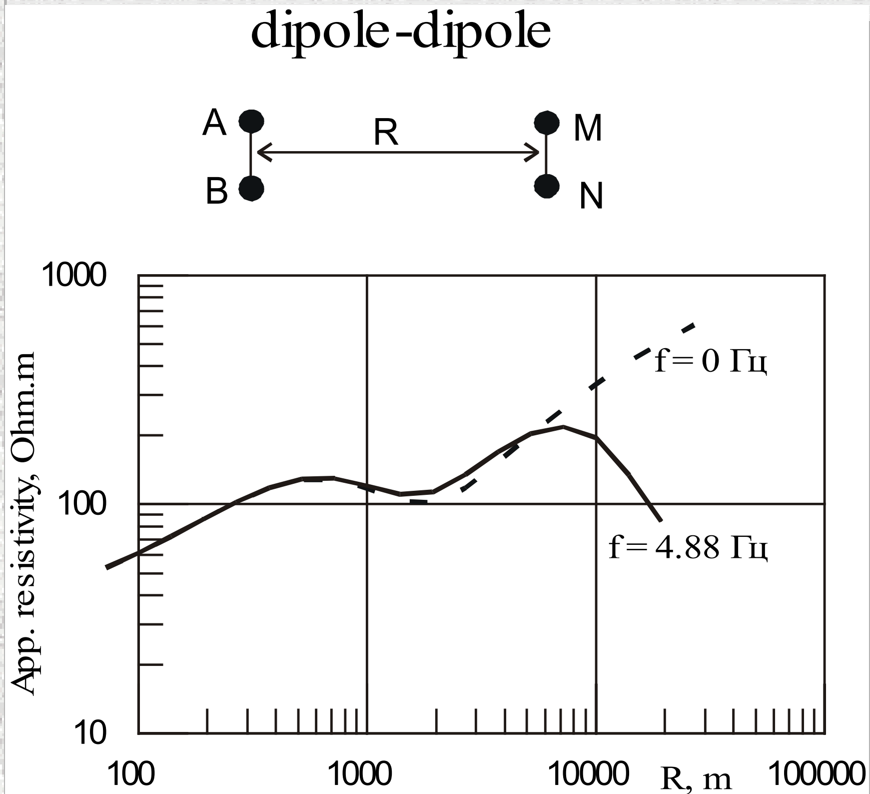
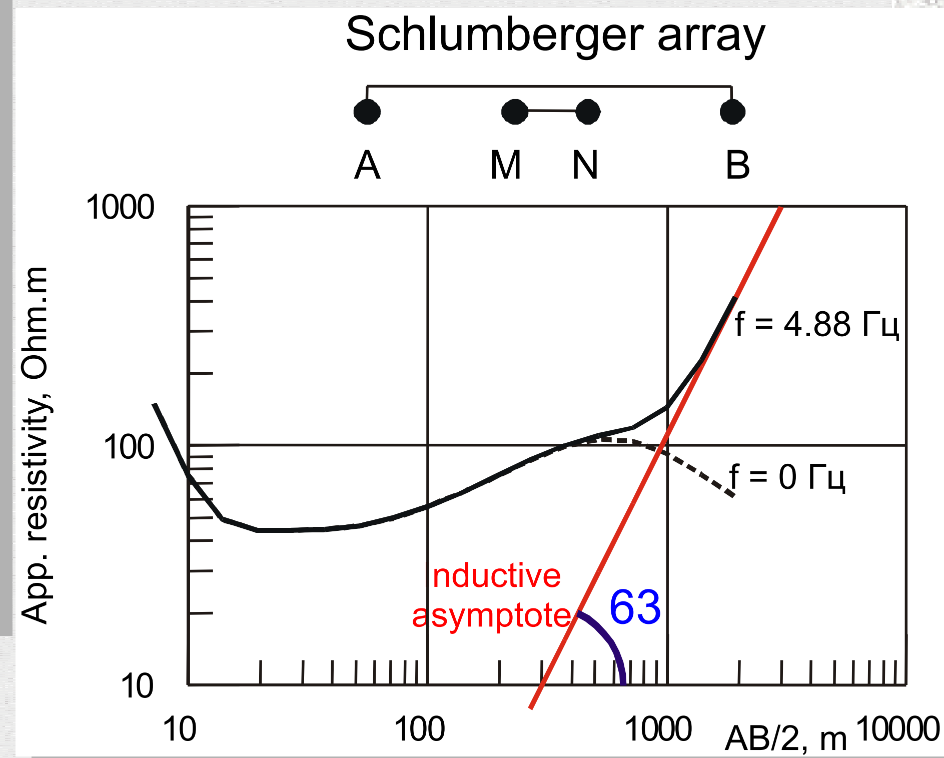
Low-frequency non-contact resistivity method

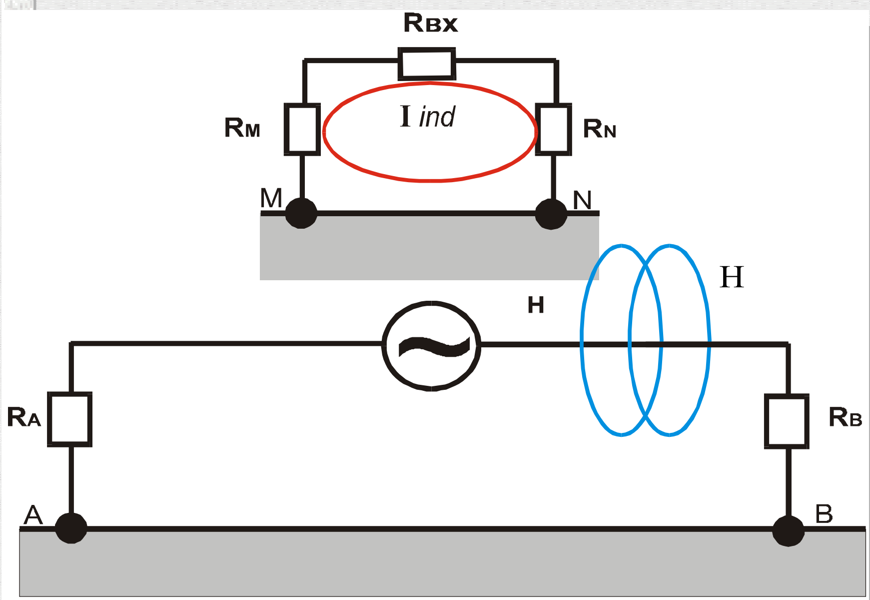
1. Low frequency AC field
2. Inductive coupling effect
3. Non-contact measurements
4. Theory of electrical field in the air

Low frequency AC field



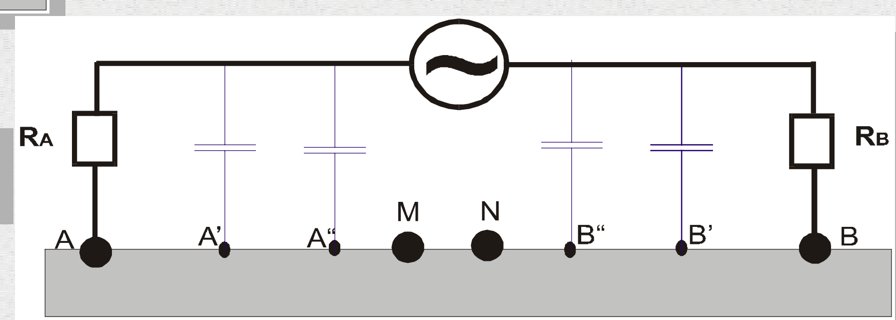


EM effects concerned with wires



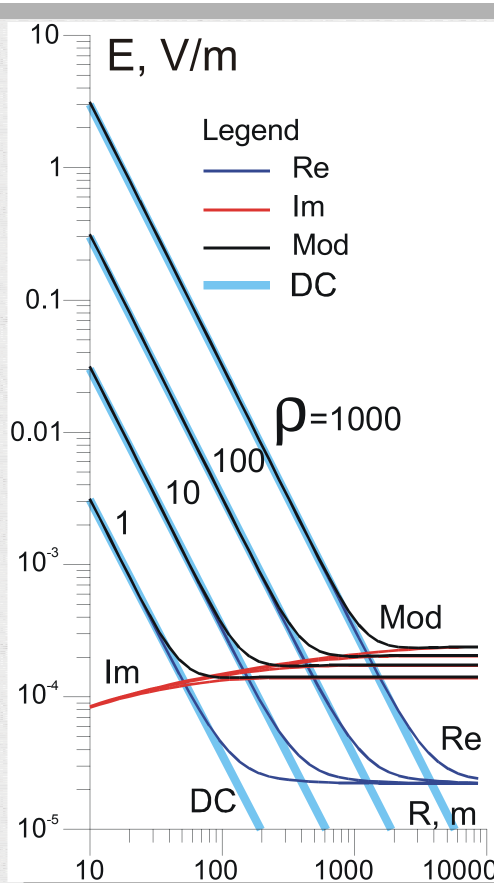
Inductive coupling effect

Capacity leakage

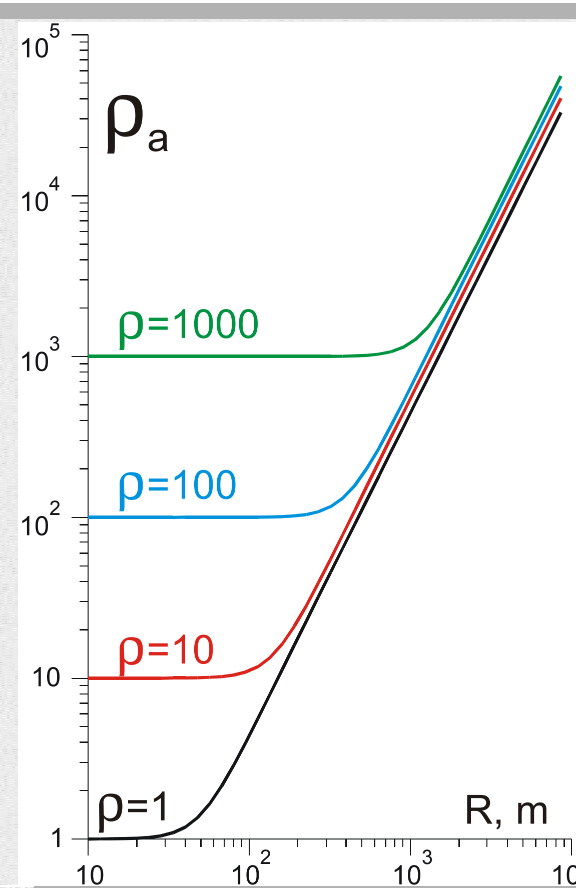


Dependence of inductive asymptote from resistivity of ground (f = 4.88 Hz)

Changes of Re, Im, E_x AC modulus and E_x DC from AB/2 spacing for Schlumberger array.



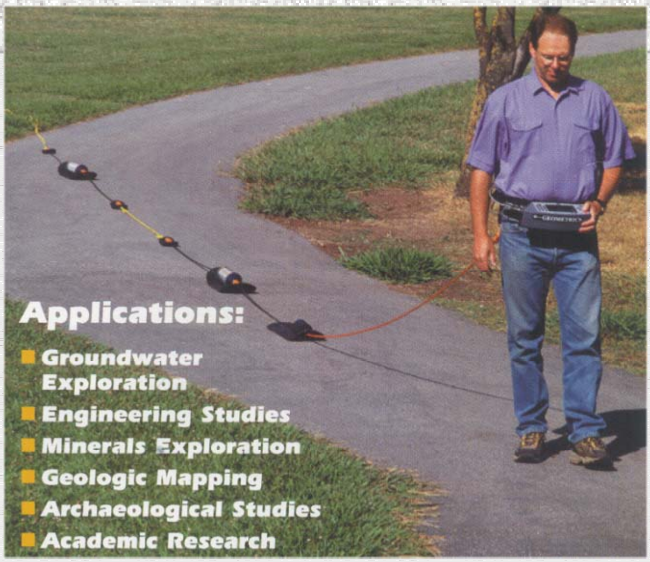
Dependence of inductive asymptote's position from halfspace resistivity for modulus E_x..



Abbas Mohammed Abbas, A. Bobachev, A.Karinski, V.Shevnin. Problem of inductive interference between current and measuring lines at electrical sounding. Proceedings of SAGEEP-2001 conference in Denver (March 2001). ERP_3, 10 p.

Non-contact measurements

OhmMapper
f=16.5 kHz



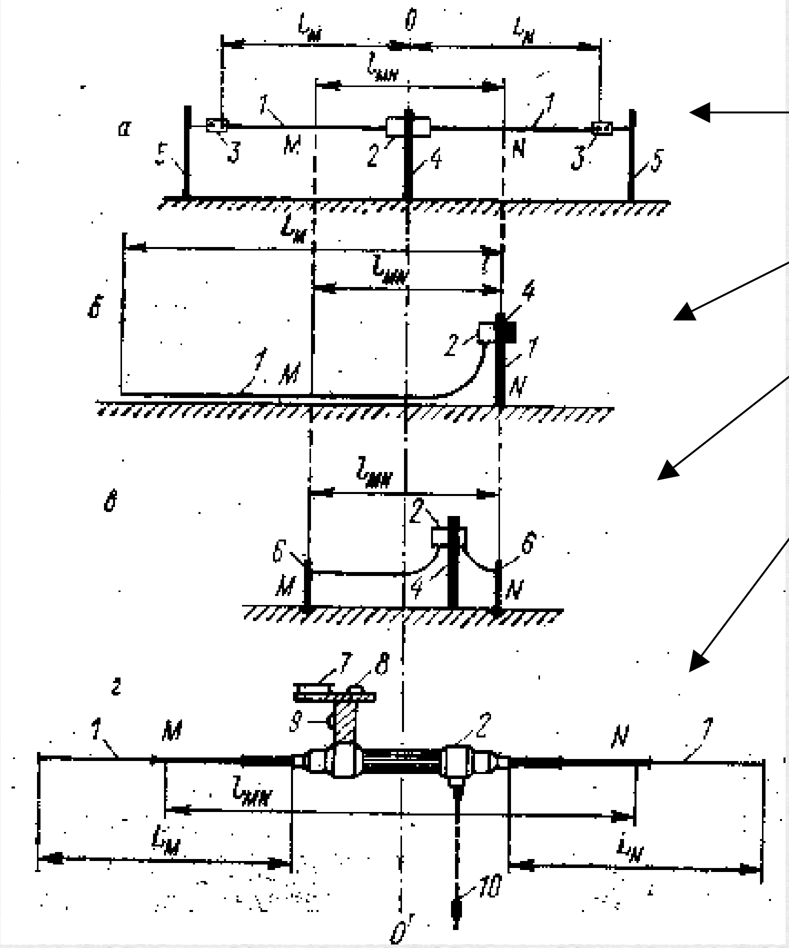
Iris Instruments **Corim**, f=12 kHz

ERA equipment, f=625Hz

Types of source

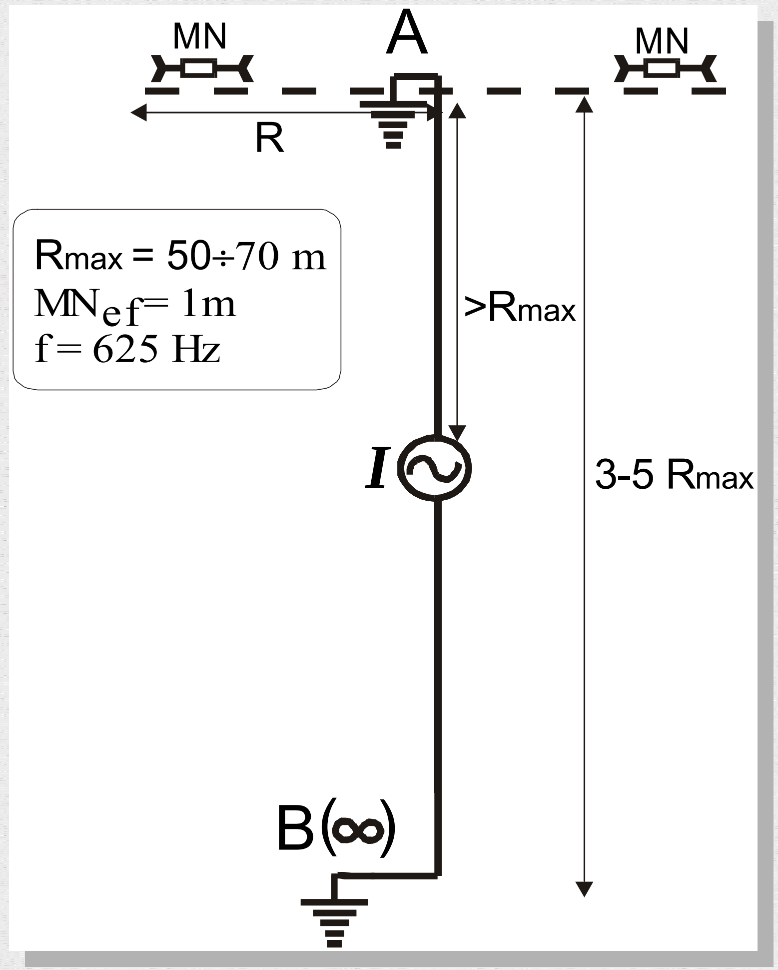
- Classical galvanic grounding
- Capacity electrode with big area
  - flat electrode
  - long wire
- Non grounded loop

Types of receiver



- Antenna (wire)
- Long wire + operator
- Grounded electrodes
- Antenna
- Active electrodes with high input impedance (~50GOhm.m)

Array for non-contact soundings



Limits of maximal resistance for electrodes

Current electrodes

Minimal suitable current

Potential electrodes

Maximal input impedance of receiver

Theory of electrical field in the air

$$\operatorname{rot}\mathbf{H} = (\sigma - i\omega\varepsilon\varepsilon_0)\mathbf{E}$$
$$\operatorname{rot}\mathbf{E} = i\omega\mu\mathbf{H}$$

$$\mathbf{E}_{ind} = i\omega\mu\mathbf{A}$$
$$\mathbf{E}_q = -\operatorname{grad} U$$

$$\mathbf{H} = \operatorname{rot}\mathbf{A}$$
$$\mathbf{E} = i\omega\mu\mathbf{A} - \operatorname{grad} U$$

$$\mathbf{E} \approx \mathbf{E}_q$$
$$\operatorname{div}(\sigma - i\omega\varepsilon\varepsilon_0)\operatorname{grad} U = 0$$

$$\operatorname{div}\mathbf{A} = 0$$

Complex resistivity

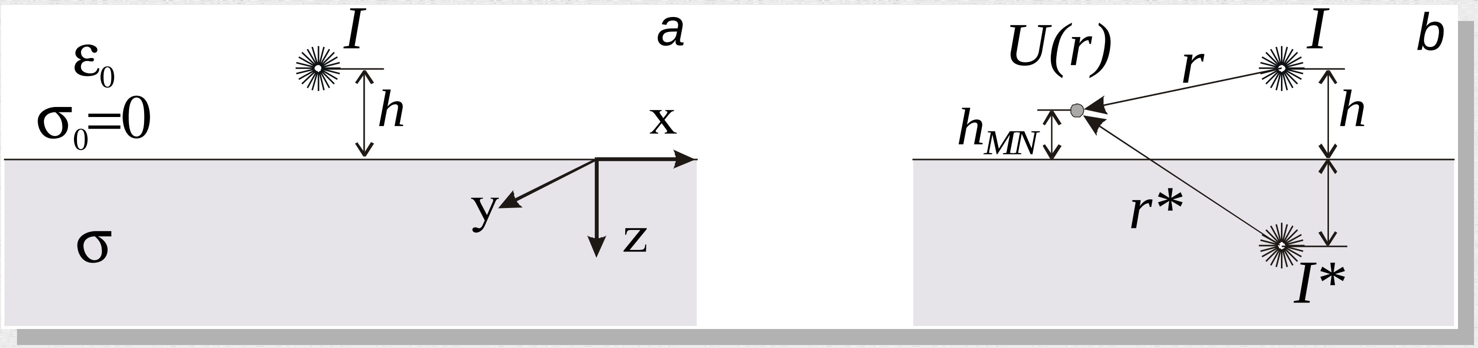
$$\mathbf{E} \approx \mathbf{E}_q$$

$$\operatorname{div}(\sigma - i\omega\varepsilon\varepsilon_0)\operatorname{grad} U = 0$$

$\varepsilon_0 = 9e^{-12}$

f, Hz	4.88	625	15000
Resistivity of the air	3.7 GOhm.m	29 MOhm.m	1.2 MOhm.m

Field of static electrode

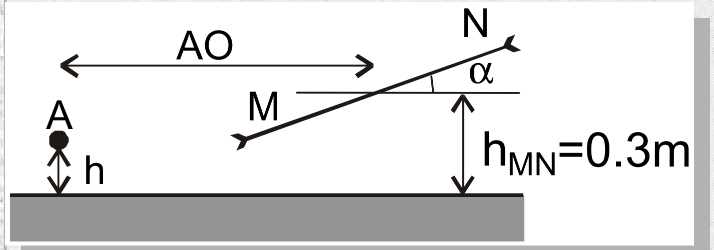


$$U_0(r) = \frac{1}{4\pi r}\frac{I}{\hat{\sigma}} = \frac{1}{4\pi r}\frac{I}{i\omega\varepsilon_0}$$

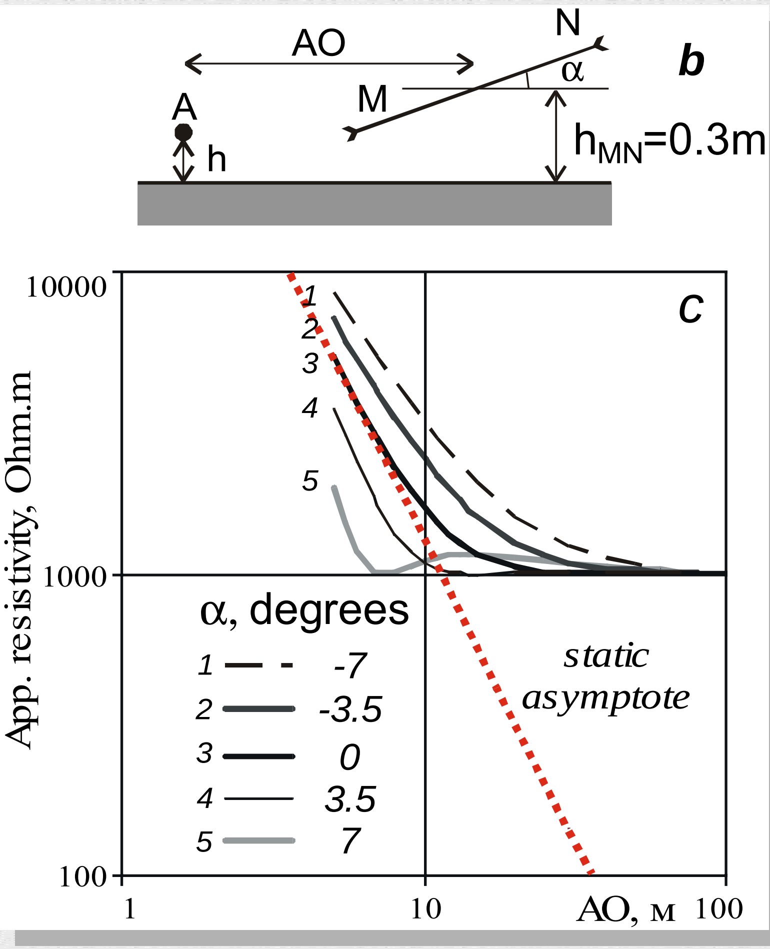
$$K_{12} = \frac{-(\omega\varepsilon_0)^2 + \sigma^2 - 2i\omega\varepsilon_0\sigma}{-(\omega\varepsilon_0)^2 - \sigma^2} \approx \frac{\sigma^2 - 2i\omega\varepsilon_0\sigma}{-\sigma^2} = \frac{2i\omega\varepsilon_0}{\sigma} - 1$$

$$\begin{cases} U(r) = \dfrac{I}{i\omega\varepsilon_0}\left(\dfrac{1}{4\pi r} + K_{12}\dfrac{1}{4\pi r^*}\right) \approx \dfrac{I}{2\pi r^*\sigma} + i\dfrac{I}{\omega\varepsilon_0 4\pi}\left(\dfrac{1}{r} - \dfrac{1}{r^*}\right), & z \le 0, \\ U(r) = \dfrac{I}{i\omega\varepsilon_0}\dfrac{1}{4\pi r}\left(1 + K_{12}\right) \approx \dfrac{I}{2\pi r\sigma}, & z \ge 0. \end{cases}$$

Electrostatic asymptote



h = 5 mm, f = 625 Hz



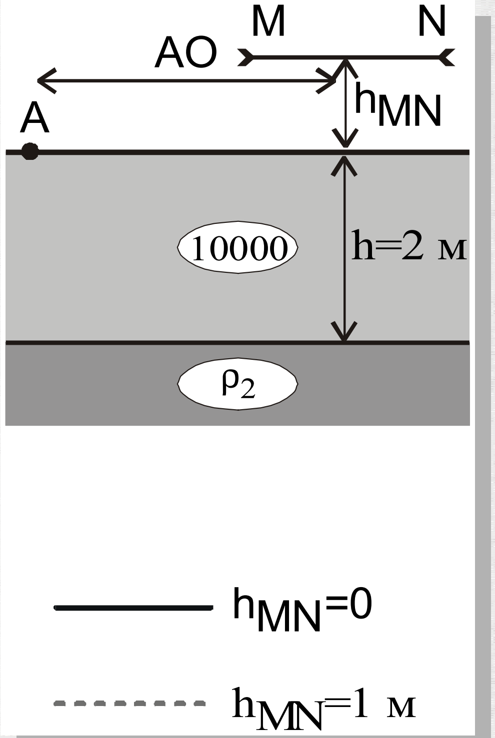
Electrical field in the air from grounded electrode

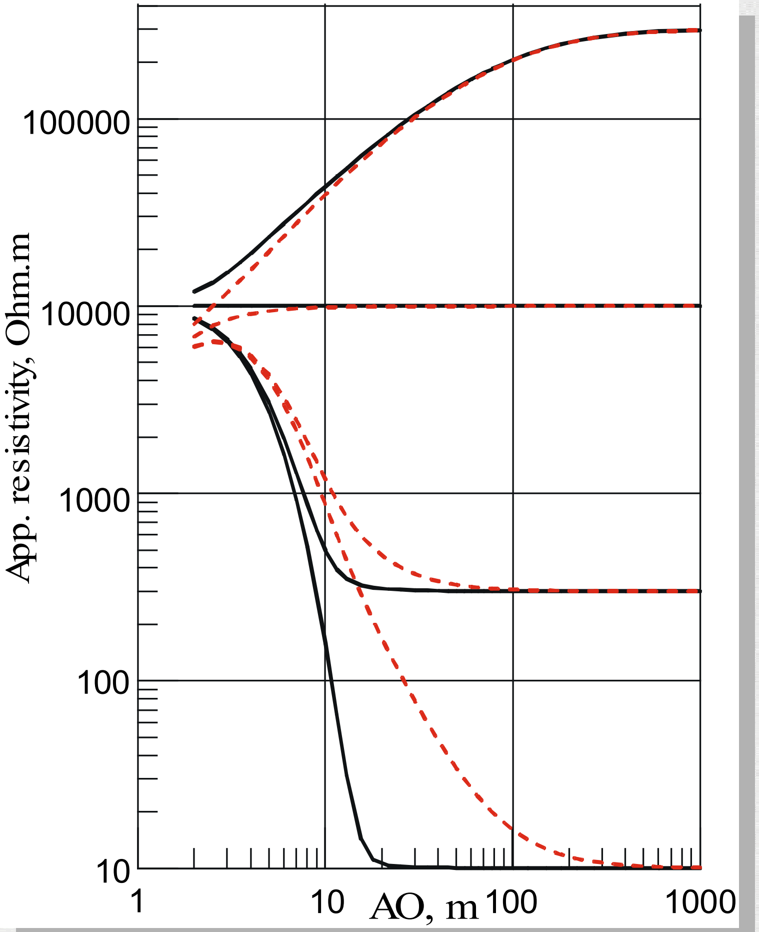
Halfspace:

$$U(r)=\frac{I}{\sigma}\frac{1}{4\pi r}(1+K_{12})\approx\frac{I}{2\pi r\sigma}\left(1-\frac{i\omega\varepsilon_0}{\sigma}\right)\approx\frac{I}{2\pi r\sigma}$$

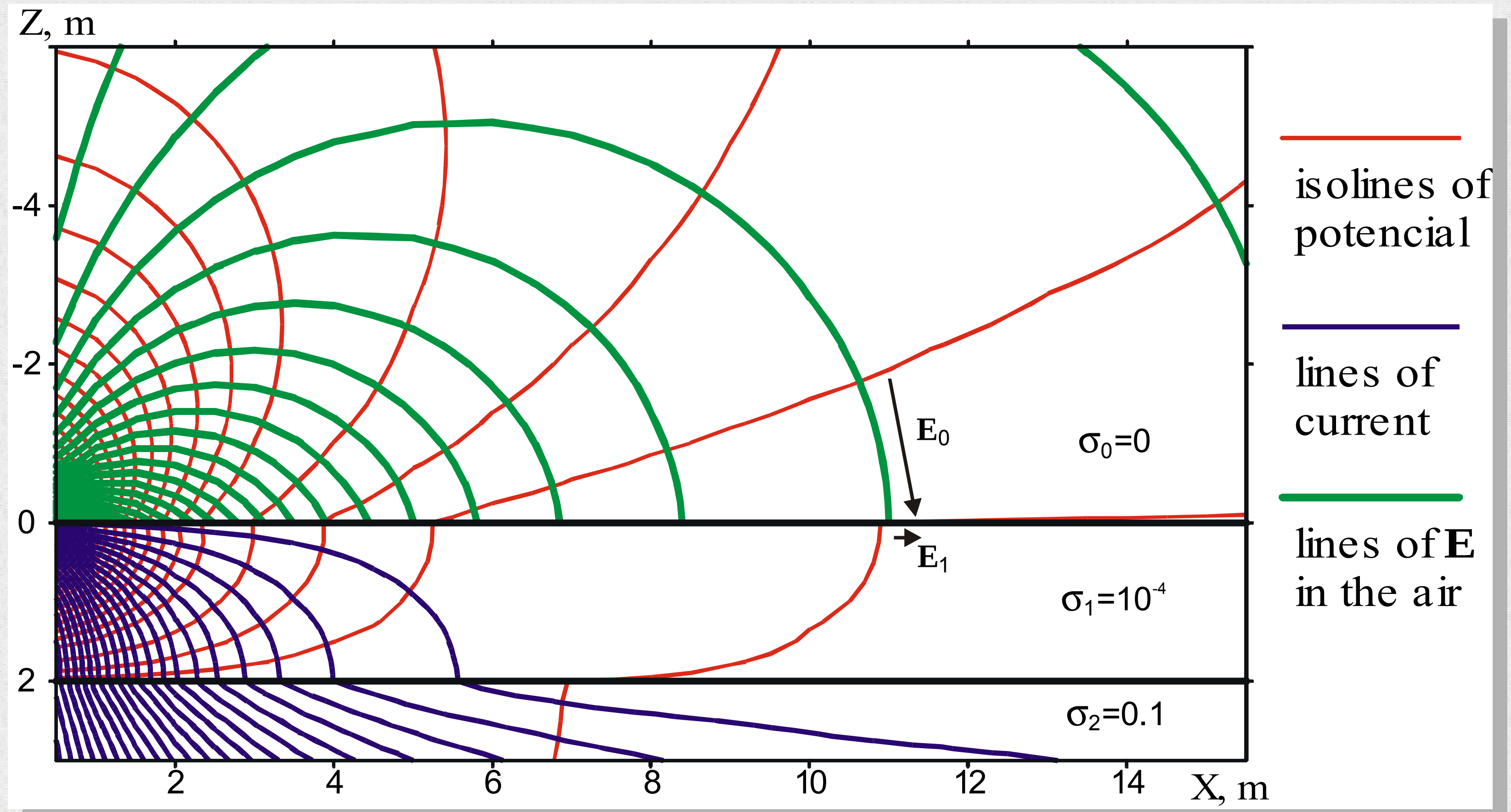
Electrical field in the air from grounded electrode

2 layers





Structure of electrical field for two-layer model



Three-layers model