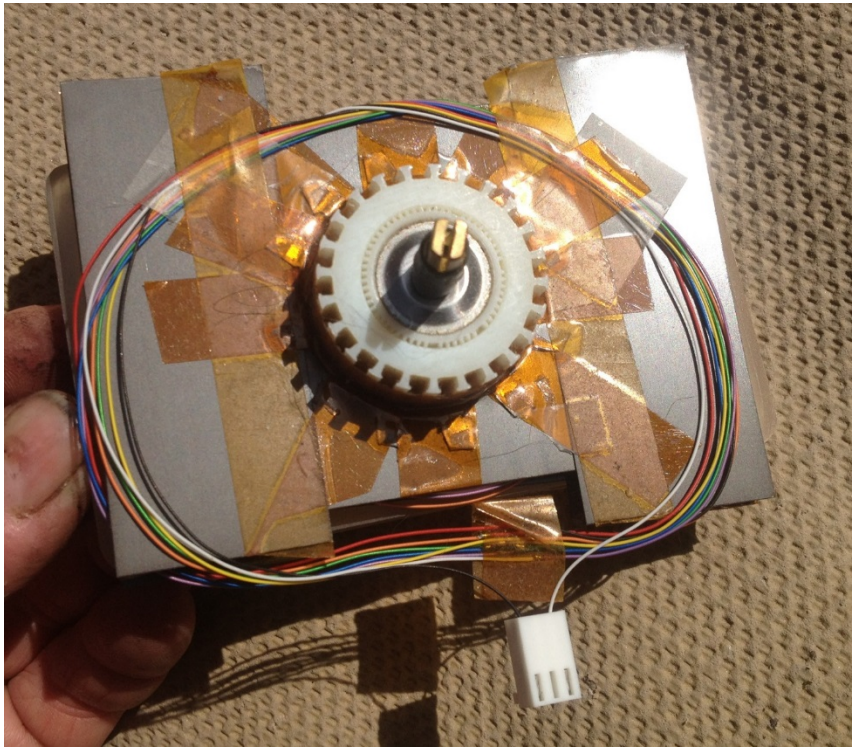
Rotor Magnet Carrier



- diameter / poles
- magnet orientation
- perimeter gap(s)



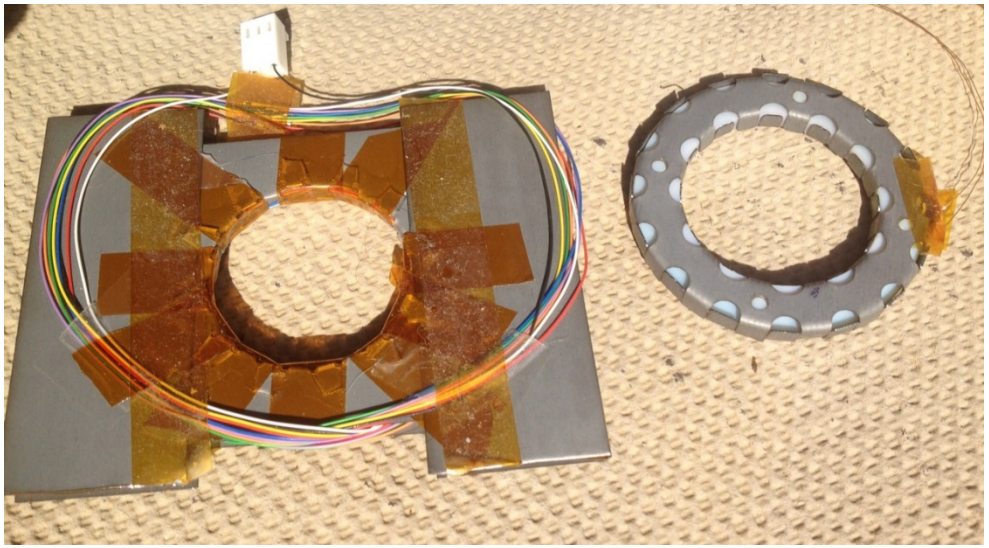
Stator Prototype



- best effort
- proof of concept
- out of form factor

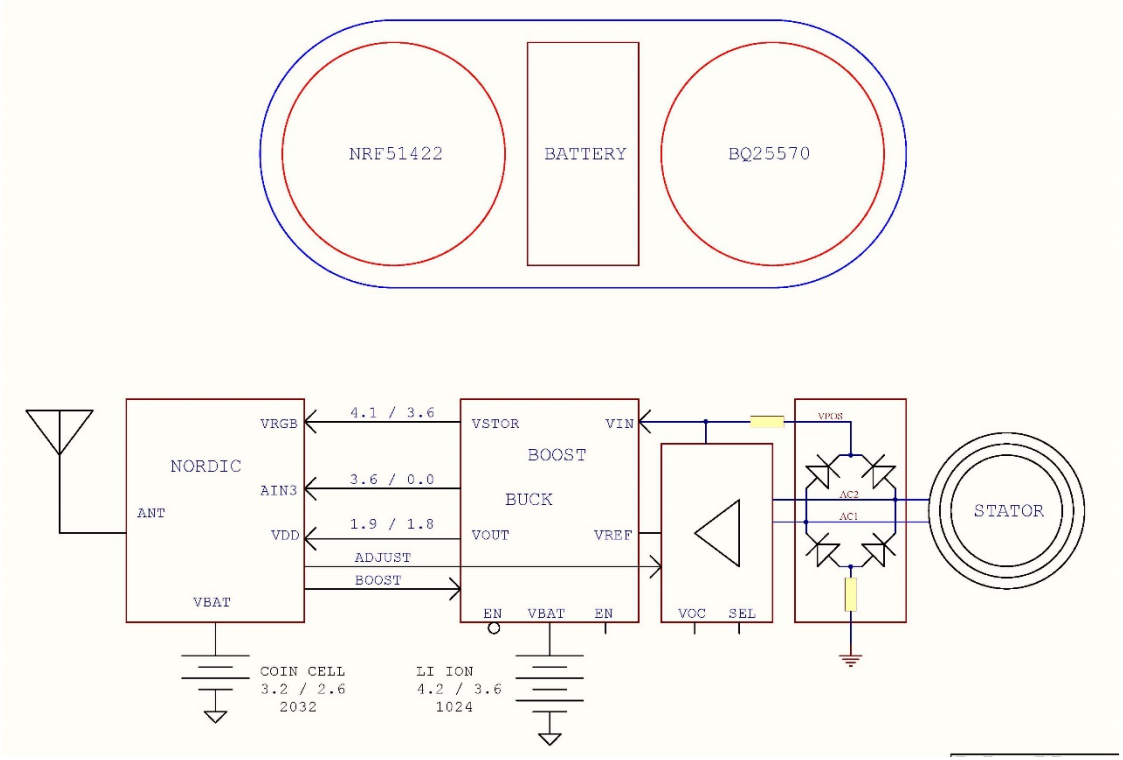
- silicon steel lamination
- hand cut with scissors
- hand wound coil

- water jet cut lamination
- press form jig
- pole path interdigitated
- printed bobbin winding



Power Conversion

- near form factor generator
- battery management (charging and regulation)



Texas Instruments BQ25570

TEXAS INSTRUMENTS

bq25570

SLUSBH2G – MARCH 2013 – REVISED MARCH 2019

bq25570 nano power boost charger and buck converter for energy harvester powered applications

1 Features

- Ultra Low Power DC-DC Boost Charger
  - Cold-Start Voltage: $V_{IN} \geq 600$ mV
  - Continuous Energy Harvesting From VIN as low as 100 mV
  - Input Voltage Regulation Prevents Collapsing High Impedance Input Sources
  - Full Operating Quiescent Current of 488 nA (typical)
  - Ship Mode with < 5 nA From Battery
- Energy Storage
  - Energy can be Stored to Re-chargeable Li-ion Batteries, Thin-film Batteries, Super-capacitors, or Conventional Capacitors
- Battery Charging and Protection
  - Internally Set Undervoltage Level
  - User Programmable Overvoltage Levels
- Battery Good Output Flag
  - Programmable Threshold and Hysteresis
  - Warn Attached Microcontrollers of Pending Loss of Power
  - Can be Used to Enable or Disable System Loads
- Programmable Step Down Regulated Output (Buck)
  - High Efficiency up to 93%
  - Supports Peak Output Current up to 110 mA (typical)
- Programmable Maximum Power Point Tracking (MPPT)
  - Provides Optimal Energy Extraction From a Variety of Energy Harvesters including Solar Panels, Thermal and Piezo Electric Generators

2 Applications

- Energy Harvesting
- Solar Chargers
- Thermal Electric Generator (TEG) Harvesting
- Wireless Sensor Networks (WSN)
- Low Power Wireless Monitoring
- Environmental Monitoring
- Bridge and Structural Health Monitoring (SHM)
- Smart Building Controls
- Portable and Wearable Health Devices
- Entertainment System Remote Controls

3 Description

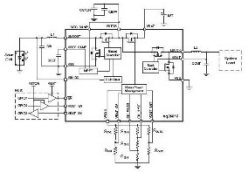
The bq25570 device is specifically designed to efficiently extract microwatts (μW) to milliwatts (mW) of power generated from a variety of high output impedance DC sources like photovoltaic (solar) or thermal electric generators (TEG) without collapsing those sources. The battery management features ensure that a rechargeable battery is not overcharged by this extracted power, with voltage boosted, or depleted beyond safe limits by a system load. In addition to the highly efficient boosting charger, the bq25570 integrates a highly efficient, nano- power buck converter for providing a second power rail to systems such as wireless sensor networks (WSN) which have stringent power and operational demands. All the capabilities of bq25570 are packed into a small foot-print 20-lead 3.5-mm x 3.5-mm QFN package (RGR).

Device Information(1)

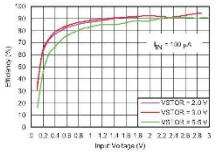
PART NUMBER	PACKAGE	BODY SIZE (NOM)
bq25570	VQFN (20)	3.50 mm × 3.50 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Typical Application Schematic



Charger Efficiency vs Input Voltage

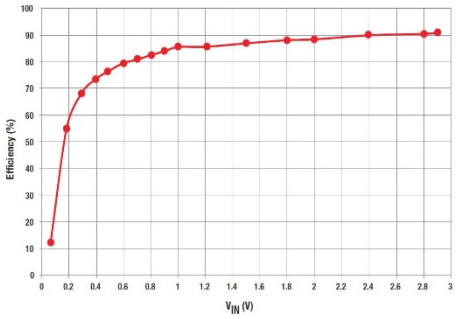


- boost to charge battery
- buck to source power
- low quiescent current

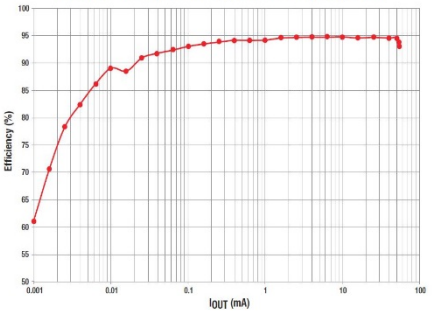
Featured Energy Harvesting ICs

Product	Description
bq25505	Ultra-low power boost converter with battery management and autonomous power path multi-plexing
bq25504	Ultra-low power boost converter with battery management
bq25570	Ultra-low power boost converter with battery management and buck output regulation
TPS62736/37	Ultra-low Iq nano-buck regulators
bq25504EVM-674	Evaluation module for bq25504 ultra-low-power boost converter
TPS62736EVM-205	Evaluation module for TPS62736 programmable output ultra-low-power buck converter

bq25504 Efficiency vs V_{IN}, (I_{IN} = 100 μA) VSTOR = 3.0 V

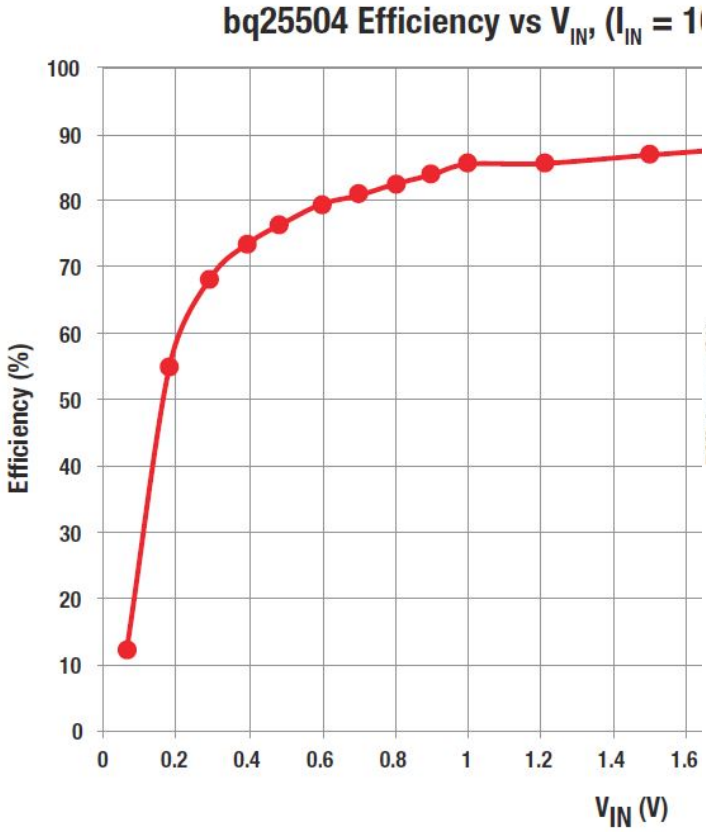


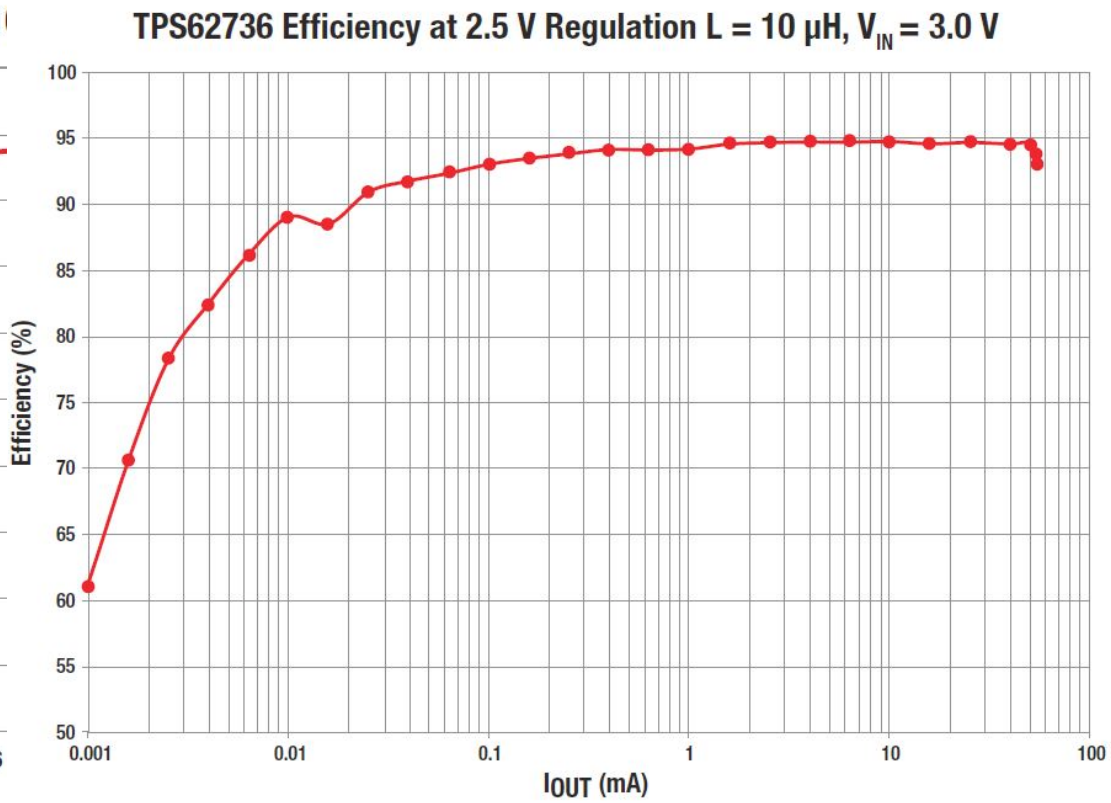
TPS62736 Efficiency at 2.5 V Regulation L = 10 μH, V_{IN} = 3.0 V



Power Conversion Efficiency

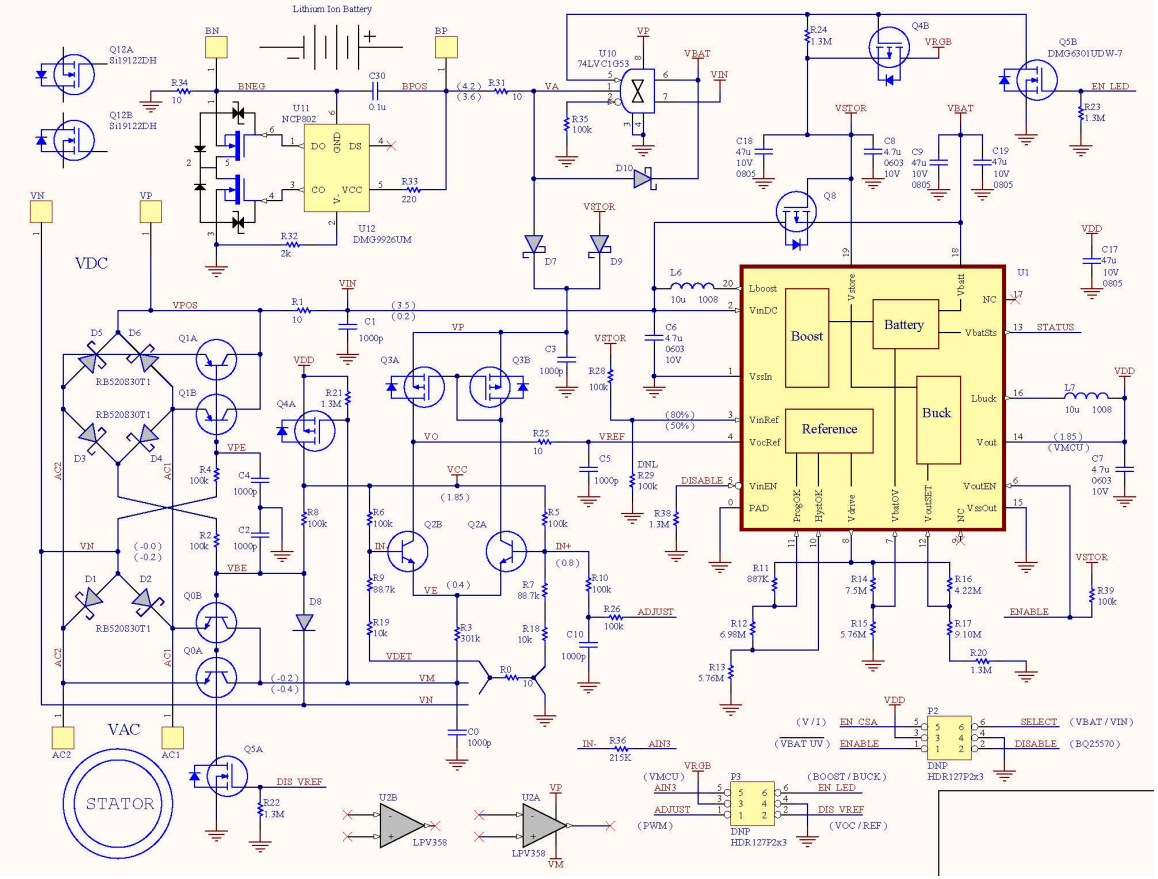
- Vin 200mV
- Iout 10uA (88 % eff)

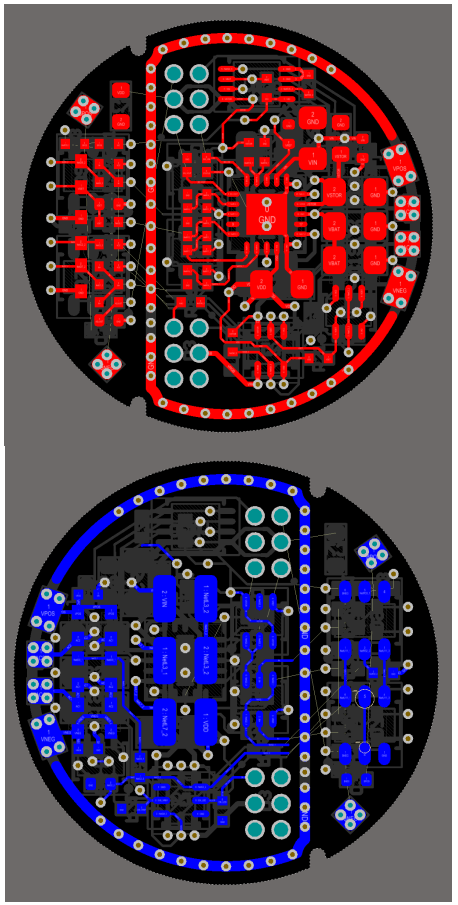




PCB Layout (4 layer)

- synchronous rectifier
- battery management





Observations / Conclusions

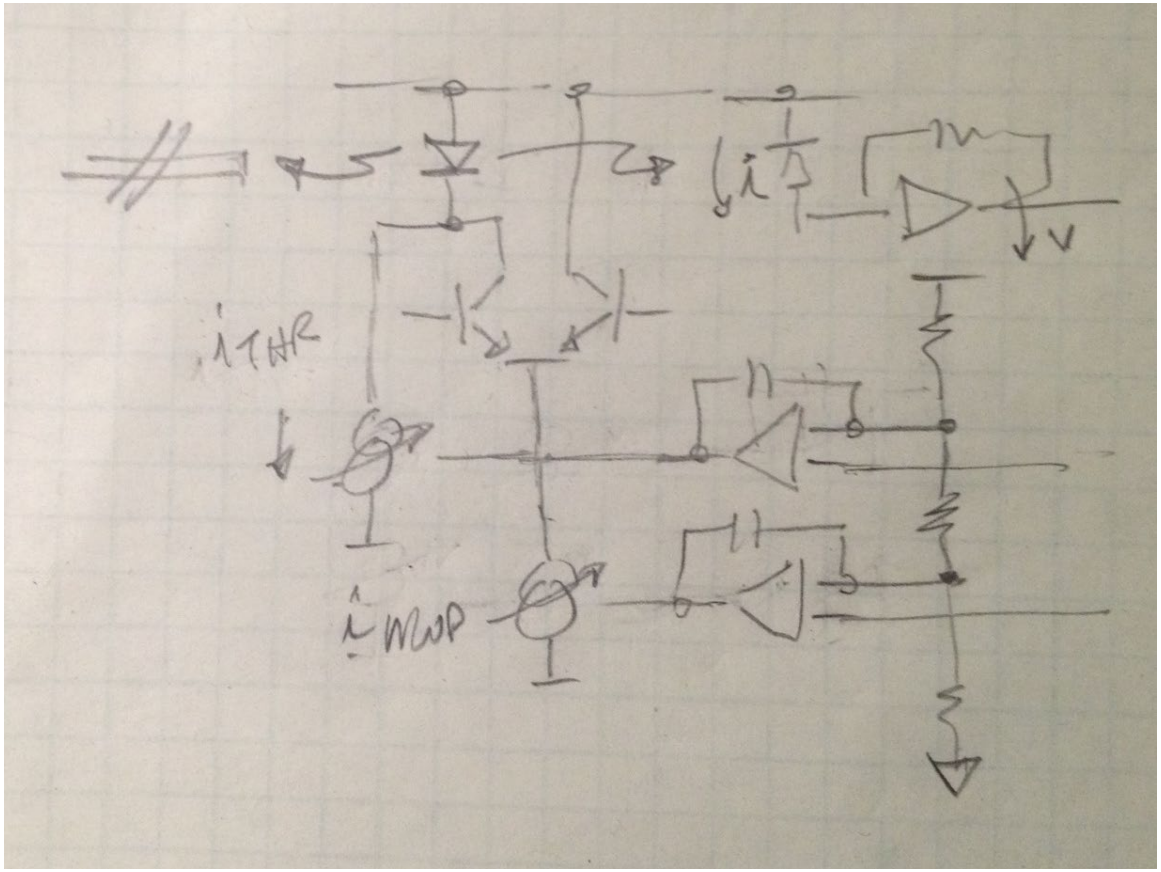
- reference designs
- application specific
- bench verification
- future challenges

- Kinetron Micro Generator
- TI BQ5570 harvester
- synchronous rectifier
- pole by pole energy
- partial turn onset
- out of form factor
- field strength control
- magnetic stiction

Fiber Optic Laser Driver

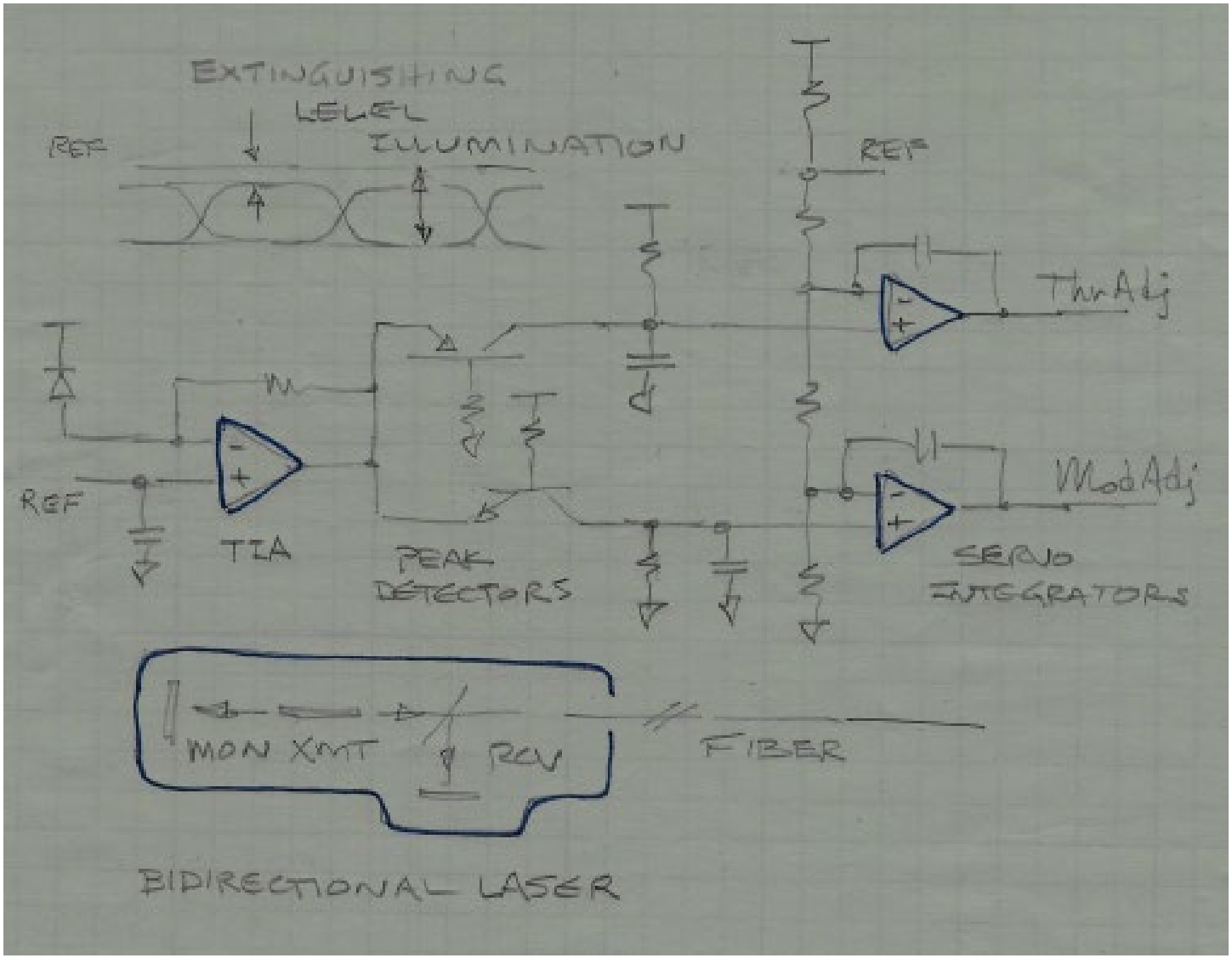
- thermal load
- temperature range
- overhead drop
- telecom optical carrier
- low cost
- optic power control

- outside aerial plant
- daily 20 thru 120 deg F
- fiber in the loop
- Sonet OC-3 and OC-12
- 128 units per shelf
- both temp and aging

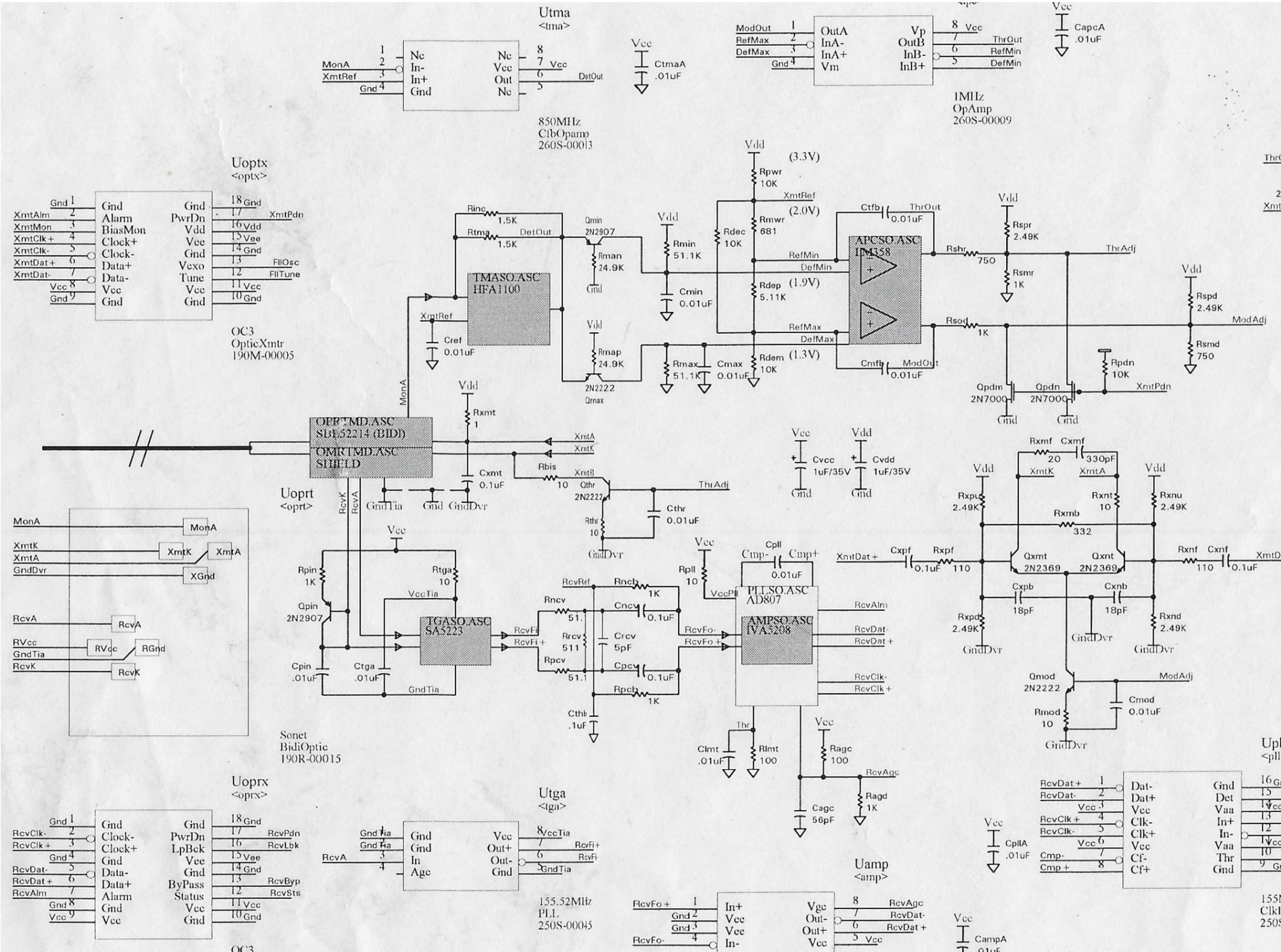


Laser Diode Driver Block Diagram

Light is emitted and coupled to optical fiber at a power level that is controlled by regulating current in a light emitting diode to provide a bias sustaining level and a full illumination level. This is necessary to accommodate the led's aging related reduction in operating efficiency.



Extinguishing and Illumination level detection with complementary bipolar transistors to servo both light power levels with the same back facet monitor photo detector diode to compensate for laser diode aging.


Utma
<tma>
Nc
In-
In+
Gnd
Nc
Vcc
Out
Nc
MonA
XmtRef
DetOut
CtmaA
.01uF
850MHz
CfbOpamp
260S-00013
ModOut
RefMax
DefMax
OutA
InA-
InA+
Vm
Vp
OutB
InB-
InB+
ThrOut
RefMin
DefMin
CapcA
.01uF
1MHz
OpAmp
260S-00009
Uoptx
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Gnd
Alarm
BiasMon
Clock+
Clock-
Data+
Data-
Vcc
PwrDn
Vdd
Vee
Vcxo
Tune
XmtAlm
XmtMon
XmtClk+
XmtClk-
XmtDat+
XmtDat-
XmtPdn
FllOsc
FllTune
OC3
OpticXmtr
190M-00005
TMASO.ASC
HFA1100
APCSO.ASC
LM358
Rpwr
10K
(3.3V)
(2.0V)
(1.9V)
(1.3V)
Rmwr
681
Rdec
10K
Rdep
5.11K
Rdem
10K
Rmin
51.1K
Cmin
0.01uF
Rmax
51.1K
Cmax
0.01uF
Rman
24.9K
Rmap
24.9K
Qmin
2N2907
Qmax
2N2222
Rinc
1.5K
Rtmg
1.5K
Cref
0.01uF
Ctfb
0.01uF
Cmfb
0.01uF
Rshr
750
Rsod
1K
Rspr
2.49K
Rsmr
1K
Rspd
2.49K
Rsmd
750
ThrAdj
ModAdj
Rpdn
10K
XmtPdn
Qpdm
2N7000
Qpdn
2N7000
OPRTMD.ASC
SBL52214 (BIDI)
OMRTMD.ASC
SHIELD
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Cxmt
0.1uF
Rbis
10
Qthr
2N2222
Rthr
10
Cthr
0.01uF
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1uF/35V
Cvdd
1uF/35V
Uoprt
<oprt>
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XmtK
XmtA
GndDvr
XGnd
RcvA
RVcc
GndTia
RcvK
RGnd
Sonet
BidiOptic
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Qpin
2N2907
Cpin
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10
Ctga
.01uF
TGASO.ASC
SA5223
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51.1
Rrcv
511
Rpcv
51.1
Cncv
0.1uF
Crcv
5pF
Cpcv
0.1uF
Rncb
1K
Rpcb
1K
Cthb
.1uF
Rpll
10
Cpll
0.01uF
PLLSO.ASC
AD807
AMPSO.ASC
IVA5208
RcvAlm
RcvDat-
RcvDat+
RcvClk-
RcvClk+
Clmt
.01uF
Rlmt
100
Ragc
100
Ragd
1K
Cagc
56pF
RcvAgc
Rxmf
20
Cxmf
330pF
Rxpu
2.49K
Rxnu
2.49K
Rxnt
10
Rxmb
332
Qxmt
2N2369
Qxnt
2N2369
Cxpf
0.1uF
Rxpf
110
Rxnf
110
Cxnf
0.1uF
Cxpb
18pF
Cxnb
18pF
Rxpd
2.49K
Rxnd
2.49K
Qmod
2N2222
Rmod
10
Cmod
0.01uF
Uoprx
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PwrDn
LpBck
ByPass
Status
RcvPdn
RcvLbk
RcvByp
RcvSts
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Agc
Out+
Out-
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Upll
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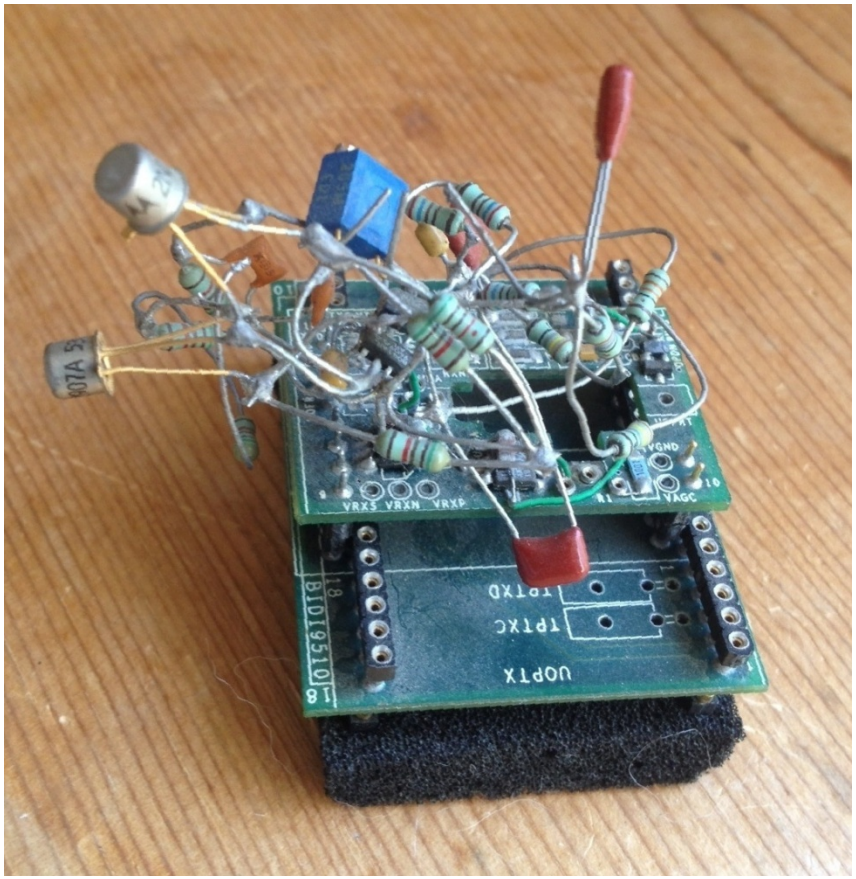
Dat+
Clk-
Clk+
Cf-
Cf+
Det
Vaa
Thr
CpllA
.01uF

Prototype and Product



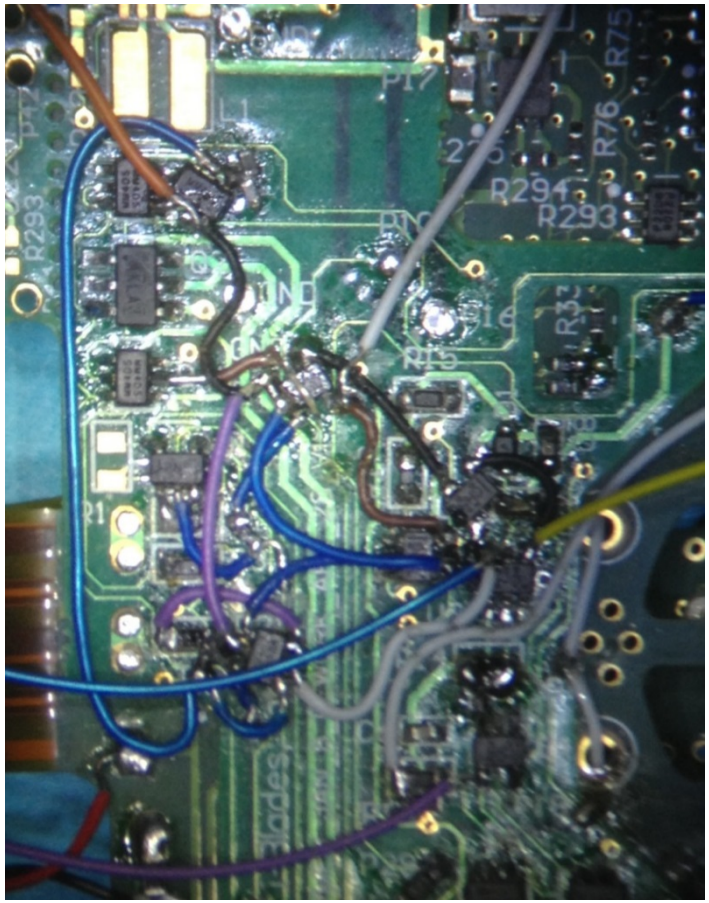
Engineering Roles

- ‘16 / ’18 Mobile IOT
- ‘14 / ’16 IOT
- ‘13 / ‘14 WPC Qi
- ‘12 / ‘13 Line Power
- ‘09 / ‘11 Mobile IC
- ‘05 / ‘08 Security
- ‘97 / ‘01 Telecom
- ‘94 / ‘97 Telecom
- ’76 / ‘94 Test Measurement
- ’69 / ‘76 BSEE Power Conv

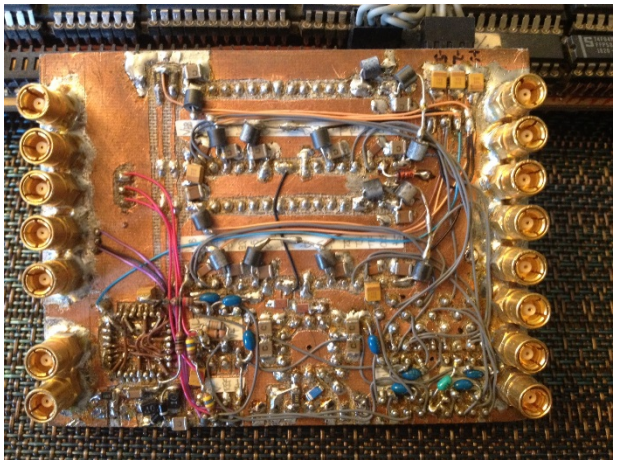
- USB MCU BATT MEM
- BTLE WIFI MCU IMU
- Wireless Power
- Surge Protection
- Wireless Power
- Software Servers
- Optic Add / Drop Mux
- Fiber Optic Last Mile
- Digital / Analog / IC
- Analog / Magnetics

Discrete Development

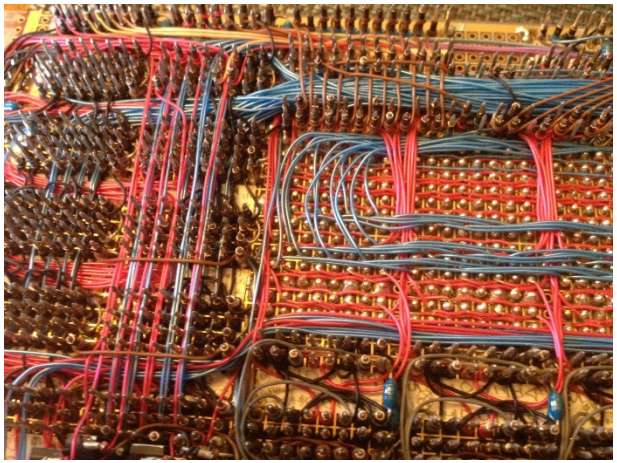
- SOT-363 with 0402



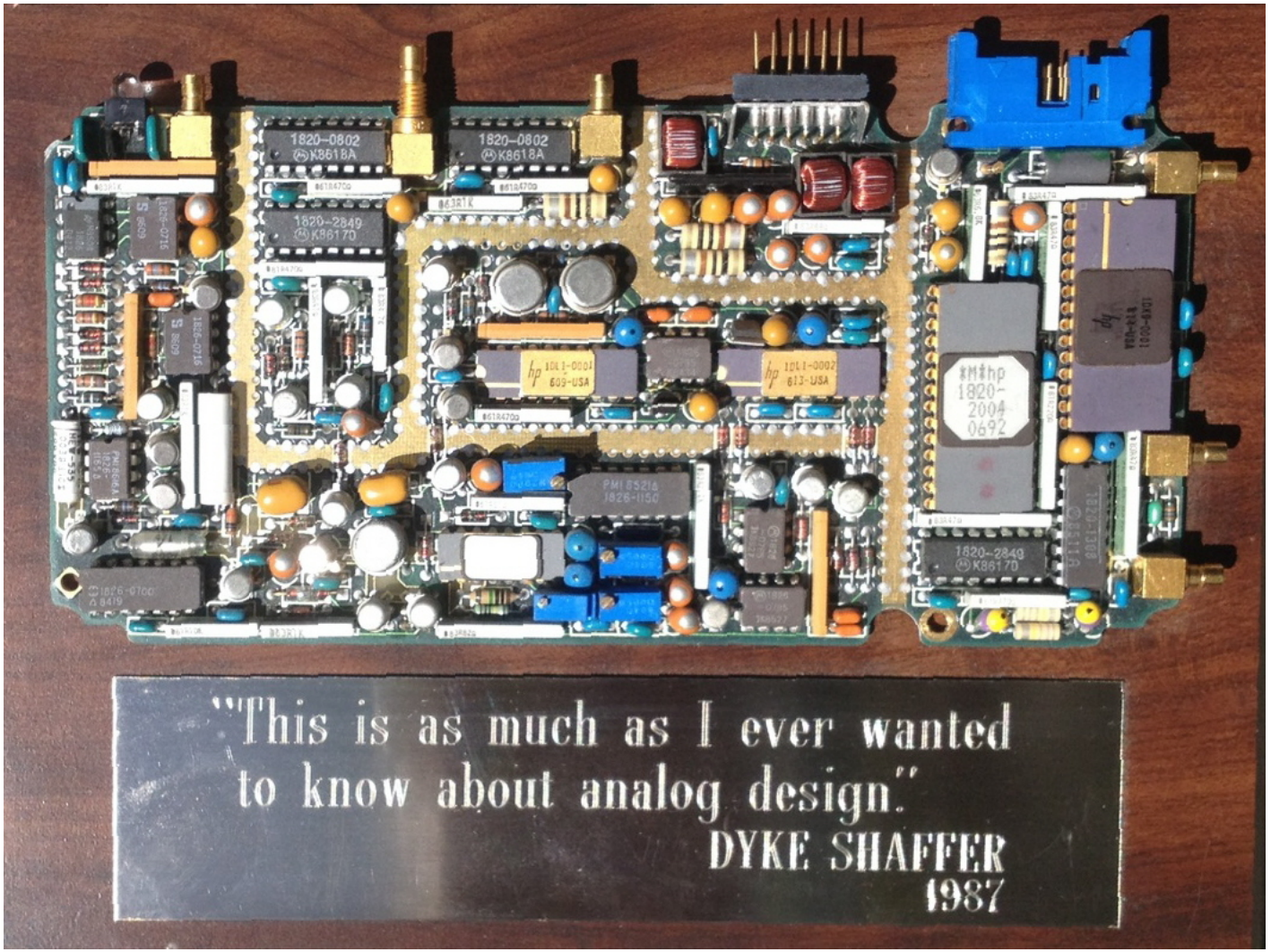
- Teflon at 400MHz



- Wirewrap VRAM array

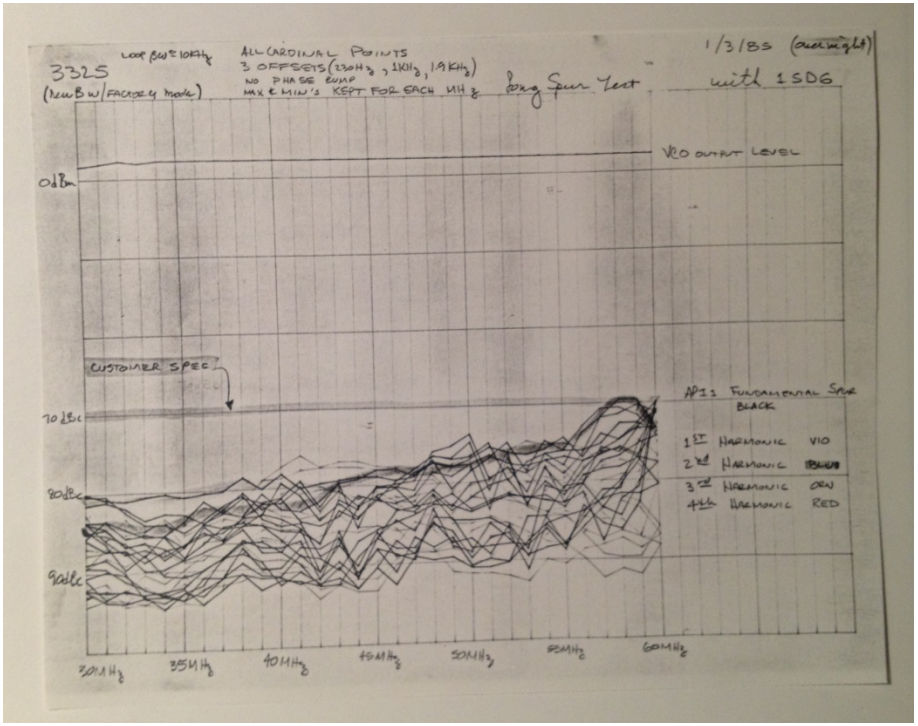


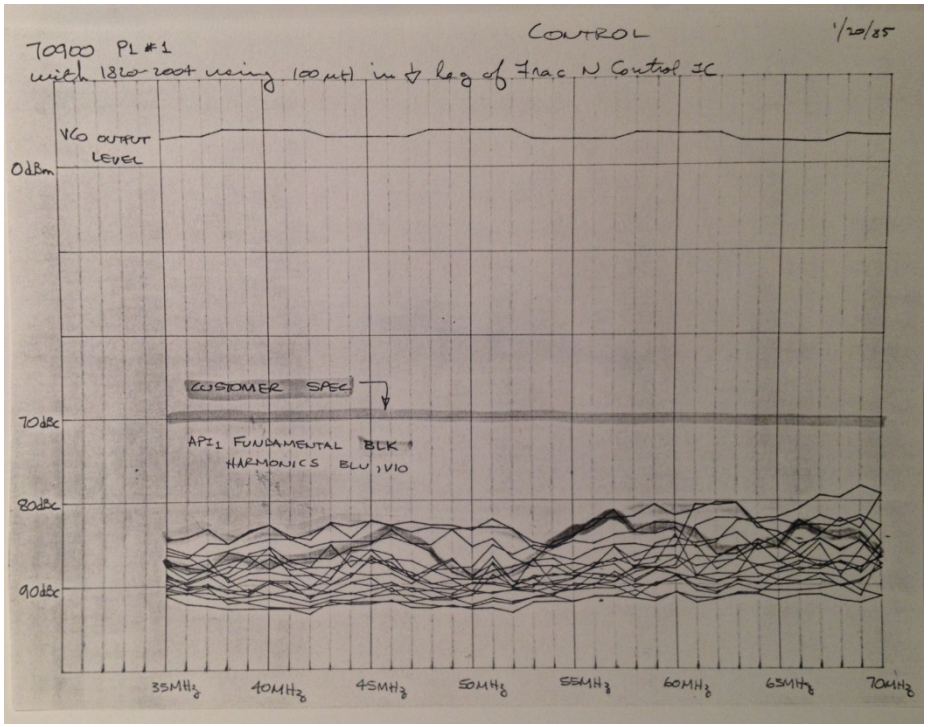
FracN (speaks for itself)



RF Synthesis Spurs

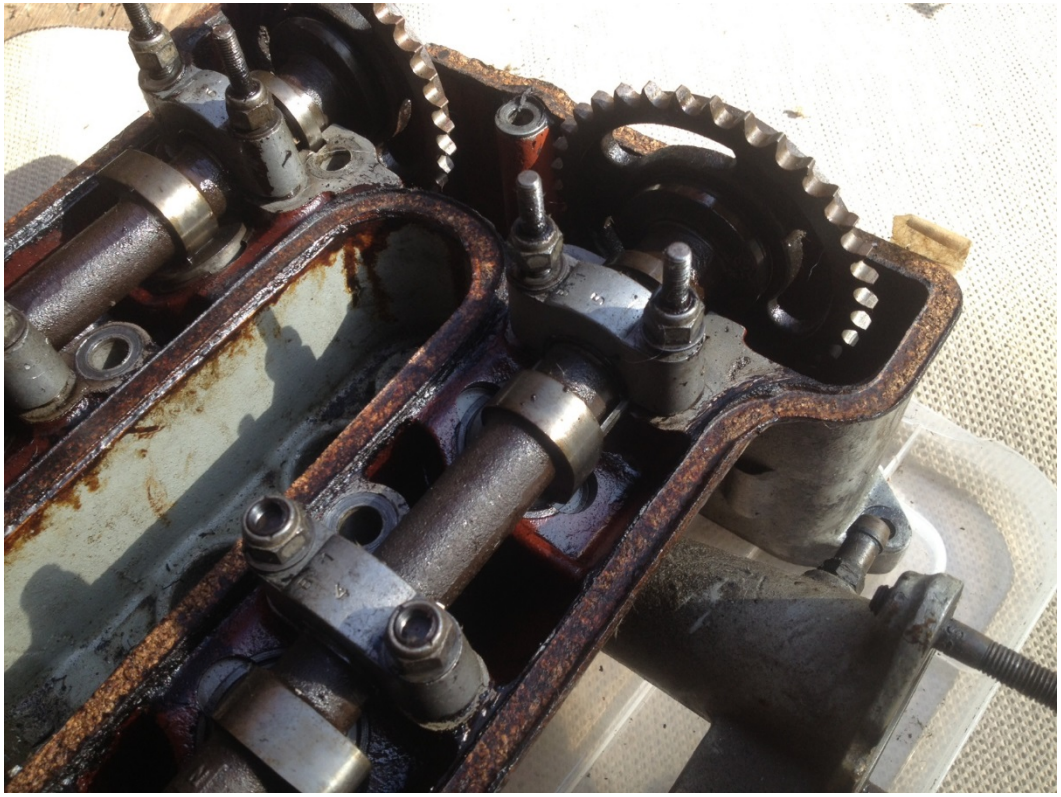
- Circa 1976 (HP3325)
- Circa 1983 (HP70900)

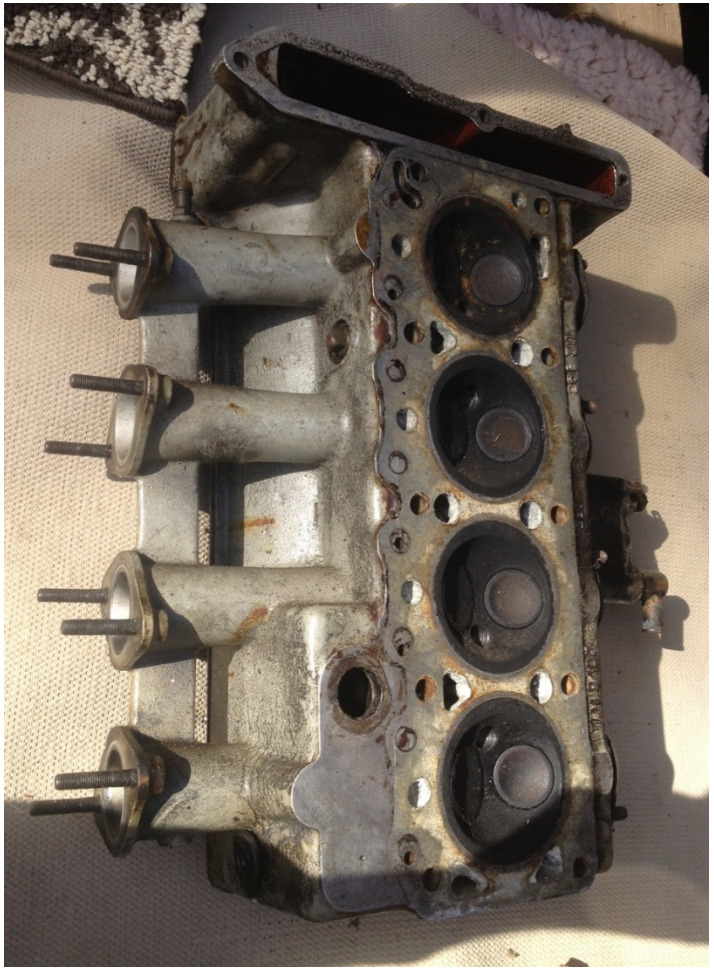




Lotus Twincam (circa 1974)

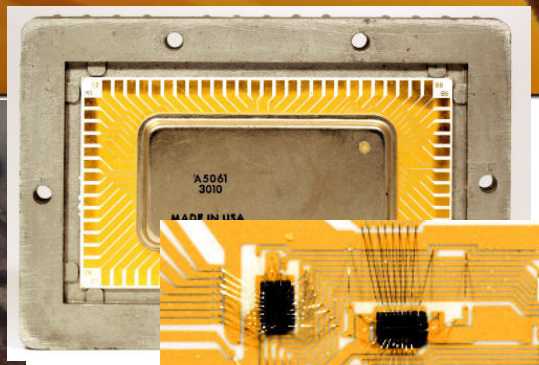
- Double Overhead CAM
- Perfection ➔
- Combustion Chambers

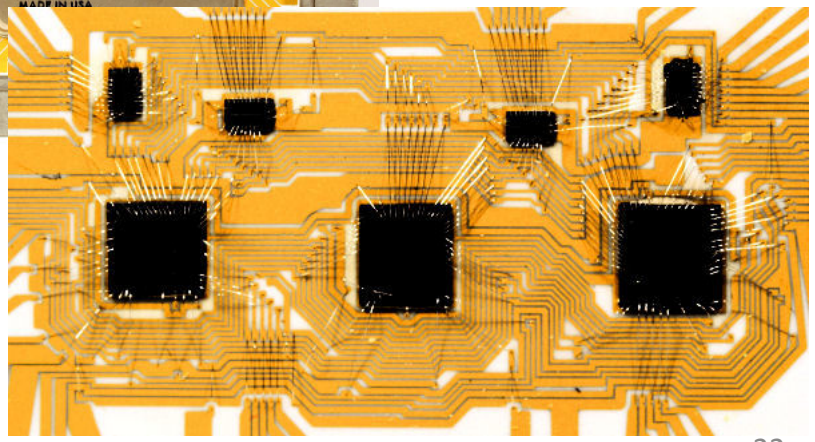




HP9825

- Hand Built
- Production





(net to pin user specific application) xc2c64 / dev.net + (physical) xc2c64 / vqfp44.dev + (logical) xc2c64 / vqfp44.sig = (instance summary) xc2c64 / dev.dev

(net) (sig) (pin) // comment

```
// vqfp44.net (ver 4/8/20) xilinx coolrunner
cpld
VCC       Vcc
GND       Gnd
//
VCC1      VccIO1      // Bank 1
VCC2      VccIO2      // Bank 2
//
VCCAUX    VccAux      // jtagPower
//
TMS       TMs         // jtagModeSelect
TCK       TCk         // jtagClock
TDI       TDi         // jtagDataInput
TDO       TDo         // jtagDataOutput
//
// lft
P2.10     -    P2.10  // Bank1 (GCK2)
P2.12     -    P2.12  // Bank1
P2.13     -    P2.13  // Bank1
P4.1      -    P4.1   // Bank1
P4.2      -    P4.2   // Bank1
P4.7      -    P4.7   // Bank1
//
// bot
P4.11     -    P4.11  // Bank1
P4.13     -    P4.13  // Bank1
P4.14     -    P4.14  // Bank1
P4.15     -    P4.15  // Bank1
STATUS_3  -    S3     // Bank2
STATUS_2  -    S2     // Bank2
STATUS_1  -    S1     // Bank2
STATUS_0  -    S0     // Bank2
BLINK     -    CTL    // Bank2
//
// rht
P3.6      -    P3.6   // Bank2
P3.3      -    P3.3   // Bank2
P3.2      -    P3.2   // Bank2
P3.1      -    P3.1   // Bank2
P1.13     -    P1.13  // Bank2 (GSR)
P1.12     -    P1.12  // Bank2 (GTS2)
P1.11     -    P1.11  // Bank2 (GTS3)
P1.10     -    P1.10  // Bank2 (GTS0)
//
// Bank1 top
P1.9      -    P1.9   // Bank2 (GTS1)
P1.3      -    P1.3   // Bank2
P1.2      -    P1.2   // Bank2
LED_RED   -    RED    // Bank2
LED_GRN   -    GRN    // Bank1
LED_BLU   -    BLU    // Bank1
P2.5      -    P2.5   // Bank1
P2.6      -    P2.6   // Bank1
P2.7      -    P2.7   // Bank1 (GCK0)
P2.8      -    P2.8   // Bank1 (GCK1)
```

(oka) (sig) (pin) // comment

```
1 :  P2.10   Pb10   -    // (GCK2)
2 :  P2.12   Pb12   -    //
3 :  P2.13   Pb13   -    //
4 :  GND     Gnd
5 :  P4.1    Pd1    -    //
6 :  P4.2    Pd2    -    //
7 :  VCCIO1  VccIO1
8 :  P4.7    Pd7    -    //
9 :  TDI     TDi
10 : TMS     TMs
11 : TCK     TCk
12 : P4.11   Pd11   -    //
13 : P4.13   Pd13   -    //
14 : P4.14   Pd14   -    //
15 : VCC     Vcc
16 : P4.15   Pd15   -    //
17 : GND     Gnd
18 : P3.15   Pc15   -    //
19 : P3.14   Pc14   -    //
20 : P3.12   Pc12   -    //
21 : P3.11   Pc11   -    //
22 : P3.10   Pc10   -    //
23 : P3.6    Pc6    -    //
24 : TDO     TDo
25 : GND     Gnd
26 : VCCIO2  VccIO2
27 : P3.3    Pc3    -    //
28 : P3.2    Pc2    -    //
29 : P3.1    Pc1    -    //
30 : P1.13   Pa13   -    // (GSR)
31 : P1.12   Pa12   -    // (GTS2)
32 : P1.11   Pa11   -    // (GTS3)
33 : P1.10   Pa10   -    // (GTS0)
34 : P1.9    Pa9    -    // (GTS1)
35 : VCCAUX  VccAux
36 : P1.3    Pa3    -    //
37 : P1.2    Pa2    -    //
38 : P1.1    Pa1    -    //
39 : P2.1    Pb1    -    //
40 : P2.2    Pb2    -    //
41 : P2.5    Pb5    -    //
42 : P2.6    Pb6    -    //
43 : P2.7    Pb7    -    // (GCK0)
44 : P2.8    Pb8    -    // (GCK1)
```

sig set attributes

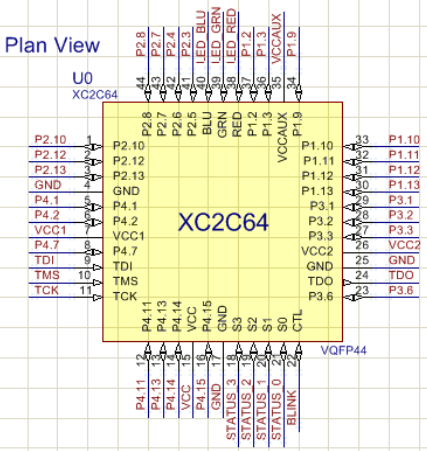
```
" vqfp.sig (ver 4/8/20) 5x(a)
( +Vcc
  +VccIO1-2
  +VccAux )a
( i(TDi,TCp,TMs),o(TDo)
   Pd15-13,11,7,2-1
   Pc15-14,12-10,6,3-1
   Pb13-12,10,8-5,2-1
   Pa13-9,3-1 )a
( _Gnd )a
```

(instance summary) xc2c64 / dev.dev

(oka) (pin) (net) // comment

```
1 :  P2.10   P2.10   P2.10   // Bank1 (GCK2)
2 :  P2.12   P2.12   P2.12   // Bank1
3 :  P2.13   P2.13   P2.13   // Bank1
4 :  GND     GND     GND
5 :  P4.1    P4.1    P4.1    // Bank1
6 :  P4.2    P4.2    P4.2    // Bank1
7 :  VCCIO1  VCC1    VCC1    // Bank 1
8 :  P4.7    P4.7    P4.7    // Bank1
9 :  TDI     TDI     TDi     // jtagDataInput
10 : TMS     TMS     TMs     // jtagModeSelect
11 : TCK     TCK     TCk     // jtagClock
12 : P4.11   P4.11   P4.11   // Bank1
13 : P4.13   P4.13   P4.13   // Bank1
14 : P4.14   P4.14   P4.4    // Bank1
15 : VCC     VCC     VCC
16 : P4.15   P4.15   P4.15   // Bank1
17 : GND     GND     GND
18 : P3.15   STATUS_3 S3     // Bank2
19 : P3.14   STATUS_2 S2     // Bank2
20 : P3.12   STATUS_1 S1     // Bank2
21 : P3.11   STATUS_0 S0     // Bank2
22 : P3.10   BLINK   CTL     // Bank2
23 : P3.6    P3.6    P3.6    // Bank2
24 : TDO     TDO     TDo     // jtagDataOutput
25 : GND     GND     GND
26 : VCCIO2  VCC2    VCC2    // Bank 2
27 : P3.3    P3.3    P3.3    // Bank2
28 : P3.2    P3.2    P3.2    // Bank2
29 : P3.1    P3.1    P3.1    // Bank2
30 : P1.13   P1.13   P1.13   // Bank2 (GSR)
31 : P1.12   P1.12   P1.12   // Bank2 (GTS2)
32 : P1.11   P1.11   P1.11   // Bank2 (GTS3)
33 : P1.10   P1.10   P1.10   // Bank2 (GTS0)
34 : P1.9    P1.9    P1.9    // Bank2 (GTS1)
35 : VCCAUX  VCCAUX  VCCAUX  // jtagPower
36 : P1.3    P1.3    P1.3    // Bank2
37 : P1.2    P1.2    P1.2    // Bank2
38 : P1.1    LED_RED RED     // Bank2
39 : P2.1    LED_GRN GRN     // Bank1
40 : P2.2    LED_BLU BLU     // Bank1
41 : P2.5    P2.5    P2.5    // Bank1
42 : P2.6    P2.6    P2.6    // Bank1
43 : P2.7    P2.7    P2.7    // Bank1 (GCK0)
44 : P2.8    P2.8    P2.8    // Bank1 (GCK1)
```

Plan View



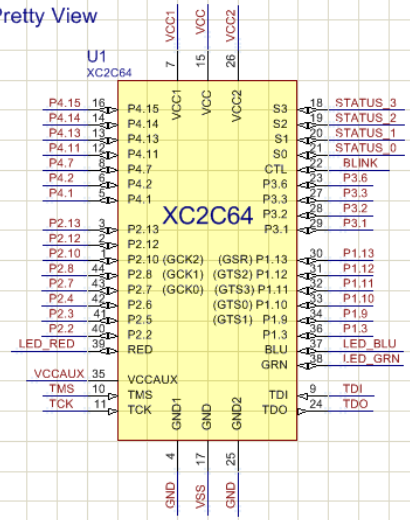

```
" vqfp44.pkg (qfp:6)(0:f:44) (ver 04/0720)

          44444333333
          43210987654

                V
                c
                c
          PPPPPPPPPAP
          bbbbbbaaaua
          876521123x9
          ---------+-
 1   Pb10|          |Pa10   33
 2   Pb12|          |Pa11   32
 3   Pb13|          |Pa12   31
 4    Gnd=          |Pa13   30
 5    Pd1|          |Pc1    29
 6    Pd2|          |Pc2    28
 7 VccIO1+          |Pc3    27
 8    Pd7|          +VccIO2 26
 9    TDi|          =Gnd    25
10    TMs|          |TDo    24
11    TCk|          |Pc6    23
          ---+-=-----
          PPPVPGPPPPP
          dddcdncccccc
          111c1d11111
          134 5 54210

          11111111222
          23456789012
```

Pretty View




```
" vqfp1.sig (ver 4/8/20) 5x(a)

/ +Vcc1
  +Vcc
  +Vcc2 \a

[   Pd15-13,11,7,2-1
    Pb13-12,10,8-5,2-1
  +VccAux
  i(TCk,TMs) )a

(   Pc15,14,12-10,6,3-1
    Pa13-9,3-1
  iTDi,oTDo ]a

\ _Gnd1
  _Gnd
  _Gnd2 /a
```

(oka) originally know as (data sheet pin name)

(pin) device annotation (application pin name)

(net) schematic interconnect (application net name)

TITLE	xc2c64 / vqfp44	
Size: A	DRAWING:	REV: 0.1
Date: 2/18/2021	Time: 8:09:43 PM	Sheet 1 Of 1
File: dev.vqfp44_EVB_ASC.SchDoc	Engineer: Dyke Shaffer	

CSA

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