Power Matters

Reverse Powering
Its Benefits and Constraints

Daniel Feldman – VP Business Development,
Microsemi

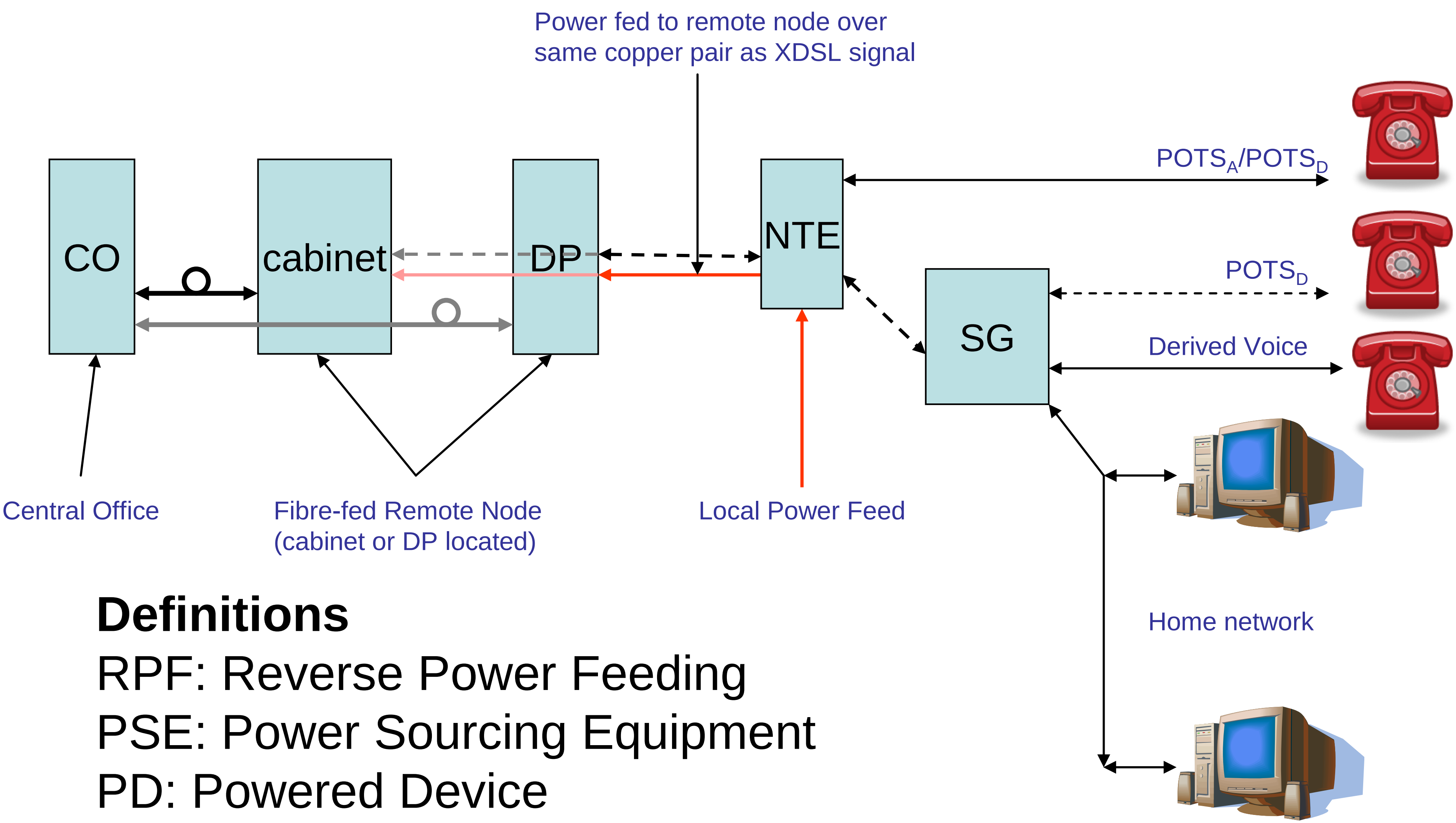
Agenda

- Why Fiber to the Distribution Point?
- MDU ONT Reverse Power Fed
- Benefits of Reverse Power Feeding (RPF)
- Force Power vs ETSI RPF
- Typical RPF Circuit
- RPF Constraints
- How much power can be delivered?
- How fair is this to the end user?
- Summary

Why Fiber to the Distribution Point (DP)?

- Cable competition can support over 1Gbit/s
  - DOCSIS 3.0: 912Mbit/s in the US, 1.2Gbit/s in Europe
  - DOCSIS 3.1: 10Gbit/s
  - Real deployments already up to 250Mbit/s
  - Works on standard hybrid coaxial/fiber already in place
- Fiber to the Home is expensive
  - Last 250 meters cost ~$1000 (source: http://arstechnica.com/tech-policy/2010/03/fiber-its-not-all-created-equal/)
- Last 250m need to compete with cable in terms of
  - Speed: G.FAST bringing up to 500Mbit/s (1Gbit/s w/vectoring)
  - Cost: Reverse Power Feeding (RPF) MDU/DSLAM from home eliminates added drilling and power metering

Multiple Dweller Unit ONT Reverse Power Fed



Definitions

RPF: Reverse Power Feeding

PSE: Power Sourcing Equipment

PD: Powered Device

Benefits of Reverse Power Feeding

- Flexibility
  - No need for AC source proximity, or location safe for AC
  - No need to wait for the electrical company to install
- Cost per user lower than $31.25
  - 8 users can be covered by a single MDU ONT+DSLAM
  - Average Smart Meter installation cost (for local power) is $250 (source: http://www.emeter.com/smart-grid-watch/2010/how-much-do-smart-meters-cost/
  - RPF benefits increase with smaller MDU ONT+DSLAM
    - $250/8=$31.25
    - $250/4=$62.50
    - $250/2=$125.00
- Standardized by ETSI
  - Interoperability
  - Safety

Microsemi

Power Matters

Force Power (non-ETSI) vs ETSI RPF

Force Power (non-ETSI)

- Lower cost – doesn't require extra components for startup protocol
- Power always exist on the line
  - Safety
  - End equipment exposed to constant high power – fire hazard
- Doesn't Interoperate with foreign power (I.E. POTS-DC) and ETSI standard

ETSI RPF Power Up protocol

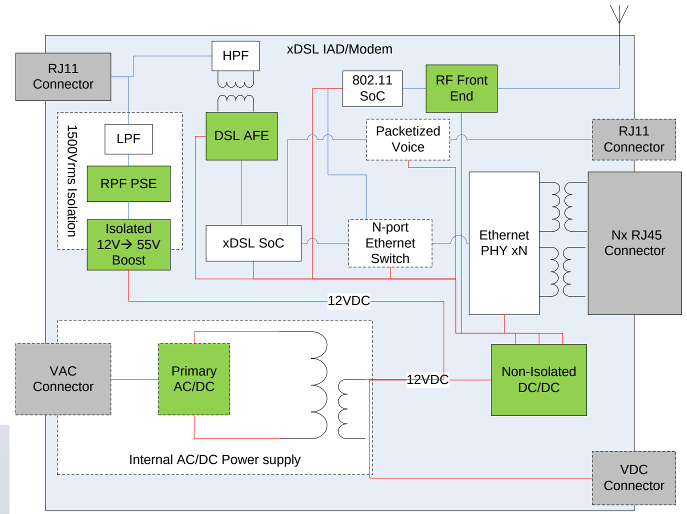
- Additional component cost
- Power enabled through successful handshaking
  - Active handshake
    - Requires both ends to be powered (battery/charge circuit)
    - Handshaking Protocol over data
  - Passive handshake
    - Resistive signature based detection doesn't require power on DP side
- Interoperability with foreign power on the line and ETSI Standard

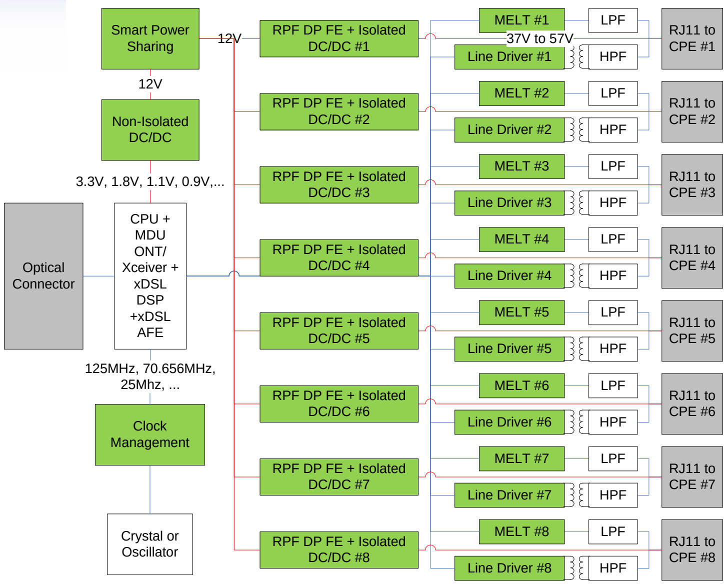
Microsemi

Power Matters

Typical RPF circuit for CPE and 8-port MDU

- CPE RPF components
  - Power injection circuitry
  - Isolated boost
  - Larger AC/DC power supply
- CPE RPF Injector
  - Works with non-RPF modem
  - Pay for RPF only once
- DPU RPF components
  - Power sharing circuit
  - 8xPower extraction circuit
  - Power conversion circuit





Reverse Power Feeding Constraints

- Primary Constraints
  - Local safety standards: If user can be exposed, voltage must be <60V
  - Wires may have 0.4mm diameter: 26.78Ω at 100m
  - CPE devices at various ranges from DP: from 10m* to 250m**
- ….so….
  - CPE Current limiting losses ➔ source output voltage is closer to 55V
  - Different power losses on every cable
  - Different input voltage on every port ➔ Need to define minimum
- …. so…..
  - Power available to power DP depends on distance and wire type
  - Load from every home is different ➔ fair power sharing needed
- Additional ETSI standard constraints
  - 21W, 15W and 10W maximum power output classes
  - POTS interoperability

Microsemi

Power Matters

Available Power for 21W class, 0.4mm cable

Cable Length	**10**	**50**	**100**	**150**	**200**	**250**
Per pair Current (Plug)	0.35	0.35	0.35	0.35	0.35	0.35
PSE Voltage at the port	55	55	55	55	55	55
PSE Output Power	19.25	19.25	19.25	19.25	19.25	19.25
Cable Resistance/length (0.4mm cable, AWG26)	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**
Cable Loop Resistance (2 wires)	2.68	13.39	26.78	40.17	53.56	66.95
Power loss on cable	0.33	1.64	3.28	4.92	6.56	8.20
PD Voltage at the PD port	54.06	50.31	45.63	40.94	36.25	31.57
Power available to DPU input RJ11 connector	18.92	17.61	15.97	14.33	12.69	11.05
Diode Bridge Vfwd	1.40	1.40	1.40	1.40	1.40	1.40
Diode losses	0.49	0.49	0.49	0.49	0.49	0.49
PD Isolating Switch losses (0.6ohm)	0.07	0.07	0.07	0.07	0.07	0.07
Input power to Isolated Converter	18.36	17.05	15.41	13.77	12.13	10.49
Isolated Converter PoE to 12V Efficiency	90%	90%	90%	90%	90%	90%
Output power at 12V (simple current sharing)	16.52	15.34	13.87	12.39	10.91	9.44
Output regulated power (w/Short protection)	**15.97**	**14.83**	**13.40**	**11.98**	**10.55**	**9.12**

Assumptions:

a) Input voltage range on PD should be 36V to 60V
b) VDSL2 application can work with 11.5W
c) Minimum desirable range is 100m

Available Power for 21W class, 0.5mm cable

Cable Length	**10**	**50**	**100**	**150**	**200**	**250**
Per pair Current (Plug)	0.35	0.35	0.35	0.35	0.35	0.35
PSE Voltage at the port	55	55	55	55	55	55
PSE Output Power	19.25	19.25	19.25	19.25	19.25	19.25
Cable Resistance/length (0.5mm cable, AWG24)	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
Cable Loop Resistance (2 wires)	1.68	8.40	16.80	25.20	33.60	42.00
Power loss on cable	0.21	1.03	2.06	3.09	4.12	5.15
PD Voltage at the PD port	54.41	52.06	49.12	46.18	43.24	40.30
Power available to DPU input RJ11 connector	19.04	18.22	17.19	16.16	15.13	14.11
Diode Bridge Vfwd	1.40	1.40	1.40	1.40	1.40	1.40
Diode losses	0.49	0.49	0.49	0.49	0.49	0.49
PD Isolating Switch losses (0.6ohm)	0.07	0.07	0.07	0.07	0.07	0.07
Input power to Isolated Converter	18.48	17.66	16.63	15.60	14.57	13.54
Isolated Converter PoE to 12V Efficiency	90%	90%	90%	90%	90%	90%
Output power at 12V (simple current sharing)	16.63	15.89	14.97	14.04	13.11	12.19
Output regulated power (w/Short protection)	**16.08**	**15.36**	**14.47**	**13.57**	**12.68**	**11.78**

Assumptions:

a) Input voltage range on PD should be 36V to 60V
b) VDSL2 application can work with 11.5W
c) Minimum desirable range is 100m

Available Power for 30W class, 0.4mm cable

Cable Length	**10**	**50**	**100**	**150**	**200**	**250**
Per pair Current (Plug)	0.50	0.50	0.50	0.50	0.50	0.50
PSE Voltage at the port	55	55	55	55	55	55
PSE Output Power	27.50	27.50	27.50	27.50	27.50	27.50
Cable Resistance/length (0.4mm cable, AWG26)	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**
Cable Loop Resistance (2 wires)	2.68	13.39	26.78	40.17	53.56	66.95
Power loss on cable	0.67	3.35	6.70	10.04	13.39	16.74
PD Voltage at the PD port	53.66	48.31	41.61	34.92	28.22	21.53
Power available to DPU input RJ11 connector	26.83	24.15	20.81	17.46	14.11	10.76
Diode Bridge Vfwd	1.40	1.40	1.40	1.40	1.40	1.40
Diode losses	0.70	0.70	0.70	0.70	0.70	0.70
PD Isolating Switch losses (0.6ohm)	0.15	0.15	0.15	0.15	0.15	0.15
Input power to Isolated Converter	25.98	23.30	19.96	16.61	13.26	9.91
Isolated Converter PoE to 12V Efficiency	90%	90%	90%	90%	90%	90%
Output power at 12V (simple current sharing)	23.38	20.97	17.96	14.95	11.93	8.92
Output regulated power (w/Short protection)	**22.60**	**20.27**	**17.36**	**14.45**	**11.54**	**8.62**

Assumptions:

a) Input voltage range on PD should be 36V to 60V
b) G.FAST application can work with 17.5W
c) Minimum desirable range is 100m

Available Power for 30W class, 0.5mm cable

Cable Length	**10**	**50**	**100**	**150**	**200**	**250**
Per pair Current (Plug)	0.50	0.50	0.50	0.50	0.50	0.50
PSE Voltage at the port	55	55	55	55	55	55
PSE Output Power	27.50	27.50	27.50	27.50	27.50	27.50
Cable Resistance/length (0.5mm cable, AWG24)	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
Cable Loop Resistance (2 wires)	1.68	8.40	16.80	25.20	33.60	42.00
Power loss on cable	0.42	2.10	4.20	6.30	8.40	10.50
PD Voltage at the PD port	54.16	50.80	46.60	42.40	38.20	34.00
Power available to DPU input RJ11 connector	27.08	25.40	23.30	21.20	19.10	17.00
Diode Bridge Vfwd	1.40	1.40	1.40	1.40	1.40	1.40
Diode losses	0.70	0.70	0.70	0.70	0.70	0.70
PD Isolating Switch losses (0.6ohm)	0.15	0.15	0.15	0.15	0.15	0.15
Input power to Isolated Converter	26.23	24.55	22.45	20.35	18.25	16.15
Isolated Converter PoE to 12V Efficiency	90%	90%	90%	90%	90%	90%
Output power at 12V (simple current sharing)	23.61	22.10	20.21	18.32	16.43	14.54
Output regulated power (w/Short protection)	**22.82**	**21.36**	**19.53**	**17.70**	**15.88**	**14.05**

Assumptions:

a) Input voltage range on PD should be 36V to 60V
b) G.FAST application can work with 17.5W
c) Minimum desirable range is 100m

Microsemi

Power Matters

Power Limits Results

- Maximum DP port consumption with existing ETSI standard
  - Worst case condition: single CPE powering multi-port DPU
  - At 250m: 9.12W ➔ is this enough?
  - At 100m: 13.40W ➔ should be enough for VDSL2 DPU
- This may not be enough for G.FAST
  - For 17.5W DPU, need a 30W class at ETSI

Microsemi

End User cost allocation: is this fair?

	20W load 10-150m				16W load 10-250m			
	0.4mm cable		0.5mm cable		0.4mm cable		0.5mm cable	
Cable Length	**10**	**150**	**10**	**150**	**10**	**250**	**10**	**250**
Per pair Current (Plug)	0.22	0.27	0.22	0.24	0.17	0.25	0.17	0.20
PSE Voltage at the port	55	55	55	55	55	55	55	55
PSE Output Power	**11.95**	**14.84**	**11.90**	**13.35**	**9.54**	**13.80**	**9.51**	**11.27**
Cable Resistance/length	0.13	0.13	0.08	0.08	0.13	0.13	0.08	0.08
Cable Loop Resistance (2 wires)	2.68	40.17	1.68	25.20	2.68	66.95	1.68	42.00
Power loss on cable	0.13	2.92	0.08	1.49	0.08	4.21	0.05	1.76
PD Voltage at the PD port	54.42	44.16	54.64	48.88	54.54	38.20	54.71	46.39
Power available to DPU input RJ11 connector	11.83	11.92	11.83	11.87	9.46	9.58	9.46	9.51
Diode Bridge Vfwd	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Diode losses	0.30	0.38	0.30	0.34	0.24	0.35	0.24	0.29
PD Isolating Switch losses (0.6ohm)	0.03	0.04	0.03	0.04	0.02	0.04	0.02	0.03
Input power to Isolated Converter	11.49	11.49	11.49	11.49	9.20	9.20	9.20	9.20
Isolated Converter PoE to 12V Efficiency	90%	90%	90%	90%	90%	90%	90%	90%
Output power at 12V (simple current sharing)	10.34	10.34	10.34	10.34	8.28	8.28	8.28	8.28
Output regulated power (w/Short protection)	10.00	10.00	10.00	10.00	8.00	8.00	8.00	8.00
PSE AC/DC efficiency	75%	75%	75%	75%	75%	75%	75%	75%
AC power consumption	15.94	19.79	15.87	17.81	12.72	18.40	12.67	15.03
Yearly power consumption	139.62	173.33	139.04	155.98	111.39	161.16	111.02	131.65
Electricity cost	$ 0.20	$ 0.20	$ 0.20	$ 0.20	$ 0.20	$ 0.20	$ 0.20	$ 0.20
Yearly electricity cost	$ 27.92	$ 34.67	$ 27.81	$ 31.20	$ 22.28	$ 32.23	$ 22.20	$ 26.33
Yearly end user cost difference		**$ 6.74**		**$ 3.39**		**$ 9.95**		**$ 4.13**

Assumptions:

a) G.FAST application consumes 20W with 2 loads

b) VDSL2 application consumes 16W with 2 loads

c) Simple current sharing used, with 100% accuracy

Fair Power Sharing

- Definition: load each DP ports based on CPE consumption including cable losses, so loads are identical
- Option 1: communicate CPE power consumption
  - CPE host reads PSE power ➔ expensive isolation on every CPE
  - DPU reads power consumed from each CPE ➔ does it interoperate?
  - Precludes RPF Injector ➔ pay for RPF every CPE refresh
- Option 2: determine power consumption on DPU
  - DPU FairPower™ infers cable length from input voltage
  - DPU FairPower™ measures no load CPE output voltage
  - Works with ANY CPE, with embedded RPF or RPF injector
  - FairPower™ circuit cost spread over multiple ports

Summary

- Reverse Power Feeding is an important G.FAST enabler
- Work to be done at ETSI to fully support G.FAST
  - 30W class support
- FairPower™ sharing can simplify the acceptance of RPF